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Ph.D. Thesis

SYNTHESIS AND PHYSICO-CHEMICAL STUDIES OF 1, 1’-SUBSTITUTED PHENYL CYCLOHEXANE

By

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AUGUST (2006)

Ph. D. THESIS BHAVESH J. GANGANI *2006*

My Thesis

Dedicated
to
My Family

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Statement under O.Ph.D. 7 of Saurashtra University

The work included in the thesis is my own work under the supervision of ***Dr. P. H. Parsania*** and leads to some contribution in chemistry subsidized by a number of references.

Dt.: -08-2006 (Mr. Bhavesh J. Gangani)
Place: Rajkot.

This is to certify that the present work submitted for the Ph. D. Degree of Saurashtra University by Bhavesh J. Gangani is his own work and leads to advancement in the knowledge of chemistry. The thesis has been prepared under my supervision.

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I express my thanks to Mrs Vijyaben, Jignesh and Maulik Parsania for the hospitality extended to me at their home during this research work.

Last but not least , the never ending process of devotion, love and affection, which was shown upon me by my beloved father Shri Jayantbhai Gangani and mother Smt. Manjuben, brother Tejas and my wife Mausami. They had enlightened my path and always boosting me to go ahead to reach the goal. At last, I would like to express my heartiest feelings towards my loving daughter Jhanvi.

(BHAVESH J. GANGANI)

CONTENTS

SYNOPSIS

SYNTHESIS AND PHYSICO-CHEMICAL STUDIES OF 1, 1'-SUBSTITUTED PHENYL CYCLOHEXANE

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SYNOPSIS OF THE THESIS TO BE SUBMITTED TO SAURASHTRA UNIVERSITY FOR THE DEGREE OF PHILOSOPHY IN FACULTY OF SCIENCE- CHEMISTRY

FACULTY : **SCIENCE**

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NAME OF THE CANDIDATE : **BHAVESH JAYANTKUMAR GANGANI**

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GENERAL INTRODUCTION

Among nitrogen containing compounds, amino compounds are more useful. They find their usefulness as intermediates for synthetic fibers and medicines.

Aromatic diamines are the important constituents for syntheses of dyes, agrochemicals, varnishes, adhesive, and coating materials, pesticides, fertilizers and in other applications. They are widely used in manufacturing thermally stable polyamides, amino and epoxy resins. They are also used as curing agents for epoxy resins and in the synthesis of variety of schiff bases for various purposes. [1-4] Schiff bases are most widely used as fine chemicals [5] medical substrates and ligands for metal complexes [6]. They are also useful as starting materials for the synthesis of important drugs like antibiotics, antiallergic, antiphologistics and antitumor [7-9]

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8 C. K. Ingold "Structure and Mechanism in Organic Chemistry." Cornell Univ. press., 2nd Ed. 1969

9 A. P. Mishra, M. Khare and S. K. Gautam "Synthesis, physico-chemicharacterization and antibacterial studies of some bioactive schiff bases and their metal chelates". Synthesis and reactivity in inorganic and metal organic chemistry, **32,** 1485, 2002

Schiff bases based on salicylaldehyde and other hydroxy aldehydes possess unique characteristic properties of improving both antiwear and corrosion inhibition of synthetic lubricating oils and greases. [10]. Owing to manifestations of novel structures, thermal stabilities, abnormal magnetic and biological properties, high synthesis flexibilities, varied co-coordinating ability and medical utility of schiff bases, a wide range of these types of compounds have been synthesized and characterized [11-16] The schiff bases are products of reaction between aldehydes or ketones and aliphatic or aromatic primary amines in the presence of acid or base as a catalyst. [17-19].

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14 S. R. Salman and F. S. Kamounah "Mass spectral study of tautomerism in some 1- hydroxy, 2-napthaldehyde schiff bases." Spectroscopy Letters, **35** , 327, 2002

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The work to be incorporated in the thesis is sub-divided into six chapters :

CHAPTER-1	Literature survey on aromatic diamines and symmetric double schiff bases
CHAPTER-2	Syntheses of 1, 1' - bis (4-aminophenyl) cyclohexane and its symmetric double schiff bases
CHAPTER-3	Spectral and physico - chemical characterization of diamine and symmetric double schiff bases
CHAPTER-4	Thermal analysis of diamines and symmetric double schiff bases
CHAPTER-5	Sound velocity and allied parameters of symmetric double schiff bases
CHAPTER-6	A comprehensive summary of the work

CHAPTER- 1: Literature survey on aromatic diamines and symmetric double schiff bases

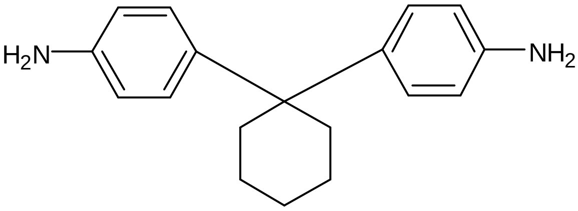
This chapter of the thesis describes the up to date literature survey on synthesis, characterization and applications of aromatic diamines and their schiff bases in the various fields of science.

CHAPTER-2: Synthesis of 1, 1’bis (4-aminophenyl)cyclohexane and symmetric double schiff bases

This chapter of thesis is further sub divided into three sections:

Section – I: Synthesis of 1, 1’ bis (4-aminophenyl) cyclohexane [DAC]

DAC was synthesized by condensing 0.12 mol aniline hydrochloride and 0.05 mol cyclohexanone at 140-150°C for 9 h and 2 h at 160-170°C. DAC was recrystallized repeatedly from benzene - hexane system.(M. F.= $C_{18} H_{22} N_2$, MW = 266,m. p = 114°C)



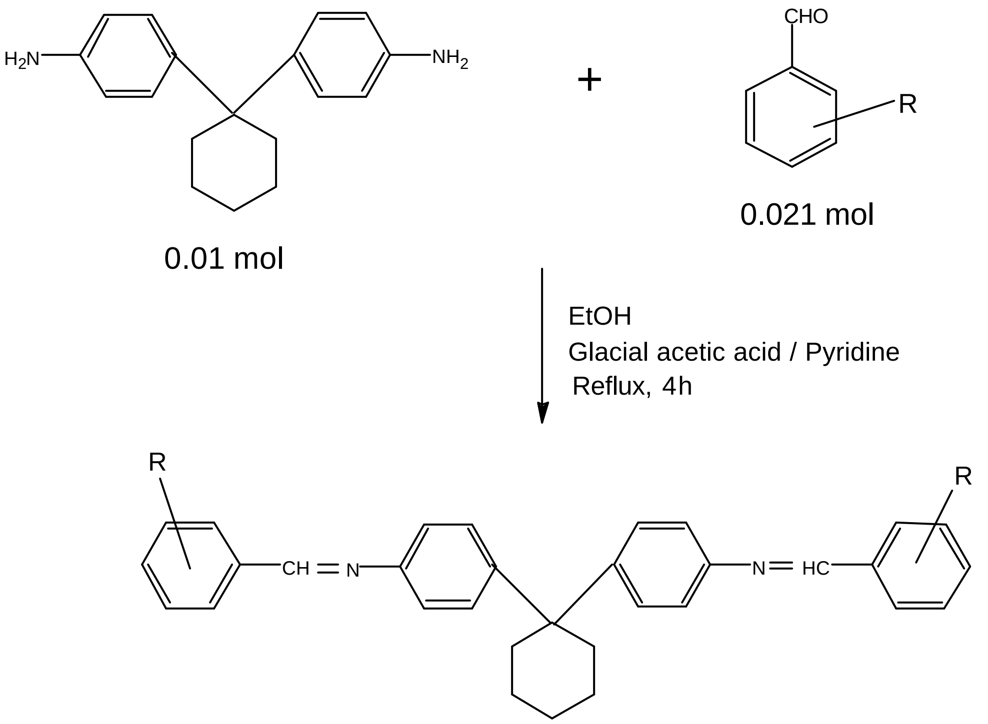
DAC

Section - II: Synthesis of symmetric double schiff bases by classical method

Schiff bases of general structure-I and II were synthesized by condensing 0.01mol DAC and 0.021mol substituted aromatic aldehydes in ethanol by using 2 ml glacial acetic acid or 2 ml pyridine as a catalyst at reflux temperature for 4 h The schiff bases were isolated from chilled water, filtered washed well with sodium bisulfite solution, water and finally with ethanol and dried in an oven at 50°C. The schiff bases were recrystallized repeatedly from appropriate solvent systems and their purity was checked by TLC in appropriate solvent system at room temperature.

Section–III: Synthesis of symmetric double schiff bases by microwave irradiation method

The microwave irradiation condensation of DAC and aromatic aldehydes were carried out in a domestic oven (L.G. 360 watts). Thus, 0.01 mol DAC and 0.02 mol aromatic aldehyde were mixed together at ambient temperature in 50 ml Erlenmeyer flask. The mixture was subjected to microwaves for optimized time interval. The compounds were repeatedly recrystallized from appropriate solvent systems and their purity was checked by TLC in appropriate solvent system at room temperature.



Scheme-I

SBDAC – 1 :- R =H

SBDAC – 2 :- R =4 - CH_3

SBDAC – 3 :- R = 2 - OH

SBDAC – 4 :- R = 4 - OH

SBDAC – 5 :- R =2 – OCH_3

SBDAC – 6 :- R = 4 – OCH_3

SBDAC – 7 :- R = 3 – OC_6H_5

SBDAC – 8 :- R = 2 - Cl

SBDAC – 9 :- R = 3 - Cl

SBDAC –10 :- R = 4 – Cl

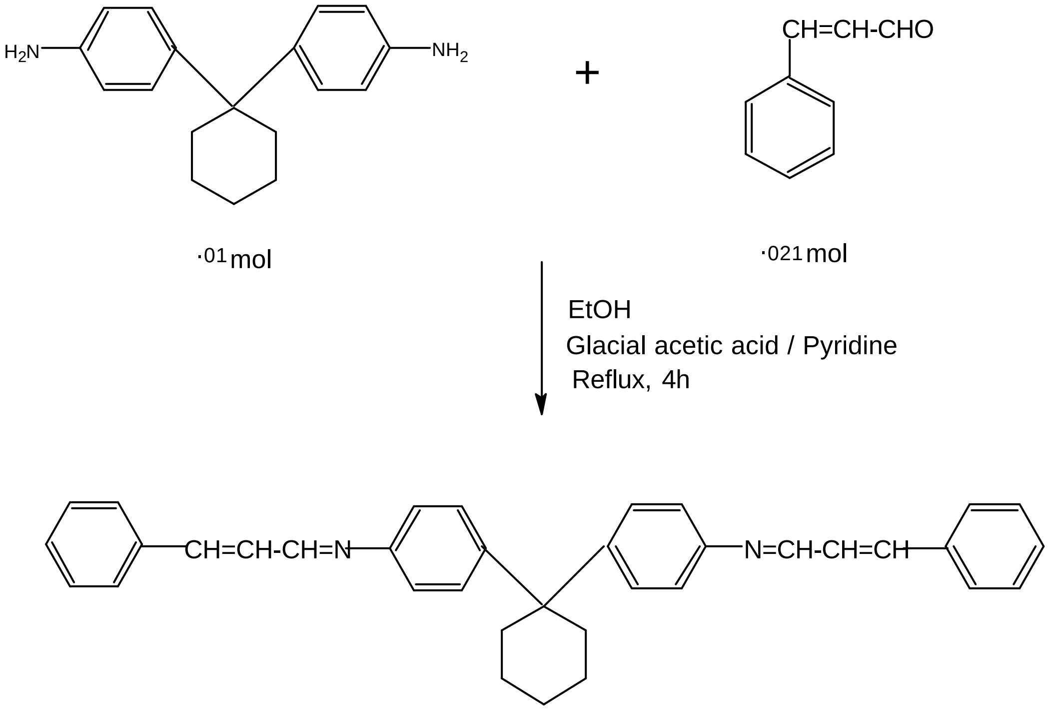
SBDAC –11 :- R = 3 – Br

SBDAC –12 :- R = 4 - F

SBDAC –13 :- R = 2 – NO_2

SBDAC –14 :- R = 3 – NO_2

SBDAC –15 :- R = 4 - N $(CH_3)_2$



Scheme II

CHAPTER – 3: Spectral and physico-chemical characterization of diamine and symmetric double schiff bases

This chapter of the thesis deals with the characterization of diamine and schiff bases and it is further sub-divided into seven sections:

Section –I: UV spectral characterization

UV spectroscopy is useful for the identification of specific chromophores / functional groups present in the compounds. In order to furnish supplementary evidences on functional groups, diamine and schiff bases are scanned in suitable solvent system and used in structure establishment.

Section –II: IR spectral characterization

The structures of diamine and symmetric double schiff bases are supported by FTIR spectral data in conjunction with other data.

Section – III: NMR- spectral characterization

In order to support quantitative structures of the compounds, NMR technique is a powerful tool. It furnishes different types of protons in a given compound. From the knowledge of chemical shifts and coupling constants as well as splitting pattern, it is possible to assign different types of protons in the compounds. In accordance with other spectral data, structures of diamine and schiff bases are elucidated by NMR technique.

Section – IV: Mass spectral characterization

Mass spectroscopy is an outstanding analytical technique in which sample is converted into rapidly moving positive ions, which are separated on the basis of their m/e ratio. It provides information regarding the fragmentation pattern when a molecule is disrupted by ionization. It is used for supplementary evidences of several groups present in the molecule. In accordance with UV, IR and NMR spectral data, it gives quantitative structure of the compound. In this section mass spectral fragmentation schemes of diamine and schiff bases are described.

Section – V: Density measurements

The density is an additive property and is dependent on the structure of the compound. The densities of schiff bases were determined by specific volume method and are compared with calculated values. The density data are interpreted in light of nature of solvent and nature of polar substituents at constant temperature.

Section – VI: Refractive index measurements

Refractive index is also an additive property. Refractive index of schiff base solutions is determined at room temperature and intrinsic refractive index of each schiff base is determined by extrapolation technique and discussed in light of structural aspects.

Section – VII: Antibacterial and antifungal activities of symmetric double schiff bases

The antibacterial and antifungal activities of schiff base were tested against different gram positive and gram negative micro organisms by cup plate method and are compared with standard drugs and the results are discussed on the basis of structural aspects.

CHAPTER – 4: Thermal analysis of diamine and symmetric double schiff bases

Thermal analysis of the material is very significant in predicting its utility under various environmental conditions, especially under high temperature applications. It is the best tool for understanding molecular architecture, decomposition mechanism and degradation pattern, etc.

This chapter of the thesis describes DSC and TG analysis of diamine and schiff bases at a single heating rate in nitrogen atmosphere. The thermal stability and kinetics of thermal degradation of schiff bases are investigated and discussed.

CHAPTER – 5: Sound velocity and allied parameters of symmetric double schiff bases

Now a day ultrasonic has become the subject of extensive research because it finds numerous applications in different fields of science like consumer industries, medical field, engineering field, process industries, etc. [20-22]. This study furnishes the knowledge on structural changes, molecular interactions occurring in the solutions. This chapter describes the measurements of sound velocity, density and viscosity measurements on schiff bases in different solvents like chloroform, DMF, 1-4 dioxane and tetrahydrofuran at three different temperatures **:** 30^o, 35^o and 40^o C. Various acoustical parameters are determined and discussed to know effect of concentration, temperature, solvent and nature of substituents on molecular interactions and structural modifications in solutions.

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22 K. A. Pethrick, J. Macromol Sci., Review, Macromol Chem. **C-9**, 91, 1973

CHAPTER – 6: A comprehensive summary of the work

This chapter of the thesis describes a comprehensive summary of the work incorporated in the thesis.

Signature of the guide	**Signature of the candidate**
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CHAPTER-1

LITERATURE SURVEY ON AROMATIC DIAMINES AND SYMMETRIC DOUBLE SCHIFF BASES

CHAPTER-1

LITERATURE SURVEY ON
AROMATIC DIAMINES
AND
SYMMETRIC DOUBLE SCHIFF BASES

CHAPTER-1

LITERATURE SURVEY ON DIAMINES AND SCHIFF BASES

[A] General introduction

Functional groups containing nitrogen are responsible for their unique chemical reactivity patterns and play important role in the preparation of drugs, dyes, agrochemicals and molecules of life. There are many functional groups, which contain one or more nitrogen atoms. Some categories of compounds based on these functional groups include nitro compounds, amines, cyanides, isocyanides and diazocompounds. The chief commercial use of amine compounds are found as intermediates in the synthesis of dyes, synthetic fibers and medicines, etc.

Methods of preparation

Amines are prepared from a variety of compounds. Some methods commonly used for the synthesis of amines are reductions of nitro compounds into amines by catalytic hydrogenation or by using a metal and an acid. Aniline is one of the most important of all amines. It is manufactured by the reduction of nitro benzene.

Physical properties of amines

Lower members of the amines are gaseous, most of the higher members are liquids, while some aromatic amines are solids. Majority of amines have unpleasant odour. Aromatic amines in general are toxic. Most of the amines are colorless in pure state. They are easily oxidized and get colored due to impurities.

Amines are more polar compounds than alkanes but less polar than alcohols and possess higher boiling points than non-polar compounds such as hydrocarbons of the same molecular masses. All primary and secondary amines form intermolecular hydrogen bonding because they are proton acceptors and hence possess higher boiling points than tertiary amines.

Solubility of amines

All the three classes of amines form hydrogen bonding with water. Amines of lower molecular masses are soluble in water, but the solubility of amines in water decreases with increasing hydrophobic part more than six carbons. The higher molecular mass amines are insoluble in water. The solubility of amines in water is low as compared to in alcohols because of weak H- bonding. Amines are soluble in common organic solvents like ether, benzene, alcohols, while insoluble in hexane.

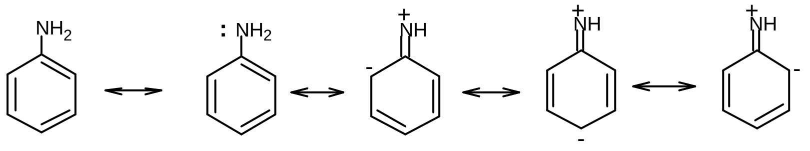
Basic character of amines

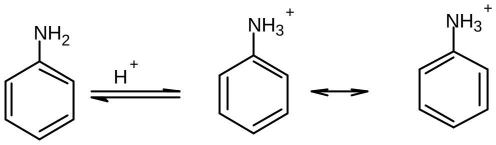
Nitrogen atoms of amine compounds contain lone pair of electrons, which have a tendency to share with acids and hence responsible for the basic character of amines. This is affected by the number and the nature of their alkyl or aryl groups. Like ammonia, amines are strong bases and react with mineral acids to form ammonium salts from which they can be liberated by treatment with a strong base such as sodium hydroxide.

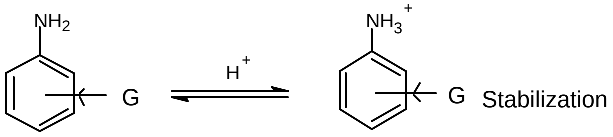
Aliphatic amines ($K_b \sim 10^{-3}$ to 10^{-4}) are some what stronger bases than ammonia ($K_b \sim 1.8 \times 10^{-5}$). Aromatic amines are weaker bases ($K_b \sim 10^{-9}$) and the substituents markedly affect the basicity

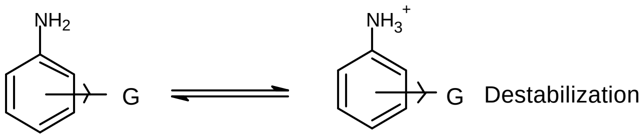
Aromatic amines are weaker bases than ammonia and aliphatic amines due to resonance stabilization in aromatic amines, e.g. the structure of aniline is a hybrid of the five contributing species because of the conjugation of unshared electron pair with aromatic ring, while there are two Kekule structures for anilinium cation. Thus, resonance stabilization in an aromatic amine is more than its ammonium cation.

An electron donating group present in an aromatic amine ring especially on o/p position stabilizes the ammonium cation formed after protonation of amine and hence increases the basic strength of the amine. An electron withdrawing group adversely affects the stability of an aromatic ammonium cation and decreases the basic strength of parent aromatic amine.



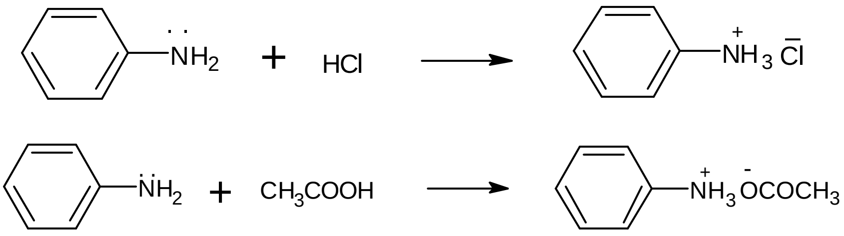






Chemical reaction of aromatic amines with acids

The reaction of amine is mainly due to participation of unshared pair of electrons of nitrogen, which acts as a nucleophile and a base. A nucleophile (-ve) is a species that attacks on electron deficient carbon and a base is a species that attacks on electron deficient hydrogen. The number of hydrogen atoms on amine nitrogen also affects the course of some reaction [1]. Reactions of amines with acids are described below.



Amine behaves as a base during reaction with an acid and forms a salt, which is water soluble and amine regenerates when treated with sodium hydroxide.

---

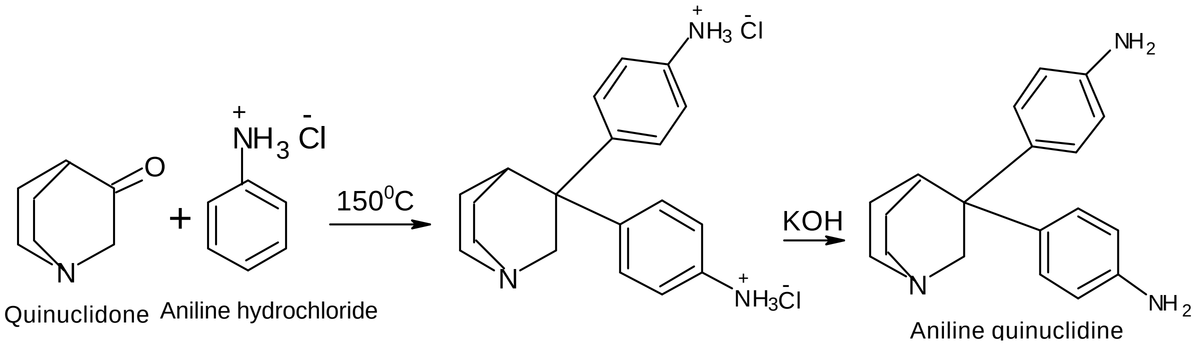
[1] S. P. Jauhar and S. K. Malhotra. "Morden's abc of Chemistry", 6th Edi. New Delhi, 2005.

[B] LITERATURE SURVEY ON DIAMINES

Diamines are the important constituents or intermediates in dyes, agrochemicals, varnish, coating, pesticides, fertilizers, etc. They are useful in manufacturing thermally stable polyimides, epoxy resins, formaldehyde resins, schiff bases and as hardeners.

Aromatic diamines based on quinuclidine are widely used for the synthesis of thermally and chemically stable polyimides. Different drugs containing quinuclidine moieties are prepared, one of them namely phenacarol provides effective relief against allergies [2].

Vygodskii et. al [3] have reported synthesis of 3-3' bis (4-aminophenyl) quinuclidine and its polymer.



22.83 g (0.22 mol) aniline hydrochloride and 10.0 g (0.1 mol) quinuclidione–3 mixture was heated at 150^{0}C and then the reaction temperature was raised to 170^{0}C. At this temperature the reaction mixture was stirred for 3h. The resultant aniline quinuclidine (AQ) hydrochloride was cooled to 140^{0}C and 25-30 ml boiling water was added to obtain transparent deep red solution. The solution was refluxed with activated charcoal and filtered. AQ was precipitated by adding 20% KOH solution, filtered, washed repeatedly with ice water and dried at 50-60^{0}C. AQ was crystallized by vacuum sublimation at 200^{0}C. The yield was 43%.

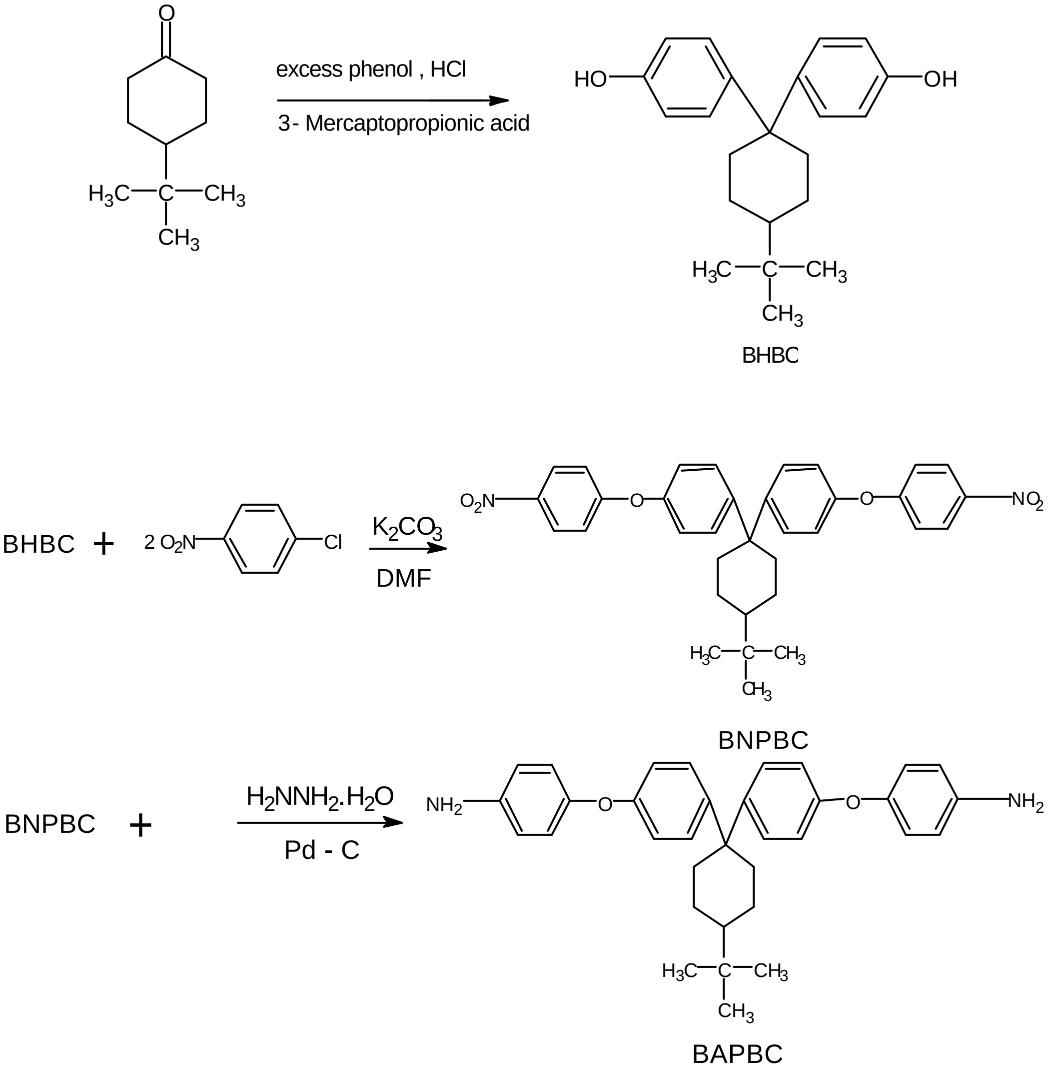
---

[2] M. D. Mashkovskii, L. S. Meditsina, Moscow, **1**, 312, 1984.

[3] Y. S. Vygodskii, N. A. Churochkina, T.A. Panova, Y. A. Fedotov. "Novel condensation functional polymers having highly basic groups". Reactive & Functional Polymers, **30,** 241, 1996.

The structure was supported by elemental and spectral techniques. IR spectrum showed absorption peak at 3380 and 3460 cm^{-1} due to primary NH_2 groups. ^1H NMR spectrum has shown a singlet at 5.62 ppm due to NH_2 groups, multiplet at 3.10 – 1.75 ppm due to quinuclidine moiety and at 7.00-6.56 ppm due to benzene ring.

Liaw et. al [4] have reported synthesis of new cardo diamine monomer 1,1'-bis [4- (4-amino phenoxy) phenyl] 4-tert butyl cyclohexane. This cardo diamine was prepared in three steps from 4-tert butyl cyclohexanone as under.



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[4] D. J. Liaw, B.Y. Liaw, and C.Y. Chung," Synthesis and characterization of new cardo polyamides and polyimides containing tert – butylcyclohexylidene units " Macromol. Chem. Phys. **201,** 1887, 2000.

1,1`-Bis(4-hydroxyphenyl)-4-*tert*-butylcyclohexane (BHBC)

A flask was charged with a mixture of 0.067 mol (10.4 g), 4-*tert*butylcyclohexanone, 0.2 mol (19 g) phenol and 1 mol 3-mercaptopropionic acid. Heat was applied and when the reaction mixture became liquid at 58^0C, anhydrous hydrogen chloride was introduced until the solution became saturated. Stirring was continued at 60^oC for 2 h, during which period white solid began to separate from the reddish-orange reaction mixture. The solid mass was dispersed in 1 L of water and the mixture was steam distilled to remove the excess phenol and 3-mercaptopropionic acid leaving an aqueous suspension. The solid residue was collected from the mixture by filteration and recrystallization from toluene twice gave1, 1'-bis (4-hydroxyphenyl)-4-*tert*-butylcyclohexane (BHBC)**.** The yield was 74% yield and m. p. 181-182^oC.

1,1'–Bis[4-(4–nitrophenoxy)phenyl]–4-tert-butylcyclohexane (BNPBC)

A mixture of 0.028 mol (9.2g) BHBC, 0.06 mol (9.44 g), p-chloro nitrobenzene, 0.07mol (9.7 g) anhydrous potassium carbonate and 50 ml anhydrous DMF was refluxed for 8 h. The mixture was then cooled and poured into methanol. The crude product, 1,1'-bis[4-(4-nitrophenoxy)phenyl]-4-tert-butylcyclohexane(BNPBC) was recrystallized from glacial acetic acid to give yellow needles (m.p. 190-191^oC) in 94% yield. The characteristic IR absorption peaks of BNPBC are 1578 and 1334 cm^{-1} (NO_2) 1243 cm^{-1} (C-O-C).

^{1}H NMR ($CDCl_3$) showed following signals (ppm): 8.21-8.16 (m, 4H, aromatic H ortho to NO_2 groups); 7.46 (d, 2H, aromatic H ortho to cardo group); 7.26 (d, 2H, aromatic H ortho to cardo group); 7.03-6.94 (m, 8H, aromatic H meta to NO_2 and cardo group); 2.76-1.21 (m, 9H, cyclohexane group); 0.81 (9H,-CH_3).

1, 1'-Bis [4-(4-aminophenoxy) phenyl] 4-tert-butylcyclohexane (BAPBC)

A 20 ml hydrazine monohydrate was added drop wise to a mixture of 0.014 mol (7.98g) BNPBC, 160 ml ethanol, and a catalytic amount of 10% palladium on activated carbon (Pd/C, 0.06 g) at the boiling temperature. The mixture became homogeneous after 1 h and the reaction was refluxed for 24h. The mixture was then filtered to remove Pd/C. After cooling, the precipitated white crystals of 1, 1' – bis [4 - (4 – amino phenoxy) phenyl] – 4 – tert –butyl cyclohexane (BAPBC) were isolated by filteration and recrystallized from ethanol to give 83% yield (m.p. 171-172^{o}C). The IR spectrum (KBr) of BAPBC exhibited characteristic absorptions at 3418, 3350 and 1613 cm^{-1} (N-H), and 1237 cm^{-1} (C-O-C).

BAPBC was reacted with various aromatic dicarboxylic acids and tetra dicarboxylic dianhydrides to produce polyamides and polyimides, respectively. Polyamides and polyimides imparted greater solubility, enhance rigidity as well as better thermo-mechanical properties.

Aromatic diamines are widely used for the synthesis of polyimides, which have been noted for their excellent characteristic properties. But their processability is poor, which limits their application area [5] and therefore various efforts have been made to synthesize soluble polyimides without sacrifice of their excellent properties. By using diamines having cyclic ring between two benzene rings, the obtained polymer showed good thermal stability as well as solubility [6,7].

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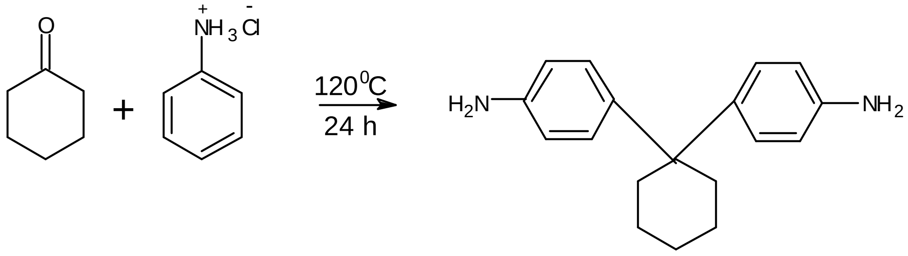
[5] D. Wilson, H. D. Stenzenberger and P.M. Hergenrother, Polyimide, Glasgow, U.K. 1991.

[6] M. H. Yi, M.Y. Jin and K.Y. Choi. Macromol, Chem. **223**, 89, 1995

[7] K.Y. Choi, M. H. Yi and M. Y. Tin. “Polymeric Materials Encyclopedia.” CRC. Boca Raton, New York, London. **Vol-7**, 5379, 1996.

Choi et. al [8] have reported the synthesis of series of novel aromatic diamines containing cyclohexane moieties. They have also synthesized and characterized soluble polyimides from1,1'-bis(4-aminophenyl)cyclohexane derivatives.



BACH

1,1'-Bis (4-aminophenyl)cyclohexane (BACH)

BACH was prepared by the condensation of cyclohexanone and excess aniline [9,10]. To a solution of 0.41 mol (40.0 g) cyclohexanone in 35% HCl aqueous solution in a 1-L autoclave equipped with a mechanical stirrer was added 1.68 mol (156.3 g) aniline and the mixture was stirred at 120 ^OC for 20 h. After cooling, the solution was made basic with aqueous NaOH solution to pH 10, and the oily layer was separated and steam distilled to remove the unreacted excess aniline. The residual crude product was recrystallized from benzene to give 86.4 g (79.4% yield) of light-yellow crystal; (m. p. 112^oC).

1,1'- Bis (4-aminophenyl)-4-methylcyclohexane (BAMC) and 1,1'- bis (4- amino phenyl)- 3,3,5- trimethyl cyclohexane (BATMC) were prepared in a similar manner to that of BACH by reacting 4-methylcyclohexanone and 3,3,5-trimethyl cyclohexanone with aniline.

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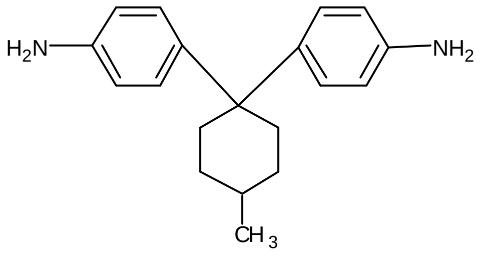
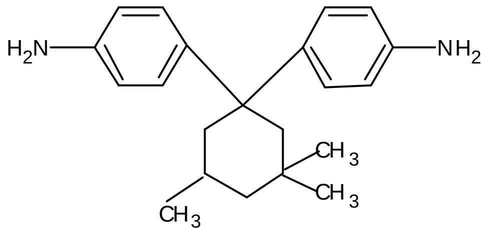
[8] M.H. Yi, W. Hung, M.Y. Tin and K. Y. Choi "Synthesis and characterization of soluble polyimides from 1,1'- bis (4 amino phenyl) cyclohexane derivatives " Macromolecules, **30**, 5606, 1997.

[9] H. Waldmann, U. Leyrer, H. P. Mueller, K. J. Idel, C. Casser, G. Fengler and U. Westeppe, Ger. Offen D.E. 4,014, 847, 1991.

[10] Myska. J. Chem. Abstra., **61,** 14558, 1964.



BAMC



BATMC

BAMC was recrystallized from isopropyl alcohol to give 70% light yellow crystals (m. p. 158.8^{0}C). BATMC was recrystallized from isopropyl alcohol to give 40% pale yellow powder (m. p. 46^{0}C). The structures of BACH, BAMC and BATMC were supported by elemental, IR, Mass and NMR spectral data. They have also proposed the mechanism of diamines formation and was confirmed by the structural identification of a major by product by ^{1}H NMR. The dehydration reaction was faster than the substitution reaction of aniline and therefore diamine yield is low.

Yi et. al [11] have reported the synthesis and characterization of soluble polyimides from aromatic diamines containing polycycloalkane structure between two benzene rings. 2,2'-Bis(4-aminophenyl) norbornane (BANB) and 2,2'-bis (4-amino phenyl) admantane (BAAD) were synthesized by HCl catalyzed condensation reaction of corresponding polycycloalkanone with aniline hydrochloride at 140-160^{o}C for 20 h. The yields of diamines were 32-35% and the structures of diamines were supported by FTIR, ^{1}H NMR, ^{13}C NMR spectroscopy and elemental analysis. The detail process and spectral data of diamine are given.

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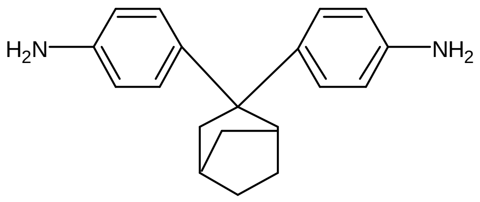
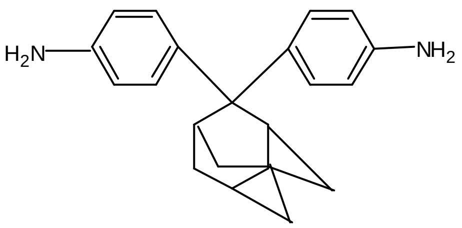
[11] M.H. Yi, W. Huang, B. J. Lee, and K.Y. Choi "Synthesis and characterization of soluble polyimides from 2,2'-bis (4-aminophenyl) cycloalkane derivatives". J. Polym. Sci. Part-A Polym. Chem., **37,** 3449, 1999.



BANB

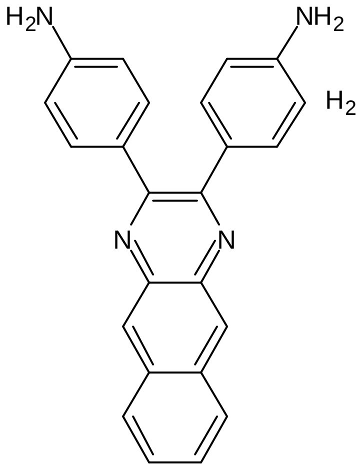


BAAD

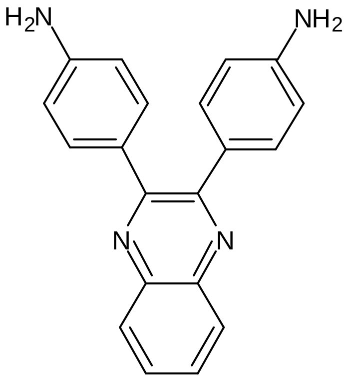
To a 500-mL four-neck flask equipped with a mechanical stirrer was placed 0.16 mol (17.6 g) of 2-norbornanone, 0.48 mol (45.0 g) aniline and 0.32 mol (41.5 g) aniline hydrochloride and the mixture was stirred at 140-160^{O}C for 20 h. After cooling, the solution was made basic with aqueous NaOH solution to pH 10, and the purple oily layer was separated and steam distilled to remove the unreacted aniline. The residual crude product was treated with active carbon to remove the dark color, and then recrystallized from ethyl acetate to give 15.0 g (35.2%) off white crystals of BANB (m. p. 202^{0}C). The structure of BANB was supported by MS [m/z 197 and 278 (M^+)], FTIR [3444 and 3359 (NH str.), 1615 (NH def)] spectral and elemental analysis.

Inoki et. al [12] have studied curing behavior and properties of epoxy resins cured with the diamines having heterocyclic ring. The diamines 2-3'- bis (4-amino phenyl) benzoquinoxaline (BABQ), 4,5-bis (4-aminophenyl)2-phenyl imidazole (BAPI), and 4,5- bis (4-amino phenyl) 2-methyl oxazole (BABQ) were prepared and used as curing agents. They have reported that DGEBA cured with aromatic diamine having heterocyclic ring, especially 2,3 bis (4-aminophenyl) quinoxaline (BAPQ) displayed both excellent bonding strength and thermal stability.

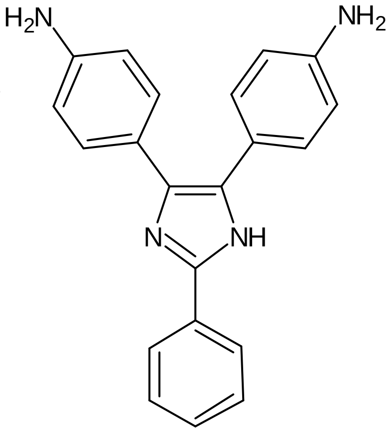
Commercially available diamines such as, 4,4'- diamino diphenyl sulfone (DDS), 4,4'-diamino diphenyl methane (DDM) or m-phenylene diamine possess high bonding strength at lower temperature, but fall at elevated temperature, while the epoxy resin cured with BAPQ has high bonding strength even at 180^{0}C.



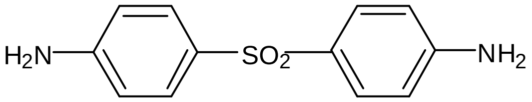
BABQ



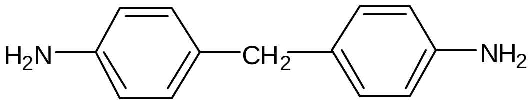
BAPQ



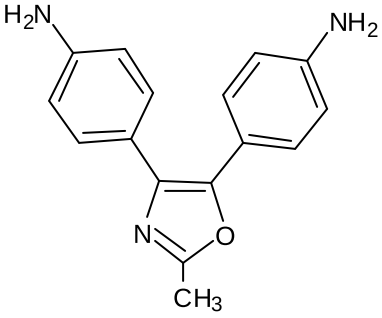
BAPI



DDS

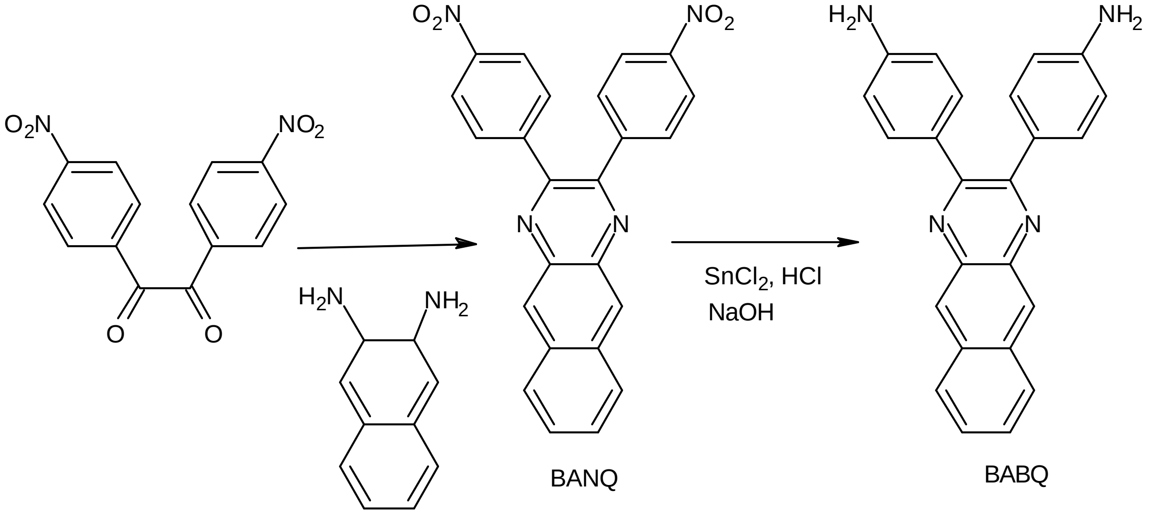


DDM



BAPO

The reaction route of BABQ is as under



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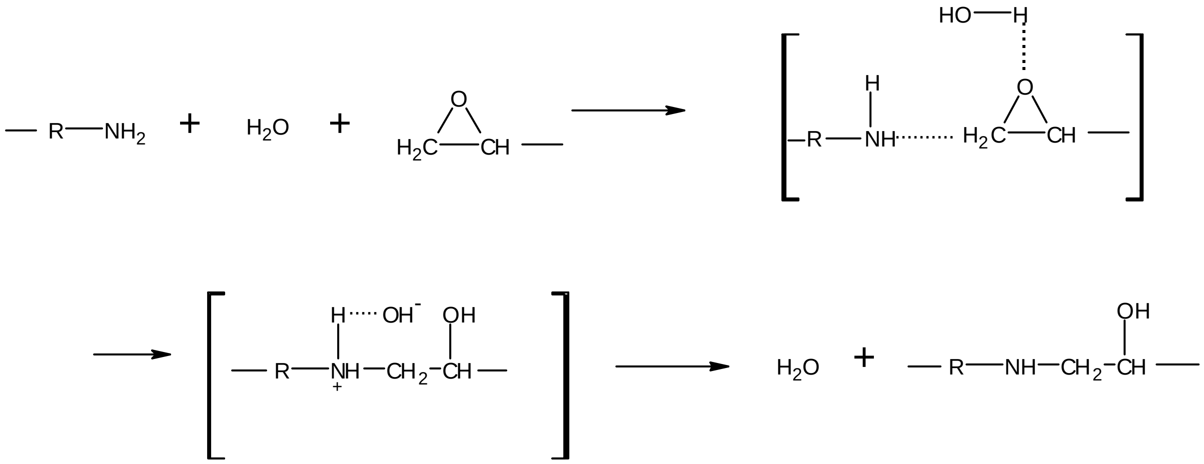
[12] M. Inoki, S. Kimura, N. Daicho, Y. Kasashima F. Akutsu and K. Marushima, “Curing behavior and properties of epoxy resins cured with diamine having heterocyclic ring” J. Macromol. Sci- Pure & App. Chem., **4,** 321, 2002.

Union Carbide Co. [13] has reported curing of polyepoxides with liquid glycol diamines ($H_2N\ (CH_2)_3O\ (C_nH_{2n}O)x\ (CH_2)_3NH_2)(I)$, where n is 2-5 and x is 1-11. The cured compounds have excellent impact strength and flexibility and are stable as protective coatings. Thus, 100 g of diglycidyl ether was mixed with 29.4g stoichiometric amount $H_2N(CH_2)_3O\ (CH_2CH_2O)_2(CH_2)_3NH_2$ for 5 min. The mixture was applied on cold-rolled steel and was cured by storing 7 days at room temperature.

Joshi et. al [12] have studied curing behavior and properties of epoxy resins of 1,1'-bis(4-hydroxy-phenyl) cyclohexane by using 50% pyromellitic dianhydride(PMDA), tetrachloro phthalicanhydride (TCP), bisphenol-C-formaldehyde resin (BCF), diamino diphenyl methane (DDM) and 1,1'-bis(4-amino phenyl)cyclohexane (DDC) as curing agents at $230^{o}C/150^{o}C$. PMDA, TCP and BCF cured resins are insoluble in all common solvents, while DDM and DDC cured resins are soluble in common solvents. BCF, PMDA, TCP and DDC cured samples are thermally stable up to about $350\text{-}365^{0}C$ except DDM cured sample ($275^{0}C$) . The reaction mechanism involved in the reaction between epoxy resins is given below.



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[C] LITERATURE SURVEY ON SCHIFF BASES

The chemistry of carbon-nitrogen double bonds has played a vital role in the progress of chemical sciences. Due to presence of a lone pair of electrons on the nitrogen atom and general electron donating character of the double bond, these compounds have found very large applications in the field of chemistry. The compounds containing >C=N group are known as imines or azomethines or anils or ligands, but generally they are known as "Schiff bases " in honors of schiff who have synthesized such compounds very first time [15,16].

The literature survey revealed that schiff bases are useful as starting material in the synthesis of important drugs, such as antibiotic, antiallergic, anticancer, antiphologistics and antitumor, etc [17-19]. Schiff base compounds are widely used as fine chemicals, analytical reagents, corrosion inhibitors as well as ligands [20, 21].

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[18] C. K. Ingold "Structure and mechanism in organic chemistry". Ithaca Cornell Univ. 2nd ed. 1969.

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[20] S. Bilgic and N. Caliskan, "An investigation of some schiff bases as a corrosion inhibitors for austenitic chromium-nickel steel in H_2SO_4". J. Appl. Electroche. **31**, 79, 2001.

[21] D. Y. Sabry, T. A. Youssef, S. M. El-Medani and R. M. Ramadan. "Reaction of chromium and molybdenum carbonyls with bis (salicylaldehyde) ethylene diimine schiff base ligand" J. Coord. Chem. **56** , 1375 ,2003.

Metal complexes synthesized from schiff bases have been widely studied because of their industrial, antifungal and biological applications [22,23]. Schiff bases possess characteristic properties like manifest of thermal stabilities, abnormal magnetic properties, relevant biological properties, high synthetic flexibility, co-ordinating ability and medicinal utility. A wide range of schiff bases have been synthesized and extensively studied [24,25]. The schiff bases are the condensation products of aromatic or aliphatic aldehydes (e.g. benzaldehyde, cinamaldehyde, crotonaldehyde, etc.),with aliphatic or aromatic mono or diamines (e.g. aniline, aminophenols,1,2-ethanediamine, benzidine, diamino diphenyl methane, diamino diphenyl sulphone, etc.)[26-28].

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[23] M. E. Hossain, M. N. Alam, J. Begum, M. A. Ali, F. E. Smith and R. C. Hynes" The preparation, characterization, crystal structure and biological activities of some copper (II) complexes of the 2-benzoyl pyridine schiff bases of 5-methyl and 5-benzyldithiocarbazate" Inorg. Chim. Acta , **249,** 207, 1996.

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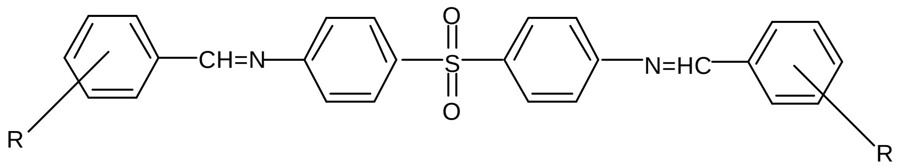
Agarwal et. al [29] have proved that schiff bases possess the unique characteristic of improving both anti wear and corrosion inhibition properties of a lubricant. Schiff bases derived from the reaction of an aromatic aldehyde such as salicylaldehyde and aromatic diamines can be added to a variety of lubricants and particularly lubricating oil greases in amount ranging up to about 5% by weight of the total composition. The lubricants containing schiff bases are very useful for high performance engine such as machinery aboard ship, submarines and particularly in the aircraft industry. The engines perform work at higher speeds, higher load and higher temperature and therefore life of lubricants and engine parts decrease, which can be prevented by using schiff bases as additives in lubricating oils and greases.

Das et. al [30] have reported metal ion uptake behavior of chelating resins derived from formaldehyde and phenolic schiff bases. The phenolic schiff base was synthesized by the condensation of 4-4' diamino diphenyl sulfone with ortho, meta and para, hydroxy benzaldehyde, respectively. The metal ion uptake behavior of these resins towards Cu^{+2}, Ni^{+2}, Co^{+2} and UO^{+2} ions in dilute aqueous media was studied. The optimum conditions for efficient uptake of metal ions were determined by varying the various parameters like contact time, size of sorbents, concentration of metal ion in the solution and pH of the reaction medium. It was observed that the structural features of the resins have profound effect on the uptake characteristics.



R=-OH at ortho, meta and para position, respectively.

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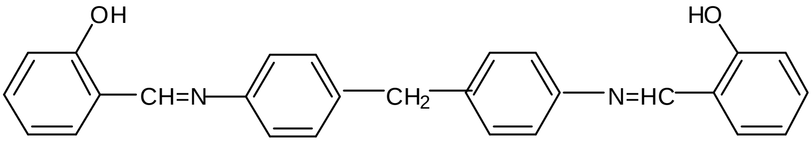
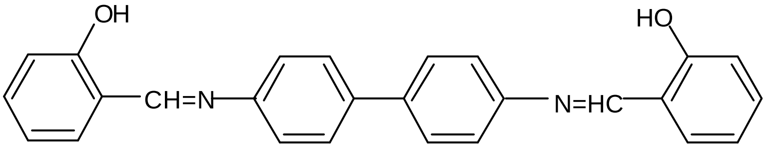
They have reported that out of three resins, resin containing -OH groups at meta position has a significant influence on the extent of metal ion uptake tendency. They have also reported that all these resins could be employed successfully to separate Cu^{2+} efficiently from binary mixture of Cu^{2+}-Ni^{2+} and Cu^{2+}-UO_2^{2+} at different pH values.

Ray et. al [31] have reported metal ion uptake behavior of formaldehyde condensed resins of phenolic schiff bases derived from the reaction of 4,4' diamino diphenyl and 4,4' diamino diphenyl methane with o-hydroxy benzaldehyde. They have examined metal ion uptake characteristic of o-HB-DDM-HCHO and o-HB-DD-HCHO towards transition metal ions like Cu^{+2}, Ni^{+2} and UO_2^{+2} under both competitive and non-competitive conditions. The resin o-HB-DDM-HCHO is more effective in removing metal ions in comparison of o-HB-DD-HCHO. Preferential adsorption of Cu^{+2} by both the resins was observed from the salt solution.



o-HB DDM



o-HB-DD

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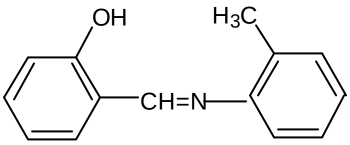
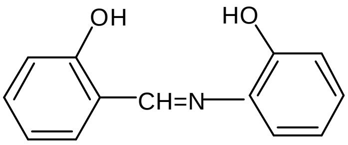
[31] A. R. Ray, S. Samal, S. Acharya and R. K. Dey. "Studies of metal ion uptake behavior of formaldehyde condensed resins of phenolic schiff bases derived from the reaction of 4, 4' diamino diphenyl and 4, 4' diamino diphenyl methane with o-hydroxy benzaldehyde" Ind. J. Chem. Technol. **11**, 695, 2004.

Several schiff bases have been investigated as corrosion inhibitors for various metals and alloys in acidic media [32-34]. The use of inhibitors is one of the most practical methods for the protection against corrosion in acidic media [35]. Acidic media HCl and H_2SO_4 are generally used in the treatment of steel and ferrous alloy. Most of the well known acid inhibitors are organic compounds containing nitrogen, sulphur and oxygen atom. The influence of heterocyclic compounds and other nitrogen containing organic compounds used as corrosion inhibitors for steel in acidic media are reported by several workers [36,37].

Bilgic and Caliskan et. al [38] have reported that schiff bases synthesized by condensation of salicylaldehyde with o-aminophenol and o-amino toluene are found powerful corrosion inhibitor for austenic-chromium-nickel steel in sulphuric acid. The chemical structure of two schiff bases are



S_1



S_2

S_1 – N (1-toluidene) salicylaldimine

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[32] M. N. Desai, M. B. Desai, C. B. Shah and S. M. Desai, Corros, Sci. **26**, 827, 1986.

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[38] S. Bilgic and N. Caliskan "An Investigation of some schiff bases as corrosion inhibitors for austenitic chromium – nickel steel in H_2SO_4". J. Appl. Elect. **31**, 79, 2001.

From the adsorption enthalpies (△H) they have concluded that:

(1) Schiff base –S1 adsorbed more strongly on the steel surface.

(2) Both schiff bases act anodically and cathodically inhibitors but their efficiency appear to be better when they are used in anodic measurements.

(3) The adsorption of schiff base S_1 obeys the Temken (multilayer) isotherm where as schiff base S_2 follow Langmuir (monolayer) isotherm. It is explained on the basis of fact that the first schiff base forms intermolecular hydrogen bonding and second contain two close space –OH groups making to form intramolecular H-bonds.

Inhibition of copper corrosion by schiff bases in aerated halide solutions has been reported by several workers [39,40]. Copper is a widely used metal with extensive industrial applications and study of its corrosion inhibition by schiff base has attracted much attention. Nitrogen and sulphur containing organic heterocyclic compounds may act as inhibitors for copper dissolution due to the chelating action of heterocyclic molecules and the formation of a physical blocking barrier on the copper surface [41].

Ma et. al [42] have reported that schiff bases synthesized from 3-methloxy salicylaldehyde with aromatic diamines exhibited strong inhibition of copper corrosion in chloride solution at different pH . In addition these molecules are environmentally friendly. The chemical structure of two schiff bases are

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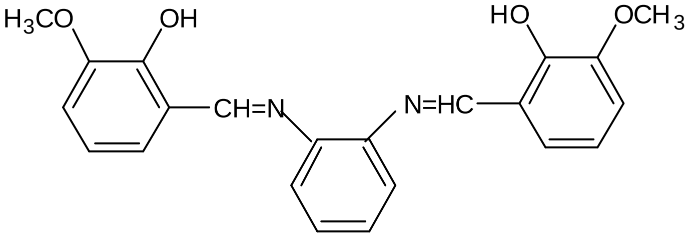
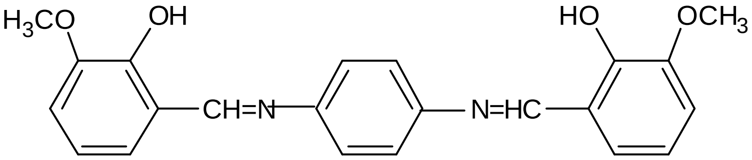
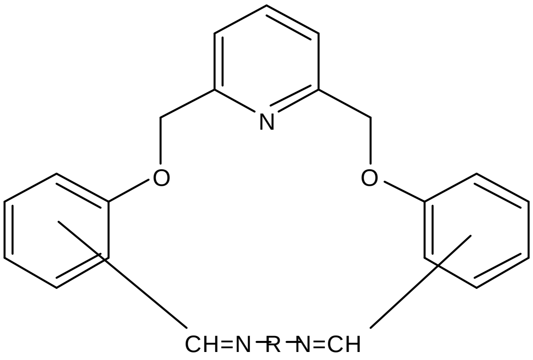


N-N' o-phenylen – bis(3-methoxy salicylidenimine)



N,N'- p -phenylen – bis(3-methoxy salicylidenimine)

Kuzmin et.al [43] have reported anticancer activity of a set of macro cyclic schiff bases based on 2,6- bis (2 and 4 formylaryl -oxy methyl) pyridines. They have derived correlation equation between the anticancer activity and structural parameters of the molecules studied.



Where R= Various aromatic and aliphatic diamines

They have proved that the increase in activity of the investigated schiff bases towards leukemia and prostate cancer is caused by the presence of F_1 fragments and the increased in number of F_2 fragments lowered the activity both towards the CNS cancer and melanoma and so average activity towards nine tumors.

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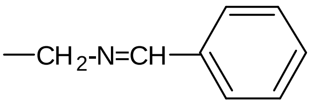
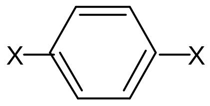
[43] V.E. Kuzmin, V.P. Lozitsky, G.L Kamalov, R.N. Lozitskaya, A. I. Zheltvay, A. S. Fedtchouk and D. N. Kryzhanovsky. " Analysis of the structure-anticancer activity relationship in a set of schiff bases of macro cyclic 2,6-bis (2 and 4-formylaryl oxymethyl) pyridines" Acta Biochimica, Polonica, **47**, 867, 2000.

Ortho-dialdehydes and aliphatic diamines macro cyclic schiff bases containing two F_1 fragments are the most effective, while the appropriate 4,4' derivatives and 1,4-phenylene diamine schiff bases containing two F_2 fragments give lower anticancer activity.

nF_1= number of structural fragments f_1, nF_2= number of structural fragments f_2



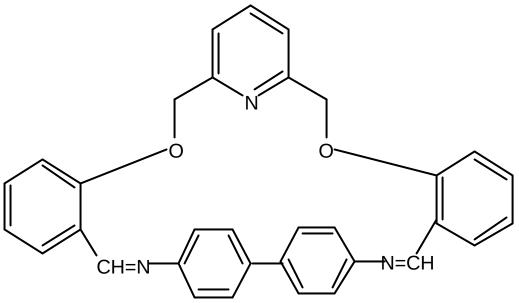
F_1

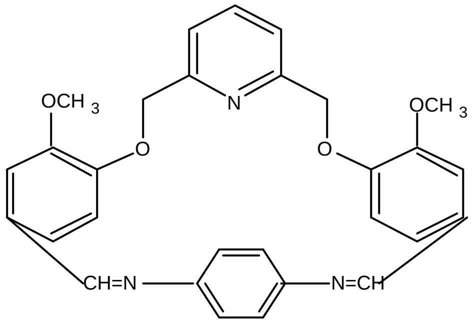


F_2

where x = non aromatic carbon atom

Lozitsky et. al [44] have reported 4D-QSAR study and anticancer activity of macro cyclic schiff bases. The schiff bases were synthesized by the condensation of various aliphatic and aromatic diamines with 2,6 - bis (2 and 4-formyl aryloxy methyl) pyridine derivatives. The results of biological activities showed that schiff bases are active towards cell growth of the nine cell culture of human malignant tumors like leukemia, CNS cancer, prostate cancer, breast cancer, melanoma, small cell lung cancer, colon cancer , ovarian cancer and renal cancer. They claimed that pyridine ring has a negative influence on anticancer activity, while the presence of the >C=N group with different substituents promotes anticancer activity. Para substituted phenyl with non-aromatic substituents prevent the activity.





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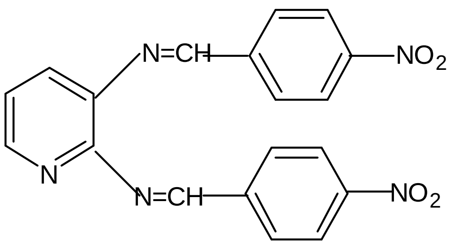
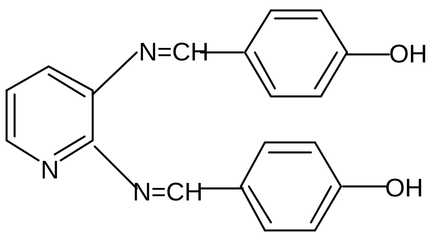
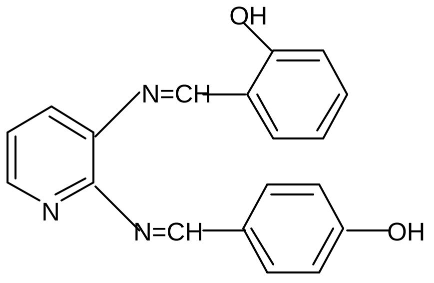
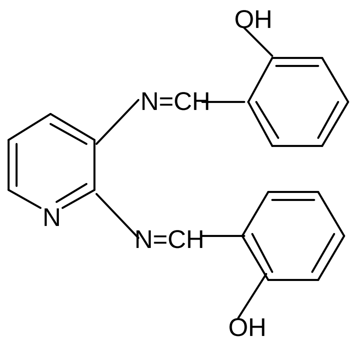
[44] V. P. Lozitsky, V. E. Kuzmin, A. G. Artemenko, R. N. Lozytska, A. S. Fedtchouk, E. N. Muratov and A. K. Mescheriakov "Investigation of anticancer activity of macrocyclic schiff bases by means of 4D-QSAR based on simplex representation of molecular structure." SAR and QSAR in Environmental Research **16**, 219, 2005.

Bhowon et. al [45] have reported antibacterial properties of schiff bases and schiff base metal complexes. The schiff bases were derived from 2,3 diamino pyridine and selected aldehydes namely, salicylaldehyde, 4-hydroxy benzaldehyde and 4-nitrobenzaldehyde. The mixed schiff base of salicylaldehyde and p-hydroxy benzaldehyde by simple condensation in ethanol for six hour. The crystalline products were characterized by elemental, IR and NMR spectral analysis. These bis schiff bases displayed antibacterial properties against bacteria Pseudomonas aeruginosa and Salmonella. The susceptibility is almost the same for both the microbes but inactive against Escherichia coli and Staphylococcus aureus. They have claimed that 2,3 diamino pyridine did not show activity against all these microbes, though all the schiff bases have been found to be active against p. aeruginosa and Salmonella. Similarly Cu^{+2} and Ni^{+2} complexes of nitro schiff base exhibited antibacterial activities against these two bacteria.









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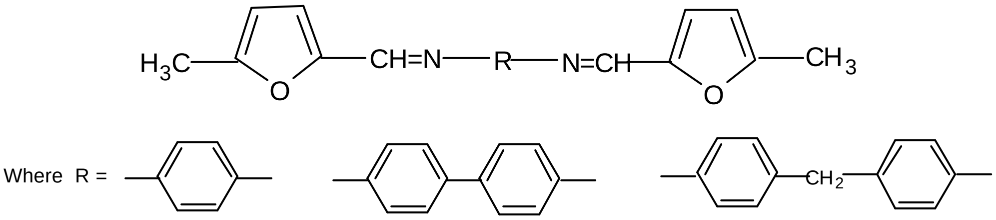
[45] M. G. Bhowon, T. Jeewoth and H.L. Kam-Wah. “Synthesis, characterization and antibacterial properties of schiff bases and schiff base metal complexes from 2,3 - diamino pyridine.” Transition Met. Chem., 445, 1999.

Kraicheva et. al [46] have reported synthesis and NMR spectroscopic study of three novel 5-methylfuryl containing schiff bases. These three schiff bases were synthesized by condensation of 5-methyl furfuraldehyde with appropriate mole ratio of 4,4'-diaminodiphenyl methane, 1,4-phenylene diamine and benzidine, respectively in diethyl ether with stirring at room temperature in nitrogen atmosphere for 4 h. Schiff bases were recrystallized from cyclohexane and characterized by elemental analysis, TLC, IR , ^{1}H NMR and C^{13} NMR spectral analysis. They have also synthesized bis (amino phosphonates) of these three schiff bases, which have biological properties and various applications in agro chemistry.



Rao et. al [47] have reported that schiff bases with -OH group in the ortho position to the imino group and their complexes derived from the reaction of 2-hydroxynaphthaldehyde and amines have been extensively studied and a number of them being used as models for biological systems [48-50].

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[46] I. Kraicheva, P. Finocchiaro, and S. Failla "Synthesis and NMR spectroscopic study of new 5-methylfuryl containing schiff bases and related bis (amino phosphonates). Phosphorus, Sulfur, and Silicon, **179**, 2345, 2004.

[47] N. S. Rao, D. D. Mishra, R. C. Maurya and N. N. Rao "Synthesis and characterization of some novel cis-dioxomolybdenum (vi) complexes of schiff bases derived from salicylaldehyde." Synth. React. Inorg. Met. Org. Chem. **25**, 437, 1995.

[48] A. Syamal and B. K. Gupta "Dimetallic manganese (ii) complexes with ONO donor tridentate schiff bases derived from ortho-iminobenzyl alcohol and salicylaldehyde and substituted salicylaldehydes" Indian J. Chem., Sect.-A, **34**,495, 1995.

[49] A Syamal and D. Kumar "New oxozironium (IV) complexes with the schiff bases derived from salicylaldehyde substituted salicylaldehydes and salicylhydrazide". Poland J.Chem., **55,** 1747,1981.

[50] P. H. Wang, J. G. Keck, E. J. Lien and M. C. Lai. "Design, synthesis testing and qualitiaive structure activity relationship analysis of substituted salicylaldehyde schiff base of 1-amino -3 hydroxy guanidine tosylate as new antiviral agents against corona virus". J. Med. Chem., **33**, 608, 1990.

Tautomerism in schiff bases with –OH group in ortho position to the amino group both in solution and in solid state have been investigated by spectroscopic and X-ray crystallographic techniques [51-53]. Schiff bases with –OH group in ortho position to the imino group are of interest mainly due to the existence of either O -H ----- N or O-----H-N bonds and due to tautomerism between the enol- imine and keto-amine form [57,58]. In these compounds hydrogen bond forms between the –OH group in the ortho position to the imino group and imine nitrogen is due to the stereochemistry. In some instances the hydrogen from the –OH group is completely transferred to the imine nitrogen. In other words enol amine ⇆ keto amine equilibrium shifts predominates [59-61]. Salman et. al [62] have studied keto-enol tautomerism and mass spectra of series of schiff bases derived from the condensation of salicylaldehyde with aniline and naphthaldehyde.

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[51] M. Yildiz, Z. Kilic and T. Hokelek "Intermolecular hydrogen bonding and tautomerism in schiff bases part – I structure of 1,8 –di [N – 2 – oxyphenyl saliacylidene] -3,6 dioxo octane ", J. Mol. Structure, **441**, 1, 1998.

[52] H. Nazir, M. Yildiz, H. Yildiz, M. N. Tahir and D. Viku "Intramolecular hydrogen bonding and tautomerism in schiff bases structure of N (2-pyridil) 2-oxo-1-naphthylidene methyl amine", J. Mol. Struct., **524**, 241, 2000.

[53] K. Wozniak, H. Y. He, J. Klinowski, W. Jones and E. Grech "Intramolecular hydrogen bonding in N-salicylideneanilines X-ray diffraction and solid state NMR studies". J. Chem. Soc. Faraday Trans. **91**, 77, 1995.

[57] S. R. Salman, S. H. Shawkat and G. M. Al-obaidi "Tautomerism in o-hydroxy schiff bases effect of alkyl group". Can. J. Anal. Sci. Spectroscopy., **35**,25, 1990.

[58] S. R. Salman, J. C. Lindon, R. D. Farrant and T. A. Carpenter. "Tautomerism in 2 hydroxy-1-naphthaldehyde schiff bases in solution and the solid state investigated by ^{13}C NMR spectroscopy." Can. J. Anal Sci. Spectroscopy, **35**, 991, 1990.

[59] G. O. Dodek and E. P. Dudek "Spectroscopic studies of keto-enol equilibria V-II, Nitrogen is substituted schiff bases." J. Am. Chem. Soc. **86**,4283, 1964.

[60] G.O. Dodek and E. P. Dudek. "Spectroscopic studies of keto-enol equilibria. IX Nitrogen -15 substituted schiff bases." J. Am. Chem. Soc., **88**, 2407, 1996.

[61] H. Unver, M. Yildiz, D. M. Zengin, S. Ozbey and E. Kendi. "Intramolecular hydrogen bonding and tautomerism in N-(3-pyridil)-2-oxo-1-naphthylidene-methylamine". J. Chem. Crystallogr , **31**, 211, 2002.

[62] S. R. Salman and F. S. Kamounah "Mass spectral study of tautomerism in some -1-hydroxy-2-naphthaaldehyde schiff bases." Spectroscopy letters, **35**, 327, 2002.

They have reported that in the UV –Vis. Spectra of the schiff bases with the –OH group in ortho position to the imino group, a new band of wave length greater than 400 nm is observed in polar and non polar solvents. This result indicates that the absorption band at 400nm belongs to the keto - amine form of the schiff base. This tautomer is always observed when the schiff base is derived from 2-hydroxynaphthaldehyde and aromatic amine. If schiff bases derived from salicylaldehyde and aromatic amine the keto-amine form is not observed in polar and non-polar solvents but observed in acidic media [63-66].

Schiff bases play an important role in Inorganic Chemistry as they easily form stable complexes with the most metal cations [67-69]. Transition metal complexes of tetradentate schiff base ligands find applications as model of certain metal enzymes, in catalysis and material chemistry [70].

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[63] R. Harzfeld and P. Nagy, "Role of the acidity and basicity of the solvent in the solvent effect observed in the absorption spectra of the certain types of schiff bases." Spectroscopy, Lett, **32**, 57, 1999.

[64] H. Unver, D. M. Zengin and K. Guven, "Intramolecular hydrogen bonding and tautomerism in 1-[N-(4-bromophenyl)] aminomethylidene-2(1-H) naphthalonene." J. Chem., Crystallogr, **30**, 359, 2000.

[65] J. W. Lewis and C.A. Sandorfy "Spectroscopic study of the solvent dependent process of the imines of benzaldehyde and salicylaldehyde" Can. J. Chem., **60,** 727, 1982.

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[66] J. W. Ledbetter "Resonance raman spectra of the tautomers of pyridoxal and salicylaldehyde schiff bases." J. Phys. Chem. **86**, 2449, 1982.

[67] H. Temel and Sekericm "Novel complexes of manganese (II), Cobalt (II), Copper (II), and Zinc (II) with schiff base derived from 1,2 bis (p-amino phenoxy) ethane and salicylaldehyde." Synth. React. Inorg. Met.-Org. Chem. **31**,849, 2001.

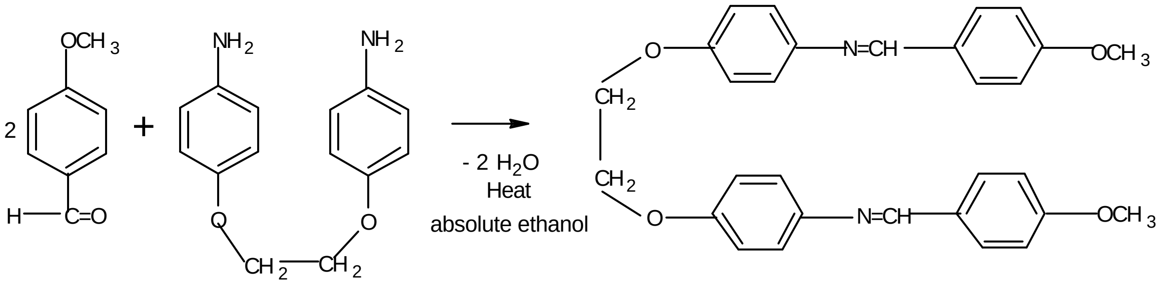
[68] H. Temel, U. Cakir and H. I. Urgas "Synthesis and characterization of Zn (II), Cu(II) and Ni(II) complexes with bidentate schiff base ligands. complexation studies and the determination of stability constant ". Russ. J. Inorg. Chem. **46**, 2022, 2001.

[69] H. Temel, M. Sekerci, S. Ilhan and R. Ziyadanogullari."Synthesis and characterization of new Cu (II), Ni (II), Co(II), and Zn(II) complexes with schiff base." Spectroscopy. Lett., **35** , 219, 2002.

[70] H. Temel, S. Ilhan and M. Sekerci, "Synthesis and characterization of new N-N'- bis (cinnemaldehydene) -1,2, bis(p-amino phenoxy) ethane and its transition metal complexes." Synth. React. Inorg. Met. Org. Chem. **32**, 1625, 2002.

In the field of co-ordination chemistry ortho-hydroxylated schiff bases have received considerable attention [71]. The introductions of lateral polar hydroxy groups enhance the molecular polarizability as well as stabilizing the liquid crystalline compounds [72]. In addition schiff base complexes are known to show antifungal activity, which is increased by the presence of hydroxy groups in the ligands [73]. Schiff bases metal complexes have been widely studied because of their industrial and biological applications.

Cakir et. al [74] have synthesized Cu(II), Ni(II), Zn(II) and Co(II) complexes of schiff base derived from 4-methoxy benzaldehyde and 1,2 bis(4-aminophenoxy) ethane. Schiff base and its complexes were characterized by magnetic susceptibility, conductance measurements, elemental analysis, UV-Vis, ^{1}H NMR and IR spectral studies. Based on the physical and chemical data of spectral studies they have proposed structure of schiff base and its complexes.



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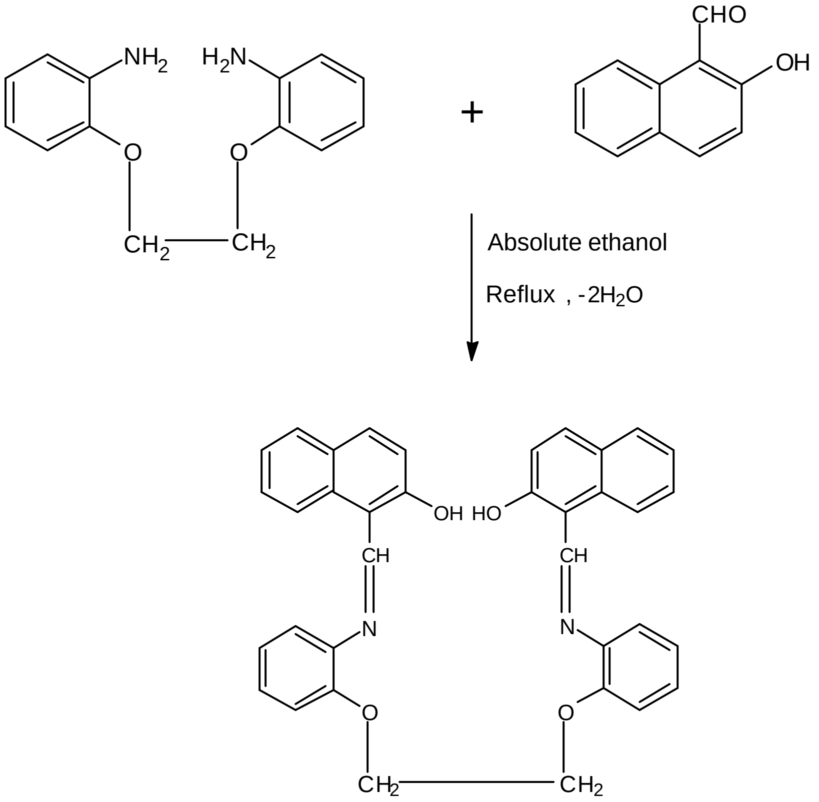
[71] H. Temel, U. Cakir, H. I. Urgas and M. Sekerci. "The synthesis, characterization and conductance studies of new Cu(II), Ni(II) and Zn(II) complexes with schiff base derived from 1,2- bis(o-amino phenoxy) ethane and salicylaldehyde." J. Coord. Chem. **56**, 943, 2003.

[72] G. Y. Yeap, S. T. Ha, P. L. Lim, P. L. Boey and W. A. K. Mahmood. "Synthesis and mesomorphic properties of schiff base esters ortho-hydroxy, para-alkyloxy benzylidene-para substituted anilines." Mol. Crystal, Liq. Cryst, **423**, 73, 2004.

[73] H. C. Lin "Synthesis and characterization of some indium complexes of schiff base." Synth. React. Inorg. Met. Org. Chem. **23**, 1097, 1993.

[74] U. Cakir, H. Temel, S. Ilhan, and H. I. Urgas "Spectroscopic and conductance studies of new transition metal complexes with a schiff base derived from 4-methoxybenzaldehyde and 1,2 bis- (4-aminopheoxy) ethane." Spectroscopy, Lett., **36**, 429, 2003.

Temel [75] has reported Cu(II), Ni(II), and Zn(II) complexes with the schiff base derived from 1,2-bis (o-amino phenoxy) ethane and 2-hydroxynaphthalin-1-carbaldehyde and are characterized by elemental analysis, magnetic measurement, ^{1}H NMR, UV – Visible and IR spectra, as well as conductance studies. Magnetic properties showed that Cu (II) schiff base complex is paramagnetic and its magnetic moment is 1.61 BM. Since Cu(II) complex is a paramagnetic and as a result its ^{1}HNMR spectrum could not be obtained, while Ni(II) and Zn(II) schiff base complexes are diamagnetic and ^{1}HNMR spectra were obtained. Conductivity studies showed that the complexes are non-electrolyte as shown by their molar conductivity measurements in DMF. Synthesis of the ligand N,N'-bis(2-hydroxy naphthalin-1-carbaldehydene)-1,2- bis (o- amino phenoxy) ethane



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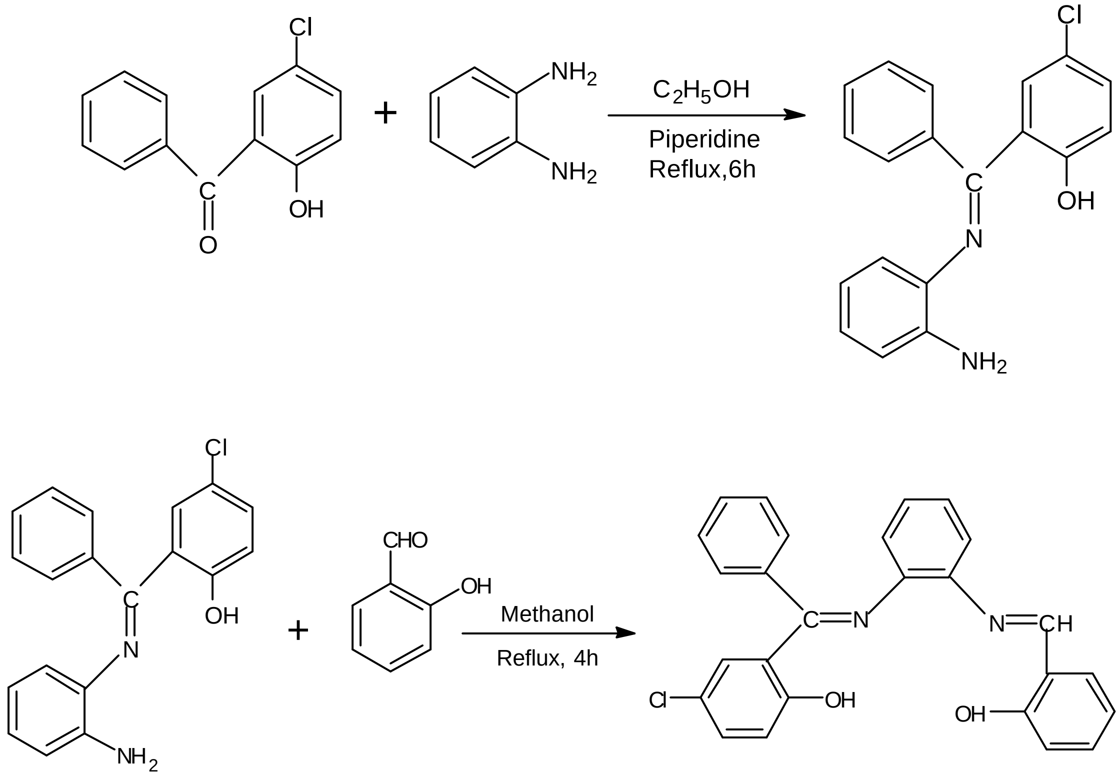
[75] H. Temel "Synthesis and spectroscopic studies of new Cu(II), Ni(II), and Zn(II) complexes with N-N^1 bis (2-hydroxy naphthalin-1-carbaldhydene)1,2-bis(o-amino phenoxy) ethane." J. Coord. Chem. , **57**, 723, 2004.

Bi and Fan [76] have reported that symmetric tetradentate schiff base complexes are used extensively as macro cycle models [77], while unsymmetric complexes are very important in biological systems and in industrial catalysis [78,79]. They have synthesized a new unsymmetric tetradentate schiff base ligands using 5-chloro-2-hydroxybenzophenone,o-phenylenediamine and salicylaldehyde. Five metal complexes of ligand have been prepared and characterized by elemental analyses, IR and UV spectra and molar conductance. Unsymmetric schiff base ligand was synthesized in two steps.



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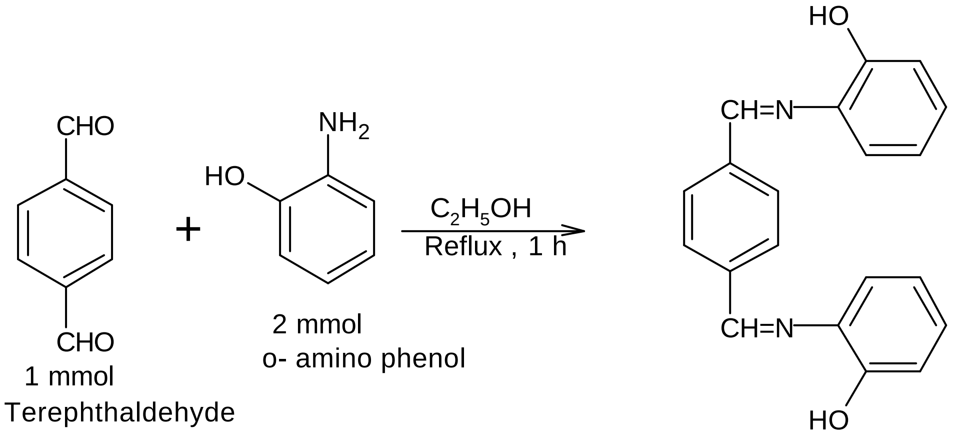
[76] C. Bi and Y. Fan "Synthesis and characterization of metal complexes with unsymmetric tetradentate schiff base legands." Synth. Rea. Inorg. Met. Org. Chem. **34**, 687, 2004.

[77] K. E. Krakowiak and J. S. Bradshow. "Synthesis and catalytic properties of ruthenium (II) unsymmetrical schiff base complexes." Bull. Chem. Soci. **13**,156, 1992.

[78] W. George and D. M. Gokel "Metal complexes with unsymmetrical tetradentate schiff base", Inorg. Chim. Acta, **82**, 101, 1984.

[79] E. Kwiatkowoski and M. Kwiatkowoski "Unsymmetrical schiff base complexes of nickel (II) and palladium (II)." Inorg. Chim. Acta, **42**, 197,1980.

Patel et al [80, 81] have reported synthesis of symmetric schiff base known as N,N’- di (o-hydroxy phenyl) terephthalaldehyde diimine. They have also reported synthesis of Mn(II), Ni(II), Cu(II), Zn(II) and Cd(II) complexes of schiff base ligand and characterized by elemental analyses, IR and electronic spectra, magnetic measurements and thermo gravimetric analysis. The schiff base was derived from terephthalaldehyde and o-aminophenol. They have noticed that when ethanolic solutions of terephthalaldehyde and o-aminophenol were mixed, a yellow crystalline solid was obtained immediately. The mixture was heated on a water bath for 1 h and the ligand was filtered, washed successively with water and ethanol and dried in air. The ligand is insoluble in organic solvents like benzene, chloroform and acetone but soluble in DMF.



N-N'di(o-hydroxy phenyl)terephthalaldehydediimin

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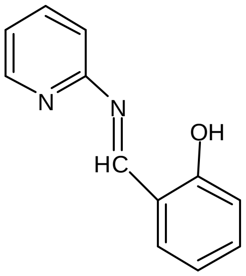
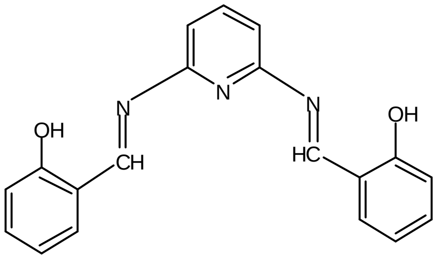
[80] N. H. Patel, K. M. Patel, K. N. Patel and M. N. Patel “Co-ordination chain polymers of transition metals with schiff base.” Synth. React. Inorg. Met-Org. Chem. **31**, 1031 2001.

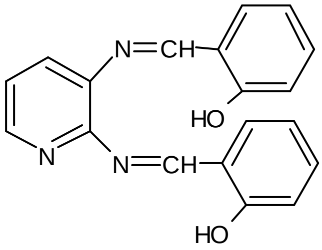
[81] N. H. Patel, P. K. Panchal and M. N. Patel “Synthesis and characterization and co-ordination polymers of trivalent lanthanides with a schiff base.” Synth. React. Inorg. Met.Org. and Nonmetal Chem. , **35**, 107, 2005.

Cimerman et. al [82] have reported that schiff bases play an important role in Analytical Chemistry because schiff bases are widely applicable in analytical determination of metal ions, as a solvent polarity indicators, spectroscopic and in tautomerism studies [83]. They have derived schiff bases from amino pyridines and salicylaldehyde. These schiff bases possess fluorescent characteristics. The fluorescence of all the compounds is strongly pH dependent and find application in fluorimetry. It was shown that the quenching effect of Cu^{+2} on the fluorescence of N, N'- bis (salicylidene)-2-3 pyridine diamine can be used for copper determination. This procedure is simple and fast. Based on the correlation of structural properties, spectroscopic characteristics and complex formation capabilities of the condensation products of amino pyridines and salicylaldehyde they attempted to design compounds with higher quantum efficiencies in non-polar organic solvents.





N-N' Bis(saliaylidene)2-6
pyridine diamine



N-N' Bis(saliaylidene)2-3
pyridine diamine

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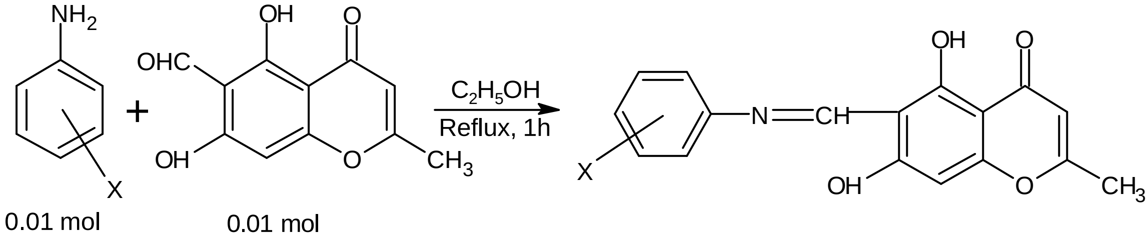
[82] Z. Cimerman, S. Miljanic and N. Galic "Schiff bases derived from amino pyridine as spectrofluorimetric analytical reagents." Crotonica Chemical Acta. ,CCACAA **73**, 81 2000.

[83] E. Jungreis and S. Thabet, "Analytical application of schiff bases" in H. A. Fluschka and A. J. Barnard. "Chelates in Analytical Chemistry.", Marcel Decker, New York, **2**, 149, 1969.

Many investigators have determined the ionization constants of a large number of schiff bases [84-86]. The effect of the solvents and the substituents on the protonation constant of sixteen schiff bases derived from salicylaldehyde and substituted anilines were studied under nitrogen atmosphere and at different percentages of dioxane, in dioxane-water media [87].

Sherif et. al [88] have reported potentiometric study on schiff bases derived from the reaction of 5,7 dihydroxy -6 formyl 2-methyl benzopyran-4-one with some aromatic amines such as aniline, anthranilic acid, o-amino phenol, 5-chloro, 2-amino phenol and 4-amino 3-hydroxy benzene sulphonic acid. The effect of ionic strength at different temperatures and solvents on the ionization of this schiff bases were studied. Various thermodynamic parameters such as Gibbs free energy (G), enthalpy (H) and entropy (S) for the ionization process were also determined.



The schiff bases obtained were recrystallized from toluene, DMF or ethanol and then characterized by elemental, mass, IR, ^1H NMR and UV spectral analysis.

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[84] C. R. Bera, S. Chattopadhayay and G. P. Sengupta, J. Ind. Chemi. Soc. **56,** 416, 1979.

[85] M.S. Mqsoud and F. M. El-Zawawy, Ind. J. Chem., **23A**, 149, 1984.

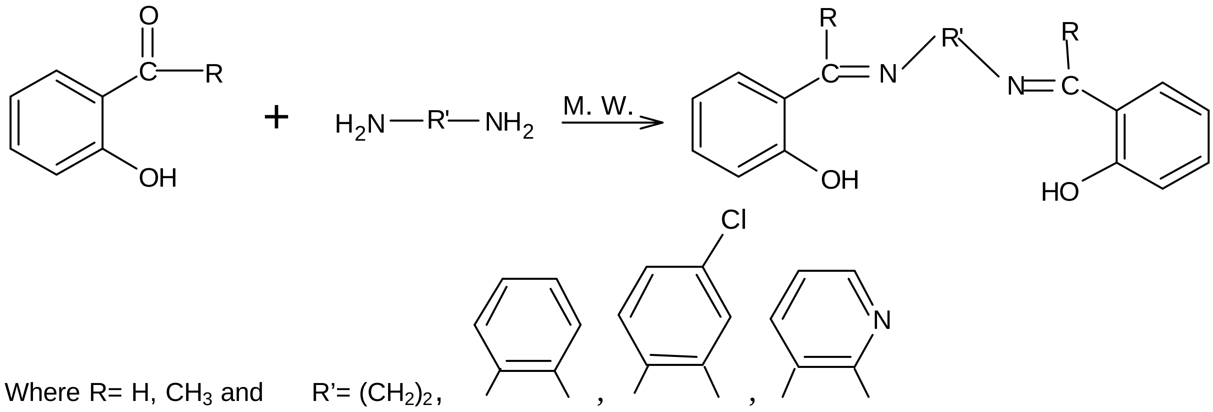
[86] T. Gundaz and K. Esma Analyst (London) **112**, 1057, 1987.

[87] T. Gundaz, E. Kilic, Ecanel and F. Koeseoglu , Anal. Chem. Acta., **282**, 489, 1993.

[88] O. E. Sherif, Y. M. Issa and S.M. Abbas, “Thermodynamic parameters of some schiff bases derived from 5,7 dihydroxy-6-formyl 2-methyl benzopyran-4-one” J. Thermal Analysis and Calorimetry, **59**, 913, 2000.

Yang et. al [89] have reported microwave assisted condensation of salicylaldehyde and aryl amines without solvent with high yields, which were confirmed by IR ^{1}HNMR, ^{13}CNMR and elemental analyses. They have reported that solvent free organic synthesis mediated by microwave irradiation (M.W.) offers significant advantages such as economy, environmental friendly, simple work up procedure and high yields along with fairly mild conditions, while on the contrary in classical organic synthesis it is common to meet the problem of removing solvents especially in the case of aprotic dipolar solvents with high boiling points or the isolation of reaction products through liquid – liquid extraction. The absence of solvent reduces the risk of hazardous explosion when the reaction takes place in a closed vessel in a microwave oven.

Aghayan et. al [90] have synthesized tetradentate schiff bases using microwave activation under solvent free condition with and without support. They have proved microwave (M.W.) enhanced chemical reaction in general and on organic supports. Microwave assisted reactions have gained popularity over the usual homogeneous and heterogeneous reactions. They can be conducted rapidly and provide pure products in quantitative yields without using solvent.



Where R= H, CH_3 and R’= $(CH_2)_2$,

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[89] H. Yang, W.H. Sun, Z. Li, and L. Wang “Solvent free synthesis of salicylaldimines assisted by microwave irradiation .” Synthetic Communications, **32**, 2395, 2002.

[90] M.M. Aghayan, M. Ghassemzadeh, M. Hoseini and M. Bolourtchian “ Microwave assisted synthesis of the tetradentate schiff bases under solvent free-and catalyst free condition” Synthetic Communication, **33,** 521, 2003.

They have synthesized tetradentate schiff bases by the reaction of salicylaldehyde or 2-hydroxy acetophenone with the corresponding diamines such as ethylene diamine, phenylene diamine, 2-3-diaminopyridine and 4-chlorophenylenediamine supported on silica gel. In short they have developed simple and rapid procedure for the synthesis of tetradentate schiff bases.

Aim and objective of the present investigation

1. To collect literature on synthesis, characterization and applications of schiff bases.
2. To synthesize cardo diamine and its symmetric schiff bases by classical and microwave irradiation technique.
3. To characterize schiff bases by spectral and other techniques.
4. To investigate biological activity of the-schiff bases.
5. To investigate thermal properties of the schiff bases.
6. To investigate acoustical properties of schiff base solutions at different temperature.
7. To summarize the important of the experimental findings.

CHAPTER-2

CHAPTER-2

SYNTHESES OF
1,1’ BIS(4-AMINOPHENYL)CYCLOHEXANE
AND ITS SYMMETRIC DOUBLE
SCHIFF BASES

SYNTHESES OF
1,1’ BIS(4-AMINOPHENYL)CYCLOHEXANE
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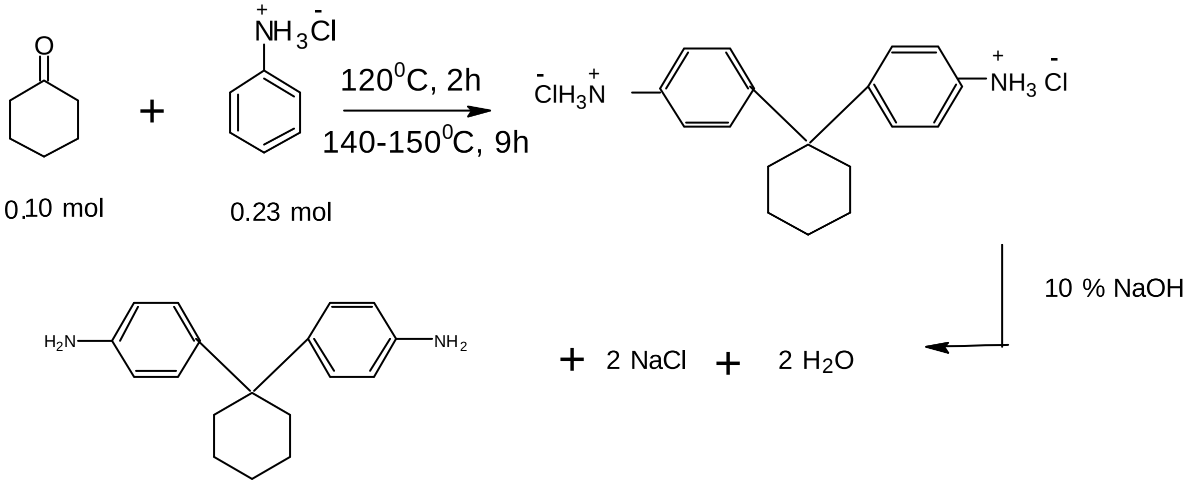
SCHIFF BASES

CHAPTER-2

SYNTHESIS OF DAC AND ITS SYMMETRIC DOUBLE SCHIFFBASES

Synthesis of 1, 1' bis (4-amino phenyl) cyclohexane (DAC)

Aromatic diamines can be synthesized by acid catalyzed condensation of aniline hydrochloride and cyclic ketones [1-3]. Thus, 0.23 mol (29.79 g) aniline hydrochloride and 0.10 mol (9.8 g) cyclohexanone were condensed with stirring at 120^{o} C for 2h and then at 140-150^{o} C for 9h. The resultant solution of 1,1' bis (4-aminophenyl) cyclohexane hydrochloride was cooled to 120^{o} C and 50ml boiling water was added to get deep red solution. The solution was refluxed with activated charcoal for 15 min and filtered off charcoal and resinous mass. The clear blood red solution was made alkaline by using 10% NaOH solution. DAC was filtered, washed well with distilled water and dried in an oven at 50^{o} C. DAC was recrystallized repeatedly from benzene-n hexane system to harvest light brown needle shaped crystals. The yield was 42% and m. p. 114^{o} C. The purity of DAC was checked by TLC in $CHCl_3$-n-Hexane (80:20 V/V) solvent system.



DAC

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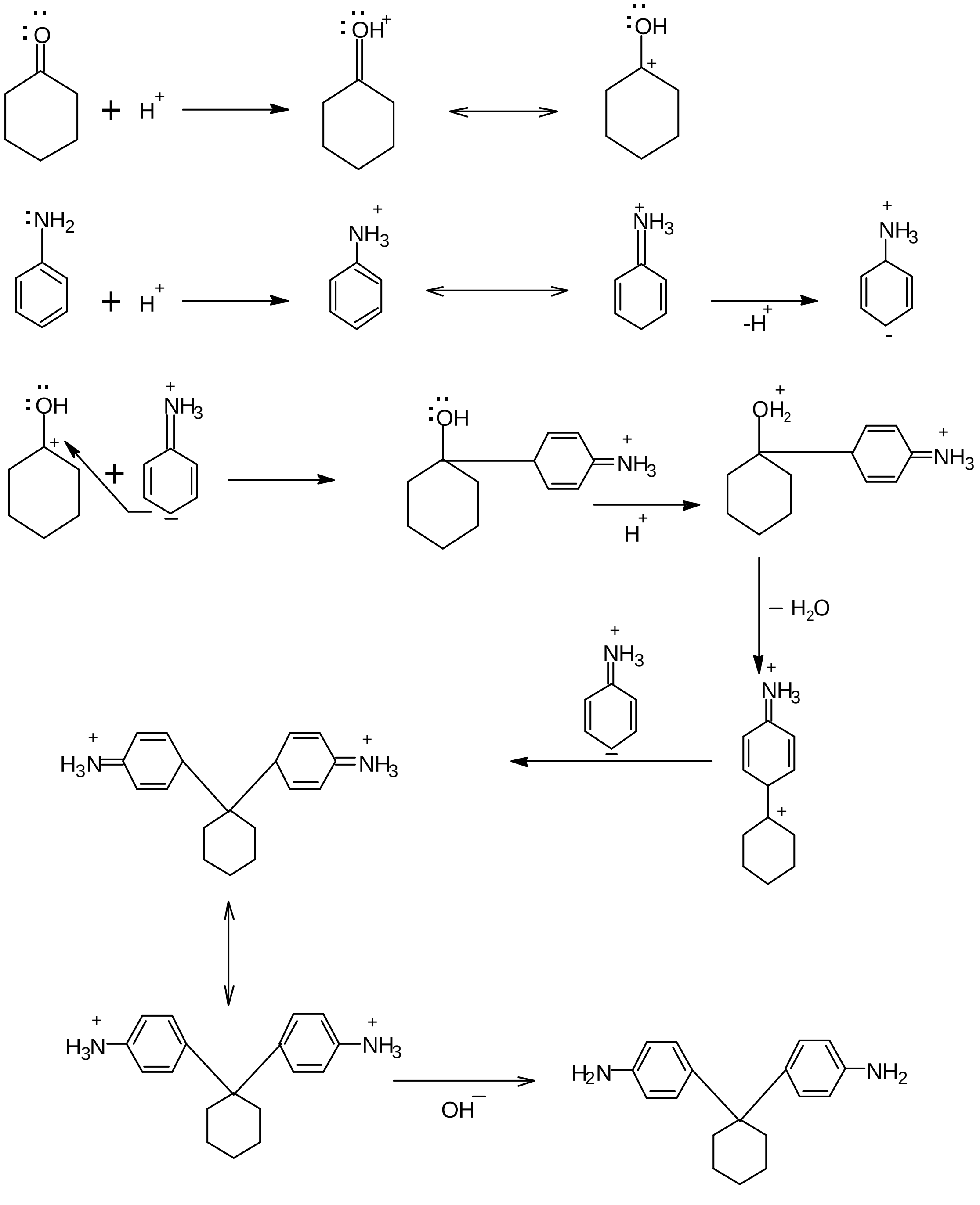
[1] Y. S. Vygodskii, N. A. Churochkina, T. A. Panova and Y. A. Fedotov "Novel condensation functional polymers having highly basic groups" , Reactive & Functional Polymers, **30,** 241, 1996.

[2] M. H. Yi, W. Huang, M. Y. Jin and K. Y. Choi "Synthesis and characterization of soluble polyamides from 1,1' bis (4-aminophenyl) cyclohexane derivatives", Macromolecules, **30**, 5606, 1997.

The reaction mechanism for DAC can be explained as under



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[3] M.H. Yi, W. Huang, B. J. Lee and K. Y. Choi "Synthesis and characterization of soluble polyimides from 2,2' bis (4-aminophenyl) cycloalkane derivatives", J. Polym. Sci. – Part A Polym. Chem., **37**, 3449, 1999.

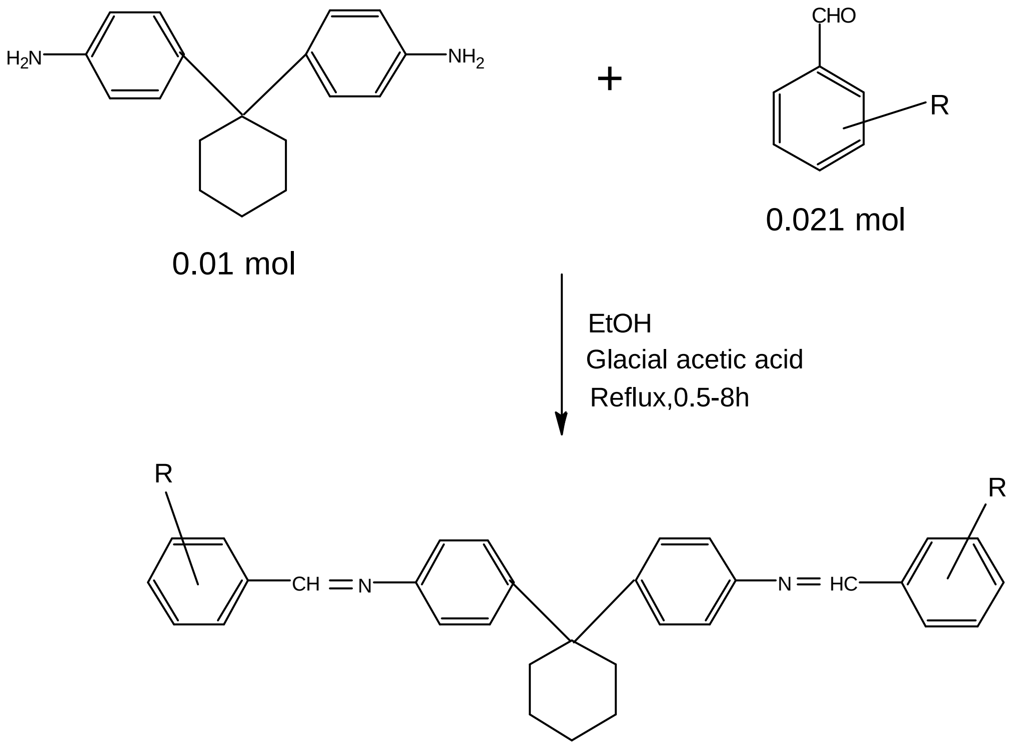
Synthesis of symmetric double schiff bases by classical method

Schiff bases of general Schemes-I & II were synthesized by condensation of DAC and substituted aromatic aldehydes in ethanol using glacial acetic acid as a catalyst at reflux temperature. Thus, into a 100 ml RBF, 0.01mol DAC was dissolved in 15ml ethanol containing 2ml glacial acetic acid. To this solution 0.021 mol aldehyde was dissolved in 10 ml ethanol and added drop wise at room temperature and then refluxed for 0.5-8 h. The product was isolated from chilled water, filtered, washed well with sodium bisulfite to remove excess aldehyde, water and finally with ethanol and dried at 50^0C in an oven. The schiff bases are soluble in common solvents like $CHCl_3$, CCl_4, benzene, THF, DMF, DMSO, 1, 4-dioxane, etc. The schiff bases were recrystallized repeatedly from appropriate solvent systems and purity was checked by TLC in appropriate solvent systems. Analytical and experimental details are described in Table 1.

Solvent free synthesis of symmetric double schiff bases by microwave irradiation

Solvent free microwave irradiation synthesis has become popular over usual homogeneous and heterogeneous reactions due to environmental friendly, economic and rapid reaction rates [4]. This technique provides pure products in quantitative yields [5,6].

The microwave irradiated condensation of DAC and aldehydes were carried out in a domestic oven (L.G. 360 watts). A 0.01 mol DAC and 0.02 mol aromatic aldehydes were mixed together at ambient temperature in a 50 ml Erlenmeyer flask. The mixture was subjected to microwaves for an optimized time. The compounds were recrystallized from appropriate solvent systems and purity was checked by TLC. The reaction time and yields are reported in Table 1.



Scheme-I

SBDAC – 1 : R =H

SBDAC – 2 : R =4 - CH_3

SBDAC – 3 : R = 2 - OH

SBDAC – 4 : R = 4 - OH

SBDAC – 5 : R =2 – OCH_3

SBDAC – 6 : R = 4 – OCH_3

SBDAC – 7 : R = 3 – OC_6H_5

SBDAC – 8 : R = 2 - Cl

SBDAC – 9 : R = 3 - Cl

SBDAC –10 : R = 4 – Cl

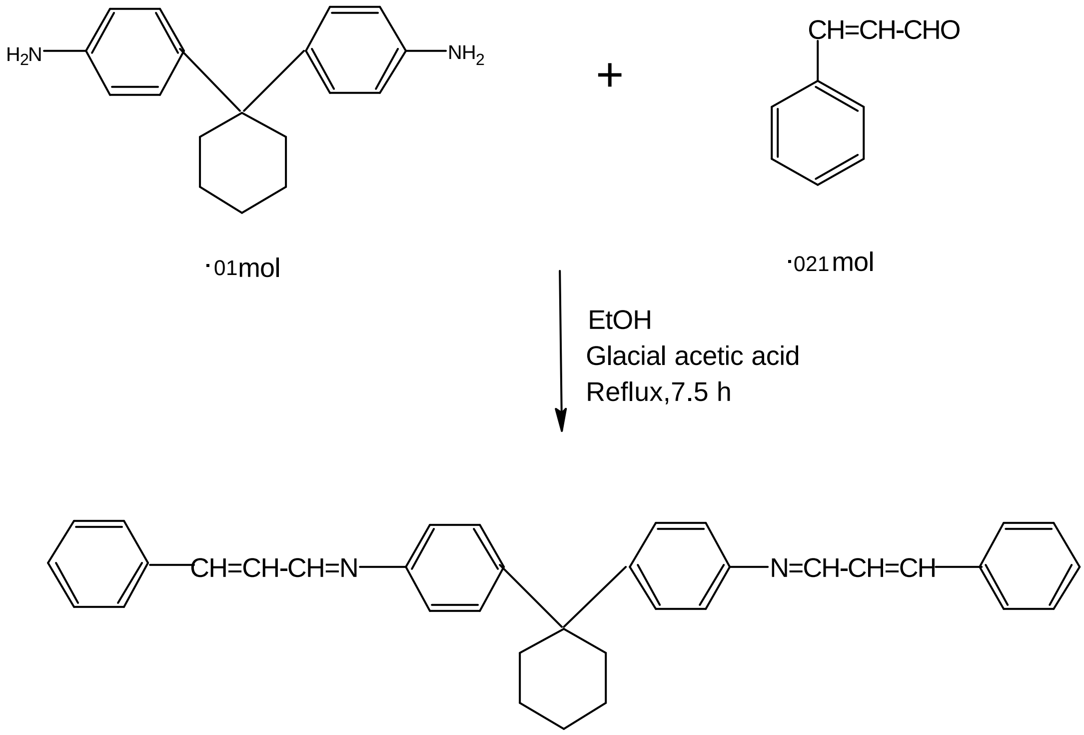
SBDAC –11 : R = 3 – Br

SBDAC –12 : R = 4 - F

SBDAC –13 : R = 2 – NO_2

SBDAC –14 : R = 3 – NO_2

SBDAC –15 : R = 4 - N $(CH_3)_2$



SBDAC-16

Scheme II

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[4] R. S. Varma, A. K Chatterjee and M. Varma, "Alumina mediated deacetylation of benzaldehyde diacetate. A simple deprotection method " , Tetrahedron Lett, **34,** 3207, 1993.

[5] M. Xia., S. H. Wang and W., Yuan "Lewis acid catalyzed electrophilic substitution of indole with aldehydes and schiff bases under microwave solvent free irradiation." , Synth. Commun., **34,** 3175, 2004 .

[6] M. M. Aghayan, M. Ghassemzadeh, M. Hoseini, and M. Bolourtchian "Microwave-assisted synthesis of the tetradentate schiff bases under solvent free and catalyst free condition " , Synth. Commun. , **33**, 521, 2003.

The reaction mechanism for schiff bases can be explained as under

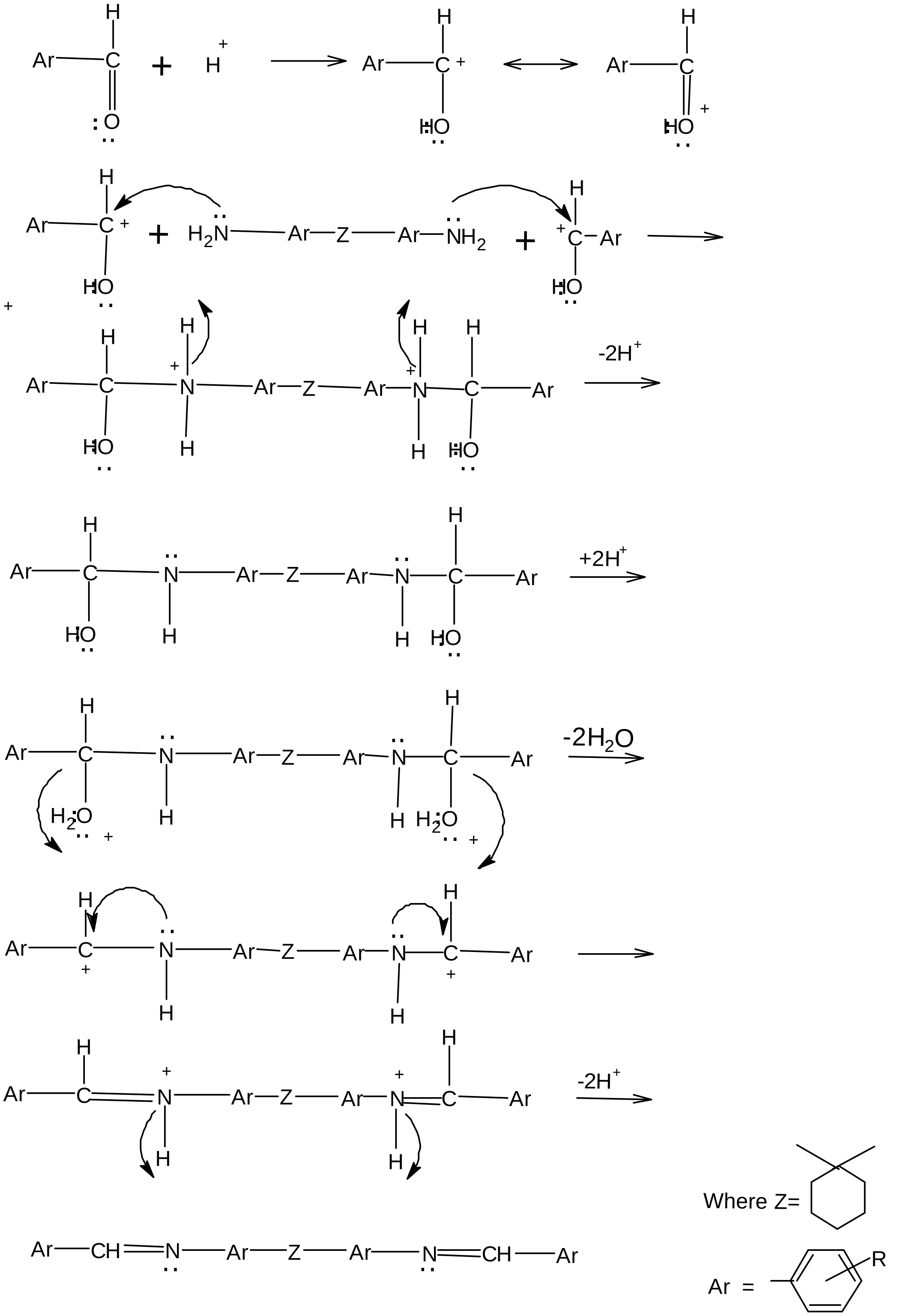

Table - 1 Analytical data and experimental details of SBDAC-1 to SBDAC-16

Code	**M.F.**	**Mol.Wt**	**M.P.,^{0}C**	**Color**	**Crystal. solvent system**	**TLC**		**Classical method**		**Microwave irradiation**	
						Solvent system	**R_f value**	**Tim, h**	**% Yield**	**Time, min**	**% Yield**
SBDAC-1	$C_{32} H_{30} N_2$	442	208	Brown	A	CF- H (90:10 V/V)	0.63	6	73	5	84
SBDAC-2	$C_{34} H_{34} N_2$	470	223	Off white	CF	CF-H (85:15 V/V)	0.82	6	78	6	86
SBDAC-3	$C_{32} H_{30} N_2 O_2$	474	245	Light yellow	A – W	EA–H (80:20 V/V)	0.78	4.5	68	9	82
SBDAC-4	$C_{32} H_{30} N_2 O_2$	474	240	Yellowish brown	A	CF– H (70:30 V/V)	0.61	5	70	6	80
SBDAC-5	$C_{34} H_{34} N_2 O_2$	502	252	Off white	A	EA–H (75:25 V/V)	0.70	6	80	6	89
SBDAC-6	$C_{34} H_{34} N_2 O_2$	502	256	Light brown	CF – H	EA–H (70:30 V/V)	0.69	6	72	6	86
SBDAC-7	$C_{44} H_{38} N_2 O_2$	626	261	Off white	CF– H	EA–H (75:25 V/V)	0.65	7	69	9	81

CF : Chloroform, EA : Ethylacetate, Ben: Benzene, Hex = n-Hexane.

Table -1 Conti.

Code	M.F.	Mol.Wt	M. P., °C	Color	Crystal. Solvent System	TLC		Classical method		Microwave irradiation	
						Solvent System	Rf value	Time, h	% Yield	Time , min	% Yield
SBDAC-8	$C_{32}H_{28}N_2Cl_2$	511	233	Off white	CF-H	EA – H (80:20 V/V)	0.63	0.75	78	3	91
SBDAC-9	$C_{32}H_{28}N_2Cl_2$	511	232	Off white	EA-H	EA – H (60:40 V/V)	0.72	0.75	75	3	92
SBDAC- 10	$C_{32}H_{28}N_2Cl_2$	511	228	Off white	EA-H	EA – H (60:40 V/V)	0.74	0.50	70	3	90
SBDAC-11	$C_{32}H_{28}N_2Br_2$	600	268	Yellow	B -H	CF – H (70:30 V/V)	0.64	2.00	69	6	93
SBDAC-12	$C_{32}H_{28}N_2F_2$	478	224	Light brown	CF	CF – H (80:20 V/V)	0.59	3.00	78	6	88
SBDAC-13	$C_{32}H_{28}N_4O_4$	532	258	Yellow	EA-H	EA – H (65:35 V/V)	0.68	8.00	72	7	95
SBDAC-14	$C_{32}H_{28}N_4O_4$	532	260	Yellow	EA-H	EA – H (65:35 V/V)	0.71	8.00	74	7	95
SBDAC-15	$C_{36}H_{40}N_4$	528	248	Light brown	CF-H	EA – H (80:20 V/V)	0.56	7.00	70	8	94
SBDAC-16	$C_{36}H_{34}N_2$	494	232	Light brown	CF-H	EA – H (75:25 V/V)	0.59	7.50	68	8	90

CHAPTER – 3

SPECTRAL AND PHYSICO-CHEMICAL CHARACTERIZATION OF DIAMINE AND SYMMETRIC DOUBLE SCHIFF BASES

CHAPTER – 3

SPECTRAL AND PHYSICO-CHEMICAL CHARACTERIZATION OF DIAMINE AND SYMMETRIC DOUBLE SCHIFF BASES

CHAPTER – 3: Spectral and physico-chemical characterization of diamine and symmetric double schiff bases

This chapter of the thesis deals with the characterization of diamine and schiff bases and it is further sub-divided into seven sections:

Section –I UV spectral characterization

Section –II IR spectral characterization

Section – III NMR- spectral characterization

Section – IV Mass spectral characterization

Section – V Density measurements

Section – VI Refractive index measurements

Section –VII Antibacterial and antifungal activities of symmetric double schiff bases

SECTION – 1: U.V. spectral characterization

This section of the thesis describes U.V. spectral analysis of DAC and SBDAC – 1 to 16.

Ultraviolet and visible spectroscopy (electronic spectroscopy) is primarily used to measure the multiple bond or aromatic conjugation within molecules. Most organic molecules and functional groups are transparent in the portions of the electromagnetic spectrum, which we call ultraviolet (U.V.) and visible (Vis.) regions that is the regions where wavelength range from 190 to 800 nm. The U.V. region extends from 1000 – 4000 A^0 or 100 – 400 nm. The further subdivision of U.V. into near U.V. (400 – 190 nm) and far or vacuum U.V.. (190 – 100 nm).Consequently, absorption spectroscopy is of limited utility in this range of wave lengths. However, in some cases we can derive useful information from these regions of the spectrum. These informations, when combined with the detail provided by infrared and nuclear magnetic resonance spectra can lead to valuable structural proposals.

Principles of U.V. spectroscopy

On passing electromagnetic radiation through a compound with multiple bonds, a portion of the radiation is normally absorbed by the compound. The amount of absorption depends on the wavelength of the radiation and the structure of the compound. The absorption of radiation is due to the subtractions of the energy from the radiation beam when electrons in orbital of lower energy are excited into orbital of higher energy. Due to electron excitation phenomenon, U.V. is some times called electron spectroscopy. Ultraviolet spectrum records the wavelength of an absorption maximum ($?_{max}$) and the strength of absorption (molar absorptivity e_{max}). From these ideas, the following empirical expression known as the Beer – Lambert law, may be formulated [1, 2].

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1. P. S. Kalsi, “Spectroscopy of organic compounds “, 5th edn., New age, International Publishers, p-7-14, 2003.
2. H.H. Jaffe and M. Orchin, “Theory and application of ultraviolet spectroscopy”, John Wiley and Sons, New York, 1962.

$A = \log (I_o/I) = e\ C\ l$ for a given wave length.

Where, A = absorbance

I_o = Intensity of light incident upon sample cell

I = Intensity of light leaving sample cell

C = molar concentration of solute

l = length of sample cell (cm.)

e = molar absorptivity

The term log (I_o/I) is known as the absorbance and represented by A. The molar absorptivity is a property of molecule undergoing an electronic transition and is not a function of variable parameters involved in preparing a solution. The size of the absorbing system and the probability that the electron transition takes place control the absorptivity. The molar absorptivity e is a constant for an organic compound at a given wavelength and is reported as an e_{max}, an alternative convention is to report its logarithm (to the base 10), $\log_{10} e_{max}$. Its value varies from 10^0 - 10^4 and one considers the absorptions of the order of 10^4 very strong and those less than 10^3 as weak.

The nature of electronic excitation on absorption of energy by a molecule in the ultra violet region changes are produced in the electronic energy of the molecule due to transitions of valance electrons in the molecule. These transitions consist of the excitation of an electron from an occupied molecular orbital to the next higher energy orbital. For most molecules, the lowest energy occupied molecular orbitals are the s orbitals, which corresponds to s – bonds. The p orbitals lie to somewhat higher energy levels, and orbitals that hold unshared pairs. The nonbonding (n) orbitals, lie at even higher energies. The unoccupied or antibonding orbitals p* and s*, are the orbital of the highest energy.

The designation of various transitions

In all compounds other than alkanes, the electron may undergo several transitions of different energy. The possibilities of various transitions and the relative energies of transitions are explained as below.

1. s → s* transition

A transition of an electron from a bonding sigma orbital to the higher energy antibonding sigma orbital is designated as s → s*.This transition available in alkanes. DAC and SBDAC – 1 to 16 possess cyclohexane ring, so this transition should be observed. But sigma bonds are very strong so this is a higher energy process. This transition required very short wave length and high energy ultraviolet light ~150 nm. A study of this transition is possible only in vacuum ultraviolet region below 200 nm. Thus, experimentally in 225 – 450 nm region this transition is not observed in U.V. spectra of DAC and SBDAC-1 to 16.

2. n → s* transitions

This transition involves saturated compound with one heteroatom with unshared pair of electrons. DAC and SBDAC–1 to 16 possess heteroatom but they are not saturated due to presence of azomethine group.

3. p → p* transition (k- band)

This transition is available in compound with unsaturated centers e.g. alkenes, aromatic, carbonyl compound. DAC possess only aromatic centre, while SBDAC–1 to 16 possess unsaturated >C=N and benzene rings. Thus, this transition will be observed. This transition required less energy than n → s*. The band due to p → p* transition in a compound with conjugated p system is usually intense and is referred as the k band (German Knjugierte). SBDAC–16 have conjugated alkenes and so possess k band.

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3. D. L. Pavia, G. M. Lampman, G. S. Kriz, “Introduction to spectroscopy”, 3^{rd} edin., Thomson Asia pvt. Ltd., Singapore, p-353-389, 2004.
4. N. D. Coggeshall and E. M. Lang, “Ultraviolet spectra of phenol in ethanol and in isooctane”, J. Am. Chem. soc., 70, 3288, 1948.

4. n ⟶ p* transition (R band)

In this transition, unshared electron pair of hetero atom is excited to p* anti-bonding orbital. DAC and SBDAC–1 to 16 possess nitrogen as a hetero atom with unshared electron pair, similarly SBDAC – 3 to 16 possess either alcohols or ethers or halogens or nitro or $-N(CH_3)_2$ as a heteroatom. Thus, n ⟶ p* transition is observed around 280 nm. This transition involves least energy than all the transition and therefore, this transition gives rise to an absorption. The band obtained due to n ⟶ p* transition is known as R- band.

5. Chromophores and Auxochromes

A chromophore is covalently unsaturated group responsible for electronic absorption e.g. C=C, >C=N, $-NO_2$, etc. Some simple compounds contain chromophore e.g. ethene, benzene, acetone, nitrobenzene. An auxochrome represents a saturated group, which when attached to a chromophore changes both the intensity as well as wave lengths of absorption maxima. e.g. –OH, $-NH_2$, -Cl, -Br, -F, $-N(CH_3)_2$ etc.

6. Red and blue shifts

A shift of absorption to a longer wavelength is called bathocromic (red shift). A shift of absorption to a shorter wave length is called a hypochrome shift (blue shift). Increase in intensity of band is known as hyperchrome effect and decrease in intensity is known as hypochromic effect .

Solvents

The choice of solvent to be used in ultraviolet spectroscopy is quite important. The first criterion for a good solvent is that it should not absorb ultraviolet radiation in the same region as the substance whose spectrum is to be determined. Usually solvents that do not contain conjugated system are most suitable for this purpose, although they vary as to the shortest wave length at which they remain transparent to ultraviolet radiation. Some common ultraviolet spectroscopy solvents with their cutoff point are water (190nm) 95% ethanol (205nm), chloroform (240nm), n-hexane (201nm), DMSO (245nm), ether (215nm).

Each of the solvents are transparent in the ultraviolet spectrum where interesting absorption peaks for sample molecule likely to occur.

A second criterion for a good solvent is its effect on the fine structure of an absorption band. Polar and non – polar solvents affect absorption band. A non-polar solvent does not form hydrogen bond with solute and the spectrum of the solute closely approximates the spectrum that would be produced in the gaseous state. In a polar solvent, the hydrogen bonding forms due to solute – solvent complex, and the fine structure may disappear.

A third criterion for a good solvent is its ability to influence the wave length of ultraviolet light that will be absorbed via stabilization of either the ground or the excited state.

Polar solvents do not form hydrogen bonds as reality with the excited states of polar molecules as with their ground states, and these polar solvents increase the energies of electronics transition in the molecules. Thus, polar solvents shift transition of the n → p* type to the shorter wavelengths. Similarly polar solvents shift transition of the p → p* type to longer wave lengths.

Mustafa Yildiz [5] has reported spectroscopic studies of polyether ligands of schiff base type. Schiff bases were synthesized by condensation of bis(2-aminophenyl)ether with salicylaldehyde, 5-methoxy salicylaldehyde, 5-bromo salicylaldehyde, 5-nitro salicylaldehyde and 2-hydroxy naphthaldehyde. The products were characterized by elemental analysis, IR, ^{1}H, ^{13}C NMR and UV-Vis techniques. The UV – Vis spectra of those schiff bases with an –OH group in the ortho position to the imino group were studied in polar and non-polar solvents such as DMSO, chloroform and benzene in acidic and basic media. The results indicate that the absorption band at 400nm belongs to the keto-amine form of schiff base. This tautomer is always observed when schiff base is derived from 2-hydroxy naphthaldehyde and aromatic amine. If schiff base derived from salicylaldehyde and aromatic amine the keto-amine form is not observed in polar and non-polar solvents, but it is observed in acidic media [6, 7].

Several scientists have reported UV – spectroscopy study of schiff bases in polar and non-polar solvents [8, 9].

After studied solubility of DAC and SBDAC – 1 to 16 it has been observed that they are easily soluble in $CHCl_3$, benzene, DMF, DMSO, all are insoluble in hexane while some are soluble in 1, 4-dioxane or tetrahydrofuran or ethanol or methanol. The U.V. spectra of DAC and SBDAC – 1 to 16 were scaned in $CHCl_3$ and DMSO, on U.V. spectrophotometer Shimadzu – 1700 and the effect of solvent on ?$_{max}$ were investigated and reported in Table 3.1. From Table 3.1 it is clear that ?$_{max}$ shifts towards longer wave length in DMSO i.e. observed shift is blue shift.

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5. M. Yildiz, " Synthesis and spectroscopic studies of some new polyether ligands of the schiff base type", Spectro. Lett. 37, 367, 2004.
6. S. R. Salman, S. H. Shawkat and G. M. Al-obaidi "Tautomerism in o-hydroxy schiff base, effect of alkyl group", Can. J. Anal. Sci. Spectro., 35, 25, 1990.
7. M. Yildiz, H. Nazir, H. Yilmaz, M. N. Tahir and D. Ulku, Intermolecular hydrogen bonding and tautomerism in schiff bases. Structure of N-(2-pyridil)-2-oxo-1-naphthylidenemethyl amine", J. Mol. Struct., 524, 241, 2000.
8. C. A. Sanderfy, J. W. Lewis, "Spectroscopic study of the solvent dependent process of the anils of benzaldehyde and salicylaldehyde", Can. J. Chem., 60, 1727, 1982.
9. M. Yildiz, Z. Kilic, and T. Hokelek, "Intramolecular hydrogen bonding and tautomerism in schiff bases. Part - I structure of 1, 8 – di [N-2-oxyphenyl-salicylidine]-3, 6 – dioxooctane. J. Mol. Struct., 441, 1-10, 1998.

Table 3.1 : ? $_{max}$ of DAC and SBDAC-1 to 16 in chloroform and DMSO.

Sample code	? $_{max}$ Chloroform	? $_{max}$ DMSO
DAC	246.0	261.2
SBDAC-1	266.0	267.0
SBDAC-2	272.0	273.2
SBDAC-3	242.0	243.2
SBDAC-4	338.2	347.2
SBDAC-5	267.6	270.0
SBDAC-6	335.2	335.4
SBDAC-7	244.8	270.0
SBDAC-8	266.0	267.4
SBDAC-9	265.0	266.8
SBDAC-10	245.4	266.0
SBDAC-11	265.2	268.8
SBDAC-12	265.4	266.0
SBDAC-13	246.0	261.4
SBDAC-14	245.2	266.4
SBDAC-15	361.4	363.4
SBDAC-16	255.4	263.4

SECTION – 2: IR SPECTRAL ANALYSIS OF DIAMINE AND SCHIFFBASES

This section of the thesis includes IR spectral data of diamine and SBDAC-1 to 16.

Information about the structure of a molecule could frequently be obtained from its absorption spectrum. The atomic and electronic configuration of a molecule is responsible for the position of absorption bands. The most structural information of organic molecules could be obtained from their IR spectra. The masses of the atoms and the forces holding them together are of such magnitudes that usual vibrations of the organic molecules interact with electromagnetic radiations to absorb and radiate in the IR region. During the absorption, it is necessary for the molecule to undergo a change in dipole moment. IR spectroscopy is an excellent method for the qualitative analysis because except for optical isomers, the spectrum of a compound is unique. It is most useful for the identification, purity and gross structure at detail. This technique is often faster than any other analytical method.

The IR spectra (KBr pellets) of diamine and schiff bases were scanned on a Shimadzu-8400 FT-IR spectrometer over the frequency range from 4000 – 400 cm^{-1}. The IR spectra of DAC and SBDAC-1 to 16 are shown in Figs. 3.1 - 3.9.The characteristic IR absorption peaks (cm^{-1}) along with aliphatic, alicyclic and aromatic groups of diamine and schiff bases are reported in Tables 3.2-3.8

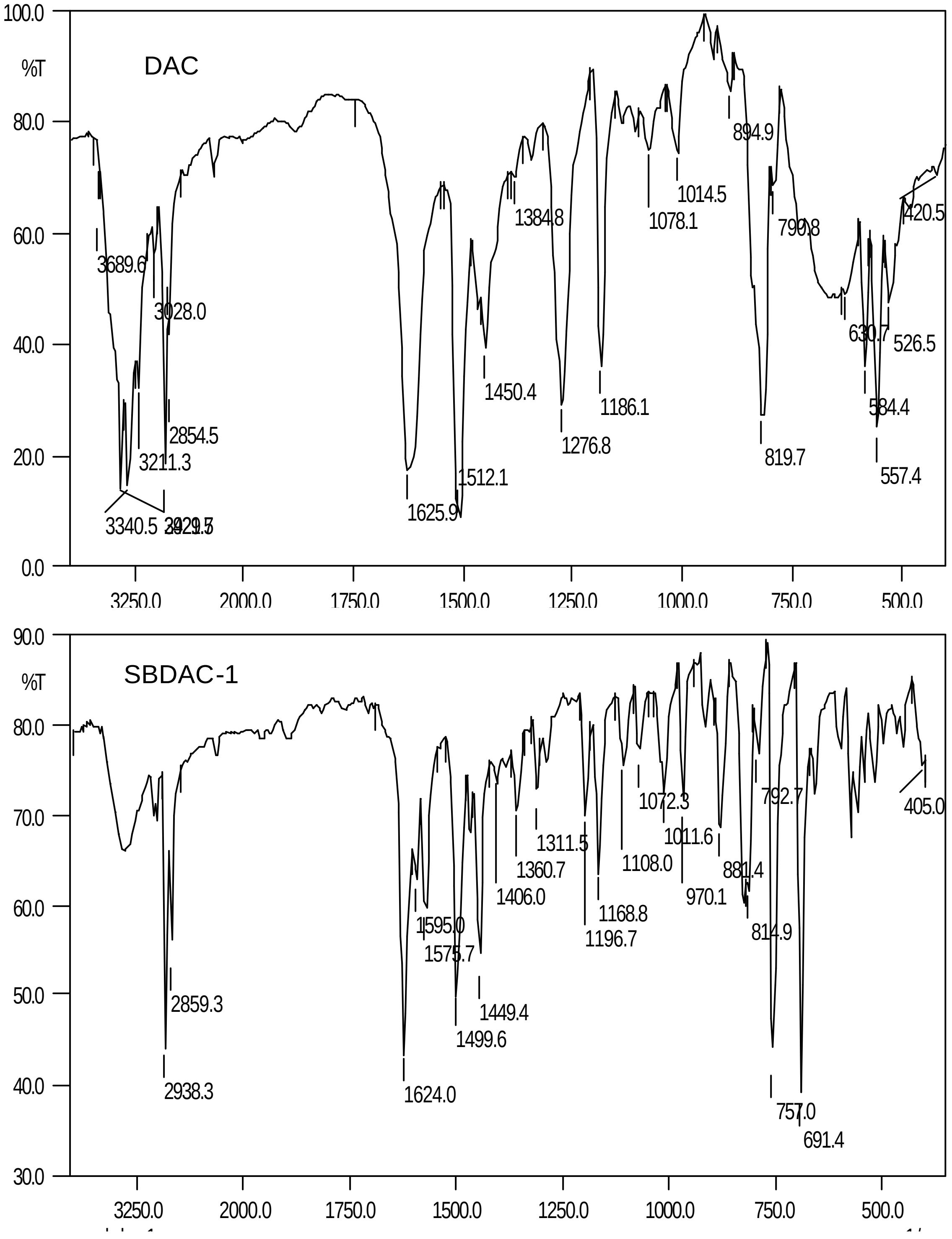

Fig.- 3.1: IR (KBr) Spectra of DAC and SBDAC-1

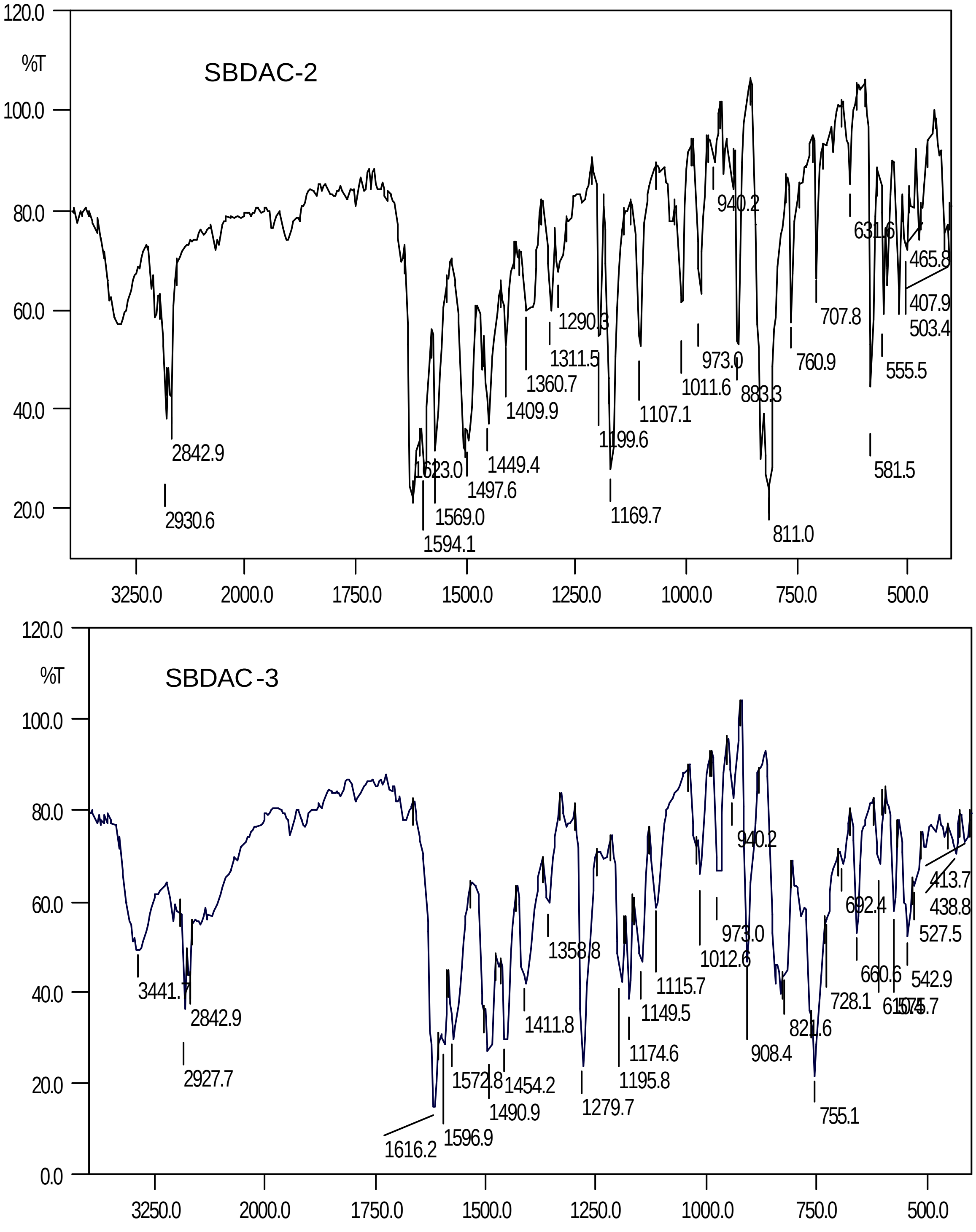

Fig.- 3.2 : IR (KBr) Spectra of SBDAC-2 and SBDAC-3

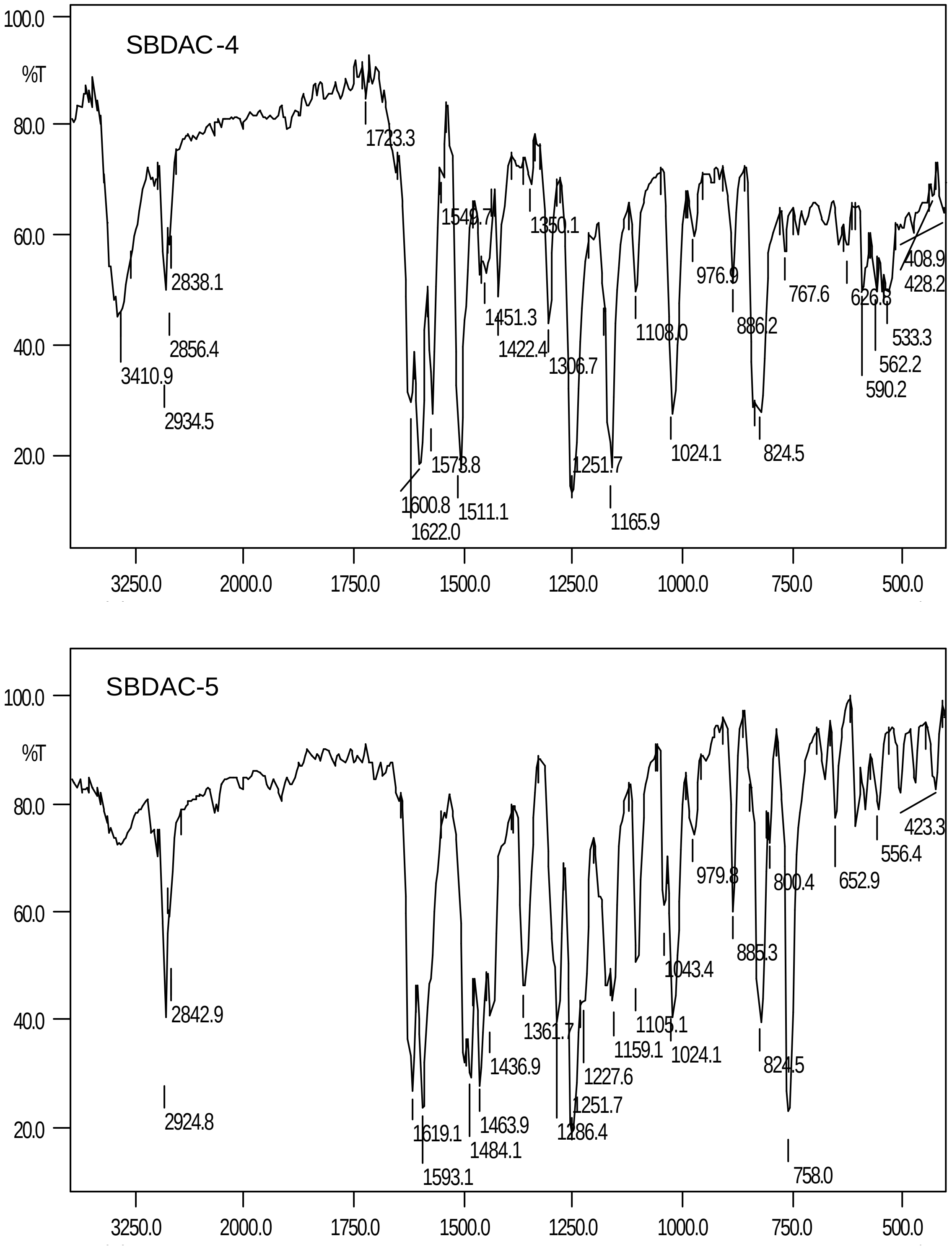

Fig.- 3.3 : IR (KBr) Spectra of SBDAC-4 and SBDAC-5

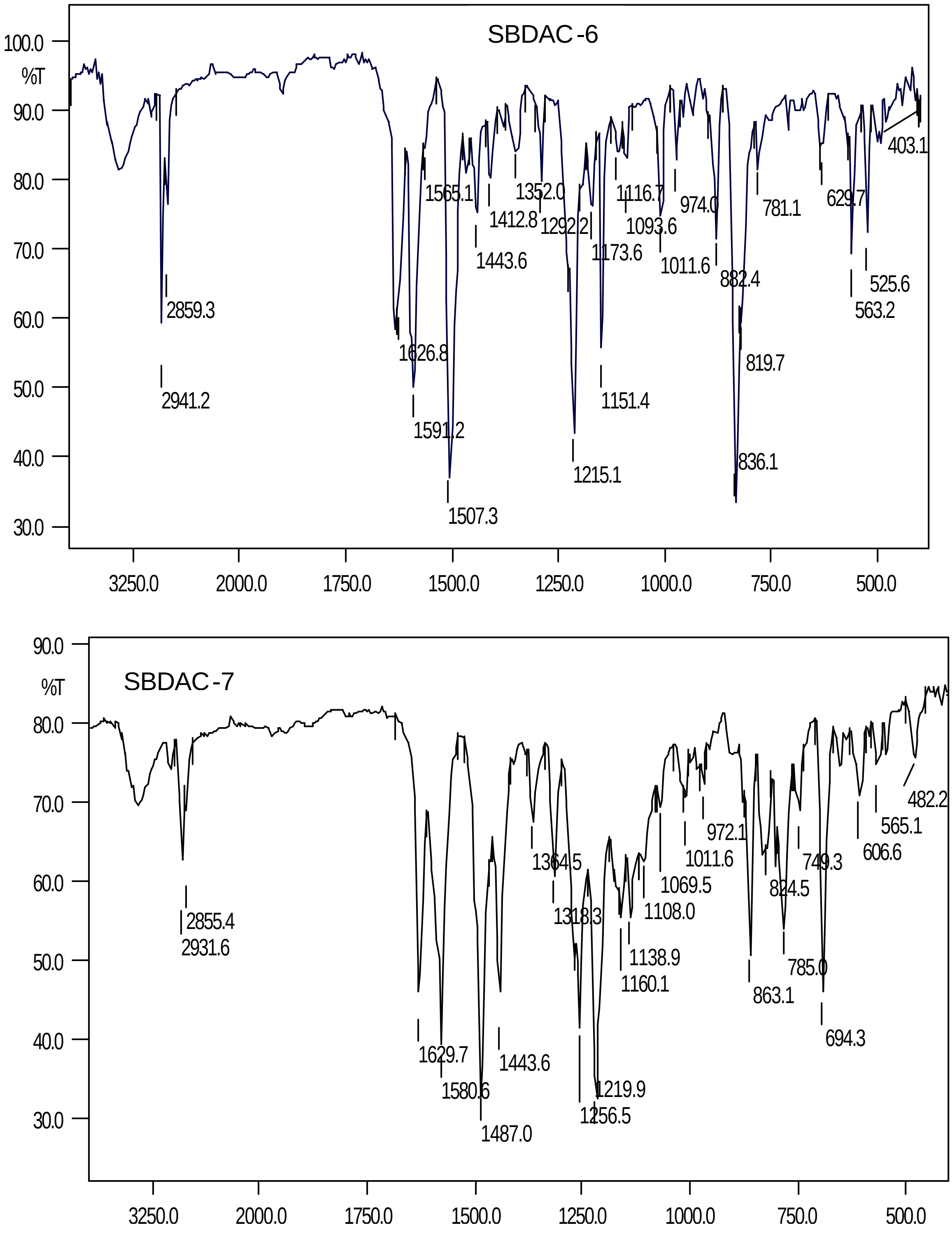

Fig.- 3.4 : IR (KBr) Spectra of SBDAC-6 and SBDAC-7

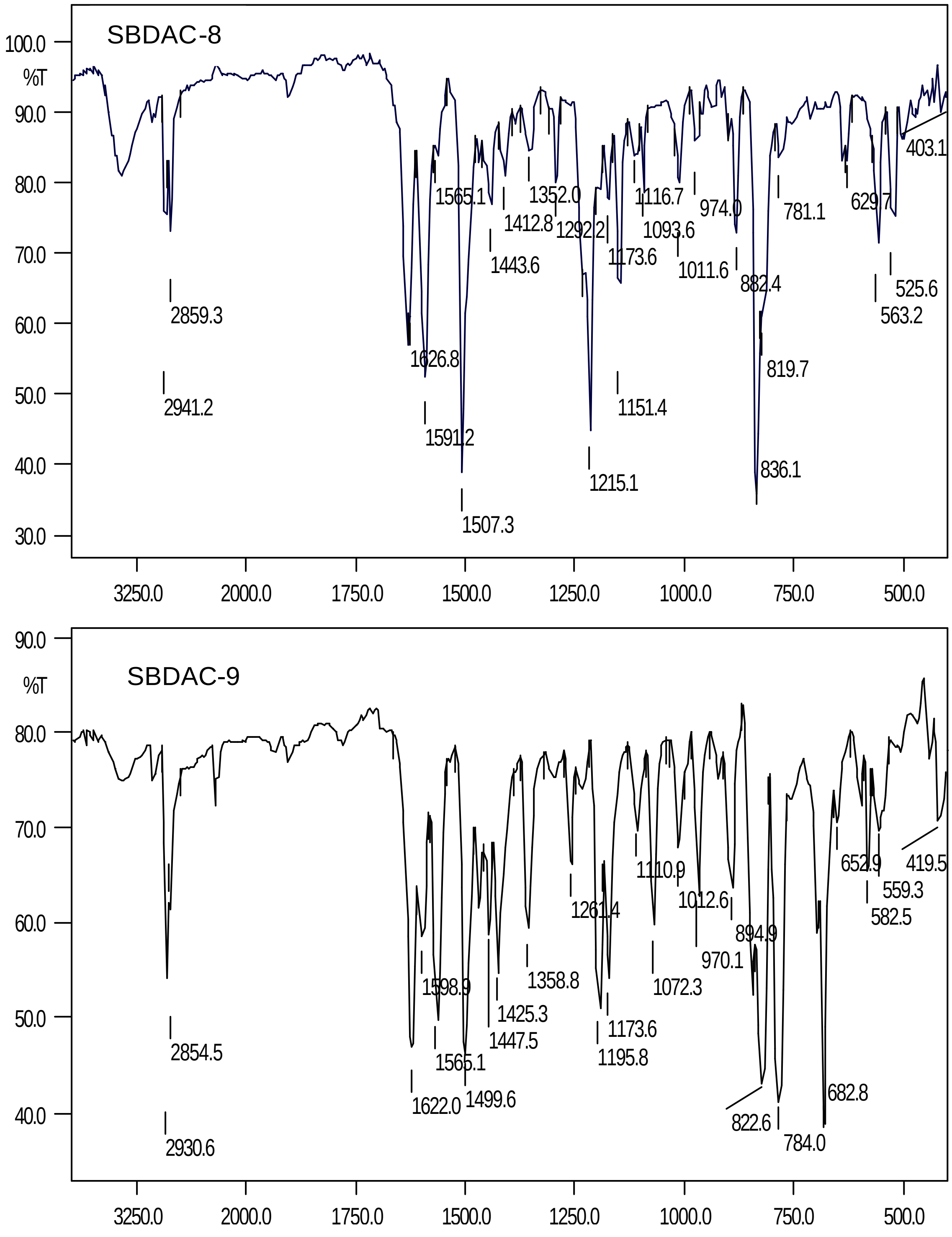

Fig.- 3.5 : IR (KBr) Spectra of SBDAC-8 and SBDAC-9

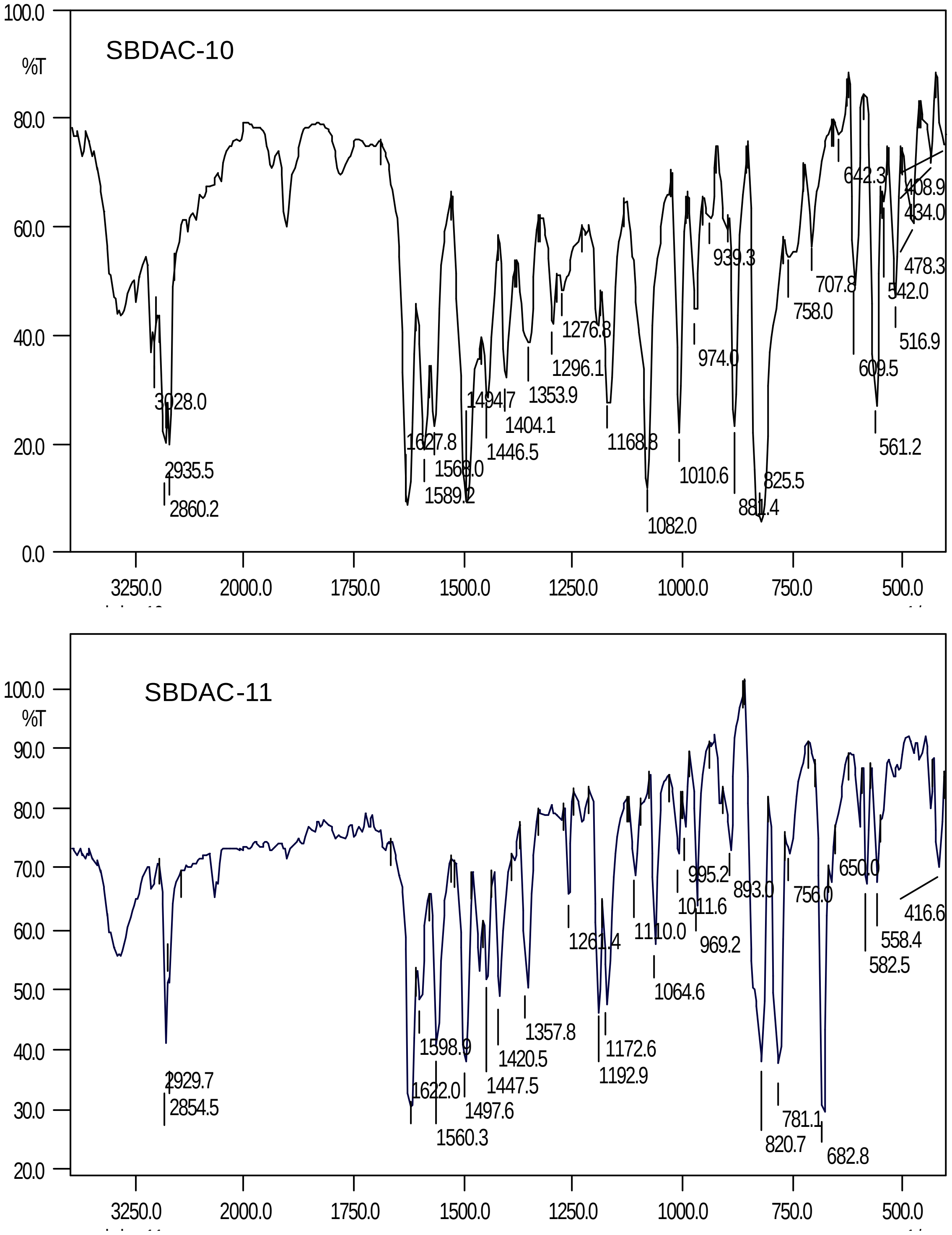

Fig.- 3.6: IR (KBr) Spectra of SBDAC-10 and SBDAC-11

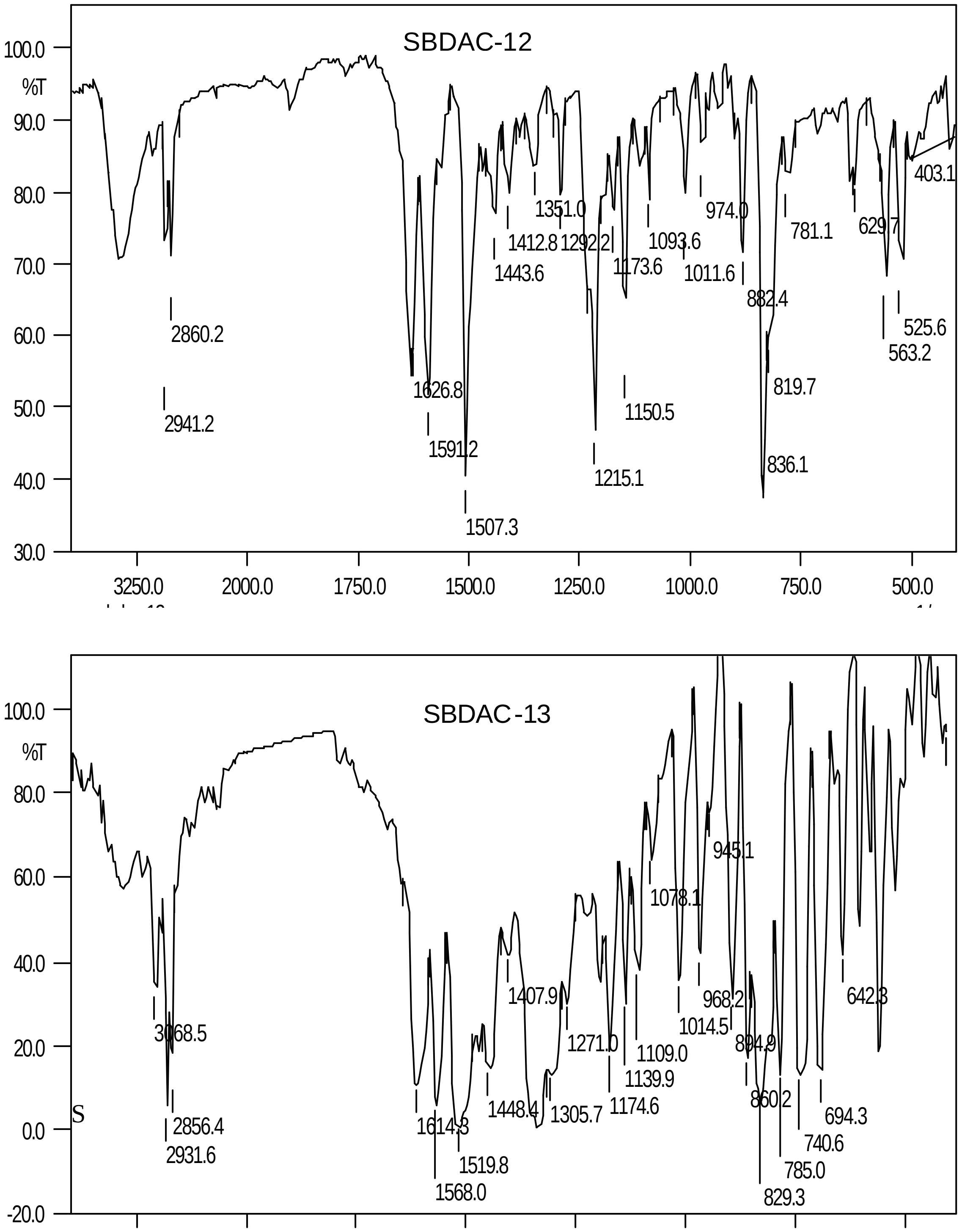

Fig.- 3.7: IR (KBr) Spectra of SBDAC-12 and SBDAC-13

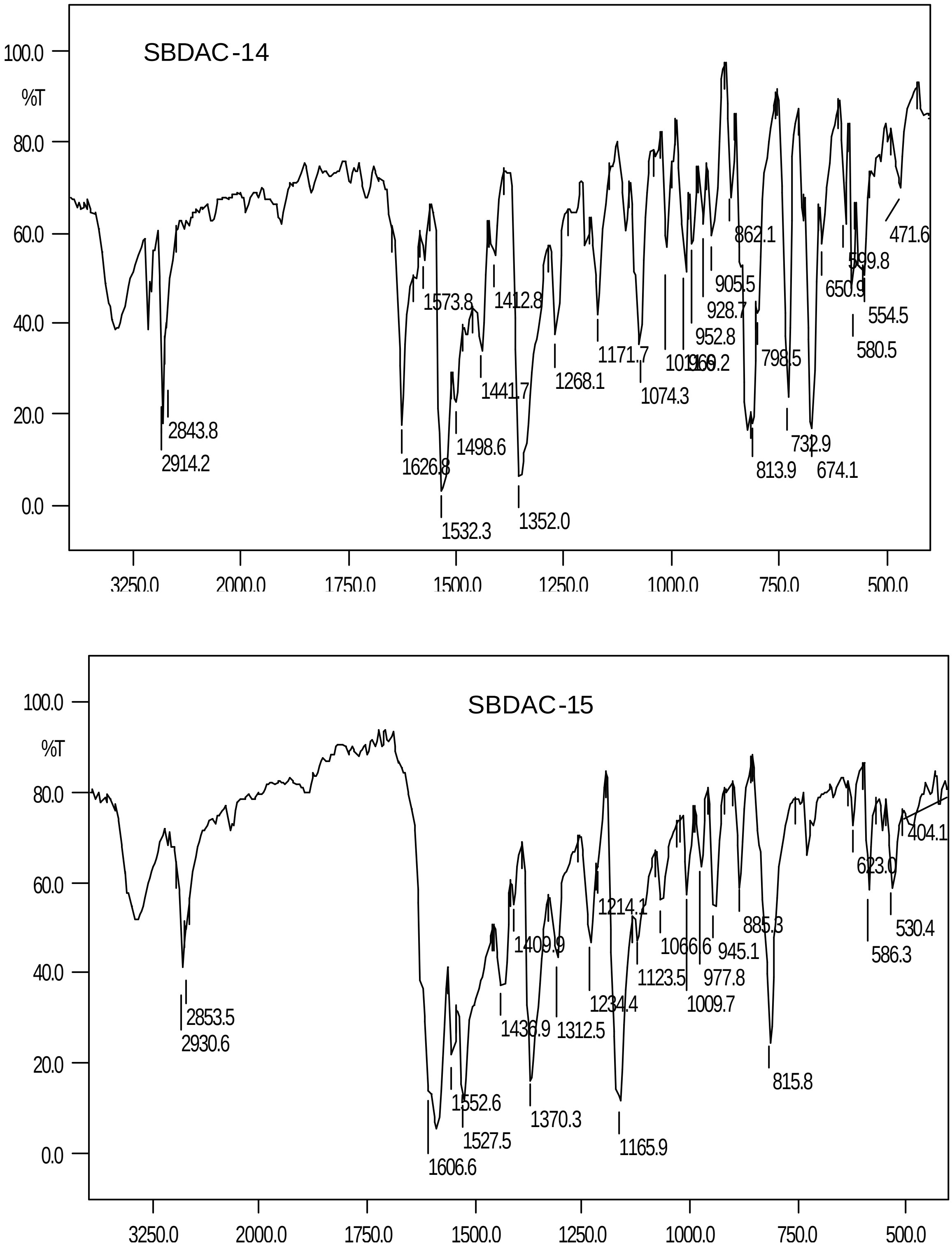

Fig.- 3.8: IR (KBr) Spectra of SBDAC-14 and SBDAC-15

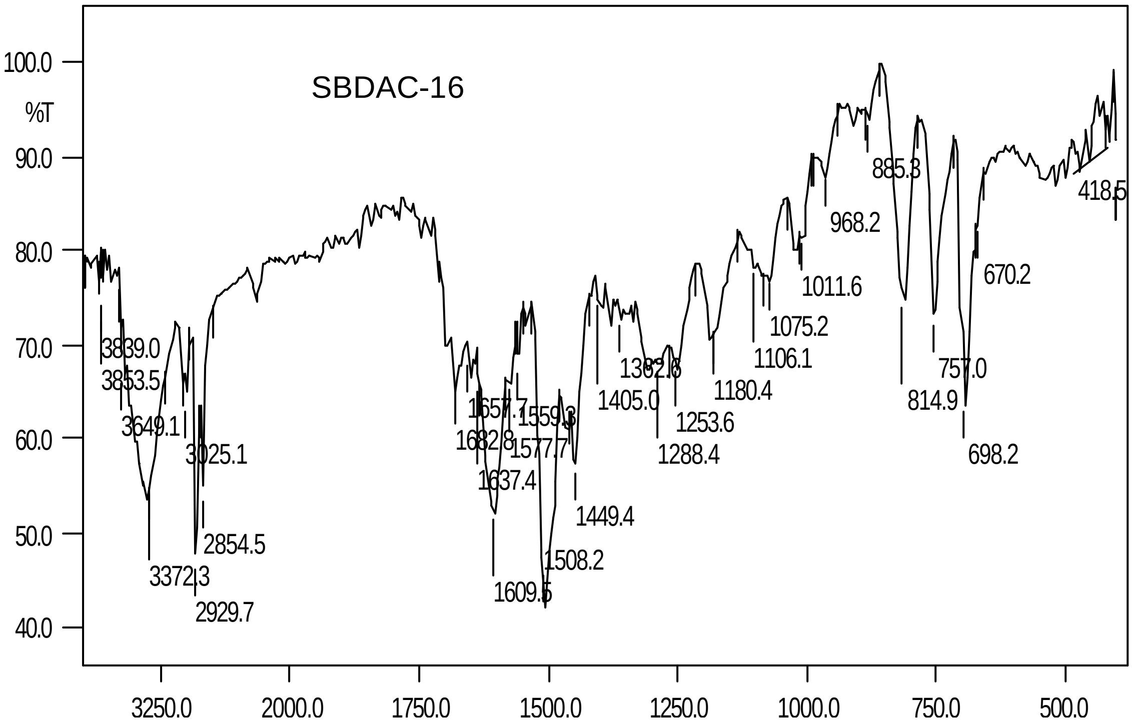

Fig.- 3.9 : IR (KBr) Spectrum of SBDAC-16

Table-3.2: The characteristic IR absorption bands (cm^{-1}) of DAC & SBDAC-1

Type	Vibration mode	Frequency in cm^{-1}		
		Observed		Reported
		DAC	SBDAC-1	
Alkane (-CH$_2$-)	C - H ?$_{as}$	2929.3	2938.3	2940-2915
	C - H ?$_s$	2854.5	2859.3	2870-2845
	C-H scissoring	1450.4	1449.4	1480-1440
	C-H twisting & Wagging	1276.8	1196.7	1250
Primary amine -NH$_2$	N-H ?$_{as}$	3340.5 3211.3	-	3550-3350
	N-H ?$_s$	3421.7	-	3450-3250
	N-H deformation	1625.9	-	1650-1580
	C-N Str.	1276.8	-	1340-1250
	N-H Wagging	819.7	-	850-750
Aromatic 1-4 disub.	C=C Str.	1512.1	1595	1579 ± 6
		1276.8	-	1258 ± 11
	C-H i.p. def.	1186.1	1168.8	1175 ± 6
		1014.5	1011.6	1033 ± 5
	C-H o.o.p. def.	819.7	814.9	817 ± 15
Mono sub.	C = C str.	-	1595	1604 ± 3
		-	1196.7	1185 ± 3
		-	1499.8	1510-1480
		-	1449.4	1452 ± 4
		-	1168.8	1177 ± 6
		-	-	1156 ± 5
	C – H i.p.d.	-	1072.3	1073 ± 4
	C – H o.p.d	-	1011.6	1027 ± 3
		-	757	751 ± 15
		-	691.4	697 ± 11
Schiff base	N = CH str. C – N vib.	- -	1624.0 1360.7 1311.5	1690 – 1635 1360 – 1310

Table-3.3.: The characteristic IR absorption bands (cm^{-1}) of SBDAC-2 to 4

Type	Vibration mode	Frequency in cm^{-1}			
		Observed			Reported
		SBDAC-2	SBDAC-3	SBDAC-4	
Alkane -CH$_2$-	C - H ?$_{as}$	2930.6	2927.7	2934..5	2940-2915
	C - H ?$_{s}$	2842.9	2842.9	2856.4	2870-2845
	C-H scissoring	1449.4	1454.2	1451.3	1480-1440
	C-H twisting & Wagging	1199.6	1279.7	1251.7	1250
Aromatic 1-2 disub.	C=C Ring str	-	1596.9	-	1607 ± 9
		-	1572.8 1454.2	-	1577 ± 4 1447 ± 10
	C-H i.p.def.	-	1279.7	-	1269 ± 17
		-	1149.5	-	1160 ± 4
		-	1115.7	-	1125 ± 14
		-	1012.6	-	1033 ± 11
	C-H o.o.p. def.	-	755.1	-	751 ± 7
Aromatic 1-4 disub.	C=C Str.	1594.1	1596.9	1600.8	1606 ± 6
		1569.0	1572.8	1578.8	1579 ± 6
		1497.6	1490.9	1511.1	1520 – 1480
		1409.9	1411.8	1422.4	1409 ± 8
	C-H i.p. def.	1199.6	1279.7	1251.7	1258 ± 11
		1169.7	1174.6	1165.9	1175 ± 6
		1107.1	1115.7	1108.0	1117 ± 7
	C-H o.o.p. def.	811	821.6	824.5	817 ± 15
Ar – OH	O – H str.	-	3441.7	3410.9	3550 – 3450
	O – H def.	-	1411.8	1306.7	1410 – 1310
	C – O str.	-	1195.8	1165.9	1230 – 1140
Schiff base Ar-N =CH -Ar	N = C Str.	1623.0	1616.2	1622.0	1690-1635
	C – N Vib.	1311.5	1358.8	1350.1	1360-1310

Table-3.4: The characteristic IR absorption bands (cm^{-1}) of SBDAC-5,6 & 8

Type	Vibration mode	Frequency in cm^{-1}			
		Observed			Reported
		SBDAC-5	SBDAC-6	SBDAC-8	
Alkane -CH$_2$-	C - H ?$_{as}$	2924.8	2933.5	2941.5	2940-2915
	C - H ?$_{s}$	2842.9	2855.4	2859.3	2870-2845
	C-H scissoring	1463.9	1453.3	1443.6	1480-1440
	C-H twisting & Wagging	1251.7	1251.7	1251.1	1250
Aromatic 1-2 disub.	C=C Ring str	1593.1	-	1591.2	1607 ± 9
		1576.7 1463.9	-	1565.1 1443.6	1577 ± 4 1447 ± 10
	C-H i.p.def.	1286.4	-	1292.2	1269 ± 17
		1159.1	-	1173.6	1160 ± 4
		1105.1	-	1151.4	1125 ± 14
		1043.4	-	1011.6	1033 ± 11
	C-H def.	758	-	781.1	751 ± 7
Aromatic 1-4 disub.	C=C Str.	1593.1	1601.8	1591.2	1606 ± 6
		1576.7	1578.8	1565.1	1579 ± 6
		1484.1	1511.1	1507.2	1520 – 1480
		1436.9	1421.4	1412.8	1409 ± 8
	C-H i.p. def.	1286.4	1251.7	1215.1	1258 ± 11
		1159.1	1165.9	1173.6	1175 ± 6
		1105.1	1107.1	1116.7	1117 ± 7
	C-H o.o.p def.	824.5	825.5	836.1	817 ± 15
Schiff base Ar-N =CH -Ar	N = C Str.	1619.1	1622	1626.8	1690-1635
	C – N Vib.	1361.7	1306.7	-	1360-1310
Ar-OCH$_3$	C-O-C Str .	1251.7	1251.7	-	1260-1200
	C-H Str asym	2924.9	2933.5	-	2975-2950
	C-H Str Sym.	2842.9	2855.4	-	2880-2860
	C-H def asym.	1436.9	1453.3	-	1470-1435
	C-H def sym	1361.7	1352.0	-	1385-1370
Halogen	C-Cl Str.	-	-	629.7	650

Table-3.5: The characteristic IR absorption bands (cm^{-1}) of SBDAC-7,9 & 11

Type	Vibration mode	Frequency in cm^{-1}			
		Observed			Reported
		SBDAC-7	SBDAC-9	SBDAC-11	
Alkane-CH$_2$-	C - H ?$_{as}$	2931.6	2930.6	2929.7	2940-2915
	C – H ?$_{s}$	2855.4	2854.6	2854.5	2870-2845
	C – H scissoring	1443.6	1447.5	1447.5	1480-1440
	C – H twisting	1256.5	1261.4	1261.4	1250
Aromatic 1 - 4 disub.	C = C str	1580.6	1598.9	1598.9 1497.6	1579 ± 6 1520-1480
		1487.0	1425.3	1560.3	1409 ± 8
	C – H i.p.d.	1256.5	1261.4	1261.4	1258 ± 11
		1160.1	1173.6	1172.6	1175 ± 6
		1108	1110.9	1110.0	1117 ± 7
		1011.6	1012.6	1011.6	1013 + 5
	C – H o..p.d	824.5	822.6	820.7	817 ± 15
Aromatic 1 - 3 disub.	C = C str.	1580.6	1598.8	1598.9	1586 ± 5
		1487.6	1499.6	1497.6	1495 ± 1470
		1443.6	1447.5	1420.5	1465 ± 1430
	C – H i.p.d.	1268.3	1261.4	1261.4	1278 ± 12
		1160.1	1173.6	1172.6	1157 ± 5
	C – H o. o. p .d.	1069.5 863.1	1072.3 894.9	1064.3 883.3	1076 ± 7 900-860
		785.0	784.0	781.1	782 ± 10
		694.3	682.8	682.8	725-680
Mono sub.	C = C str.	1598.9	-	-	1604 ± 3
		1195.8	-	-	1185 ± 3
		1487	-	-	1510-1480
		1443.6	-	-	1452 ± 4
	C – H i. p. d.	-	-	-	1177 ± 6
		1160.1	-	-	1156 ± 5
		1069.5	-	-	1073 ± 4
		1011.6	-	-	1027 ± 3
	C – H o. o. p .d	749.3	-	-	751 ± 15
		694.3	-	-	697 ± 11
Schiff base Ar-N=CH-Ar	N = C str.	1629.7	1622.0	1622.0	1690-1635
	C – N vib	1364.5	1358.8	1357.8	1360-1310
Ar-O-Ar ether	C – O – C	1219.9	-	-	1260-1200
Halogen	C-Cl str.	-	652.9	-	650
	C-Br str.	-	-	682.8	690-550

Table-3.6.:The characteristic IR absorption bands (cm^{-1}) of SBDAC-10,12&15

Type	Vibration mode	Frequency in cm^{-1}			
		Observed			Reported
		SBDAC-10	**SBDAC-12**	**SBDAC-15**	
Alkane $-CH_2-$	C - H ?$_{as}$	2935.5	2941.2	2930.6	2940-2915
	C - H ?$_{s}$	2860.2	2860.2	2853.5	2870-2845
	C-H scissoring	1446.5	1443.6	1436.9	1480-1440
	C-H twisting & Wagging	1296.1	1215.1	1234.4	1250
Aromatic 1-4 disub.	C=C Str.	1589.2	-	1606.6	1606 ± 6
		1568.1	1591.2	1552.6	1579 ± 6
		1494.7	1507.3	1527.5	1520 – 1480
		1404.1	1412.8	1409.9	1409 ± 8
	C-H i.p. d.	1296.1	1292.2	1234.4	1258 ± 11
		1168.8	1173.6	1165.9	1175 ± 6
	C-H o.o.p.d.	-	1150.5	1123.5	1117 ± 7
		825.5	836.1	815.8	817 ± 15
Schiff base Ar-N=CH-Ar	N = C Str.	1627.8	1626.8	1606.6	1690-1635
	C – N vib.	1353.9	1351.0	1312.5	1360-1310
	C-Cl Str.	609.5	-	-	650
	C-F Str	-	1093.6	-	1100-1000
$N-(CH_3)_2$	C-H Str. asym.	-	-	2930.6	2975-2950
	C-H Str. sym.	-	-	2853.5	2880-2860
	C-H def. asym.	-	-	1436.9	1470-1435
	C-H def .sym.	-	-	1370.3	1385-1370

Table-3.7: The characteristic IR absorption bands (cm^{-1}) of SBDAC-13&14

Type	Vibration mode	Frequency in cm^{-1}		
		Observed		Reported
		SBDAC-13	SBDAC-14	
Alkane-CH$_2$-	C - H ?$_{as}$	2931.6	2914.2	2940-2915
	C – H ?$_{s}$	2856.4	2843.8	2870-2845
	C – H scissoring	1448.4	1441.7	1480-1440
	C – H twisting	1271.0	1268.1	1250
Aromatic 1-2 disub.	C=C Ring str	1614.3	-	1607 ± 9
		1568.0	-	1577 ± 4
		1448.4		1447 ± 10
	C-H i.p.def.	1271.0	-	1269 ± 17
		1174.6	-	1160 ± 4
		1139.9	-	1125 ± 14
		1014.5	-	1033 ± 11
	C-H def.	740.6	-	751 ± 7
Aromatic 1 - 4 disub.	C = C str	1568.0	1573.8	1579 ± 6
		1519.8	1498.6	1520-1480
		1407.9	1412.8	1409 ± 8
	C – H i.p.d.	1271.0	1268.1	1258 ± 11
		1174.6	1171.7	1175 ± 6
		1109.0	-	1117 ± 7
	C – H o..o. p.d	1014.5	1016.2	1013 ± 5
		829.3	813.9	817 ± 15
Aromatic 1 - 3 disub.	C = C str.	-	1573.8	1586 ± 5
		-	1498.6	1495 ± 15
		-	1441.7	1465 ± 30
	C – H i.p.d.	-	1268.1	1278 ± 12
		-	1171.7	1157 ± 5
		--	1074.3	1076 ± 7
	C – H o.p.d.	--	862.1	900-860
		-	798.5	782 ± 10
		-	674.1	725-680
Schiff base Ar-N=CH-Ar	N = C str.	1614.3	1626.8	1690-1635
	C – N vib	1305.7	1352.	1360-1310
C – No$_2$	NO$_2$ str. asym	1519.8	1532.3	1590 – 1500
	NO$_2$ str. sym	1271.6	1305.7	1390 – 1250
	C-N vib.	829.3	905.5	920 – 830

Table-3.8 :The characteristic IR absorption bands (cm^{-1}) of SBDAC-16

Type	**Vibration mode**	**Frequency in cm^{-1}**	
		Observed	**Reported**
Alkane(-CH$_2$-)	C-H-?$_{as}$	2929.7	2940 – 2915
	C-H ?$_s$	2854.5	2870 – 2845
	C-H Scissoring	1449.4	1480 – 1440
	C-H twisting	1253.6	1250
Aromatic 1- 4 disub	C=C str	1609.6	1606 ± 6
		1577.7	1579 ± 6
		1508.2	1520 – 1480
		1405.0	1409 ± 8
	C-H i.p.def.	1253.6	1258 ± 11
		1180.4	1175 ± 6
		1106.1	1117 ± 7
		1011.6	1013 ± 5
	C-H o.o..p.d	814.9	817 ± 15
Mono sub.	C = C str.	1609.5	1607 ± 3
		1180.4	1185 ± 3
		1508.2	1510 – 1480
		1449.4	1452 ± 4
		1180.4	1177 ± 6
	C - H i.p.def.	1106.1	1156 ± 5
		1075.2	1073 ± 4
		1011.6	1027 ± 3
	C – H o.o.p.d.	757	751 ± 15
		698	697 ± 11
Schiff base	N = CH str.	1609.6	1690 – 1635
	C – N vib.	1362.6	1360 – 1310
Alkenes	C = C	1657.7	1665 – 1635 (cis)
		1682.8	1675 – 1665 (trans)
	C – H i.p.d.	1449.4	1430 – 1400 (cis)
		968.2	980 – 960 (trans)
	C – H o.o.p.def	698.2 968.2	730 – 665 (cis) 980 – 960 (trans)

CHARACTER…..

SECTION-3: NMR SPECTRAL CHARACTERIZATION

This section of the thesis includes NMR spectral data of diamine and schiff bases.

Some nuclei spin about their axes in a manner to that electrons spin. In the presence of an externally applied magnetic field, a spinning nucleus can only assume a limited number of stable orientations. Nuclear magnetic resonance occurs when a spinning nucleus in a lower energetic orientation in a magnetic field absorbs sufficient electromagnetic radiation and excites to a higher energetic orientation. The excitation energy varies with the type and environment of the nucleus. NMR spectroscopy can be used for the quantitative chemical analysis [10-12]. NMR spectroscopy consists of measuring the energy that is required to change a spinning nucleus from a stable orientation to a less stable orientation in the magnetic field. Different spinning nuclei in the magnetic field absorb different frequencies of radiation to change their orientations. The frequencies at which absorption occur can be used for qualitative analysis.

NMR spectrometer was invented in 1945 by Falix Bloch (Stanford University) and Edward Purcell. They shared the Nobel Prize (1952) in Physics for their work.

The NMR spectra of diamine and schiff bases were scanned on a Bruker FTNMR (300MHz) spectrometer by using $CDCl_3$ as a solvent and TMS as an internal standard and are presented in Figs.3.10 to 3.16

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10 V. M. Parikh, “Absorption Spectroscopy of Organic Molecules”, Addission Wesley Pub., p. 243-258, 1978

11 R. M. Silverstein, G. C. Bassler and T. C. Morrill, “Spectrometric identification of organic compounds”, 6th Ed. John Willey and Sons, New York, 1996

12 C. N. Rao, “Chemical applications of infrared spectroscopy”, Academic Press, New York, p 317-333, 1963

The chemical shifts, types of protons and coupling constant (J) of DAC and SBDAC-1 to SBDAC-16 are reported in Table 3.9. The integrated areas under the NMR peaks have revealed the labeled protons in each schiff base. The solvent $CDCl_3$ appeared at about 7.25-7.24 ppm either as a separate peak or overlapped with peak due to aromatic protons. Thus, NMR spectral data indicated expected number and types of the protons in a given schiff base molecule.

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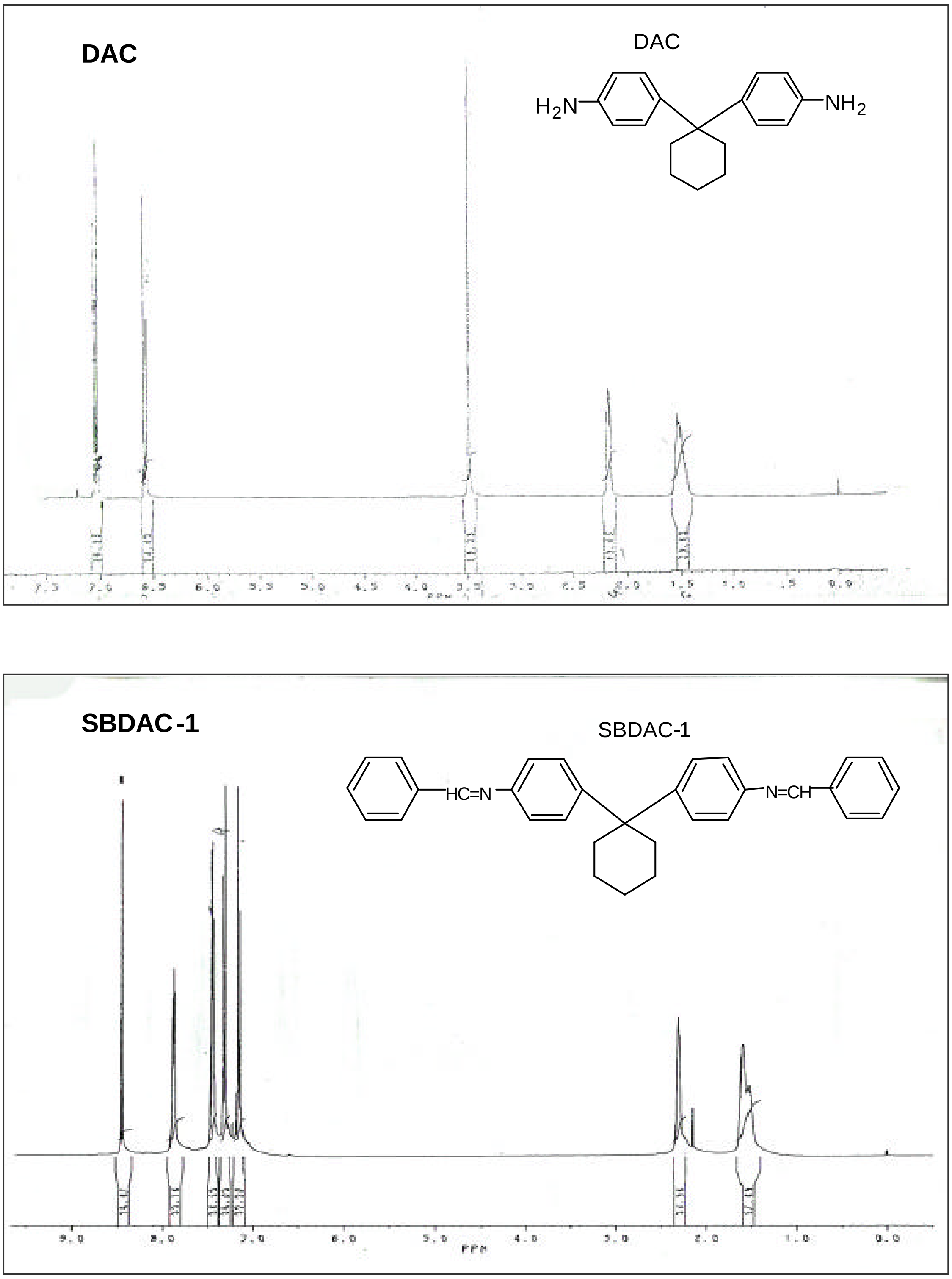
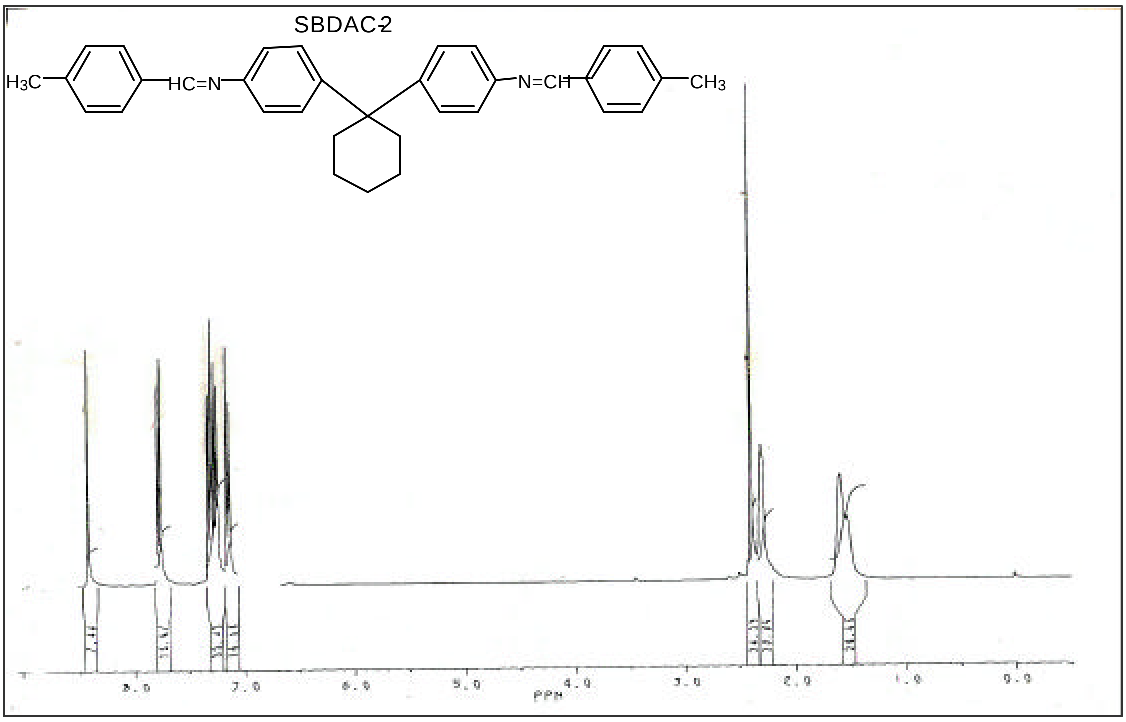


Fig.- 3.10:^{1}H NMR spectra of DAC and SBDAC-1 in $CDCl_3$.



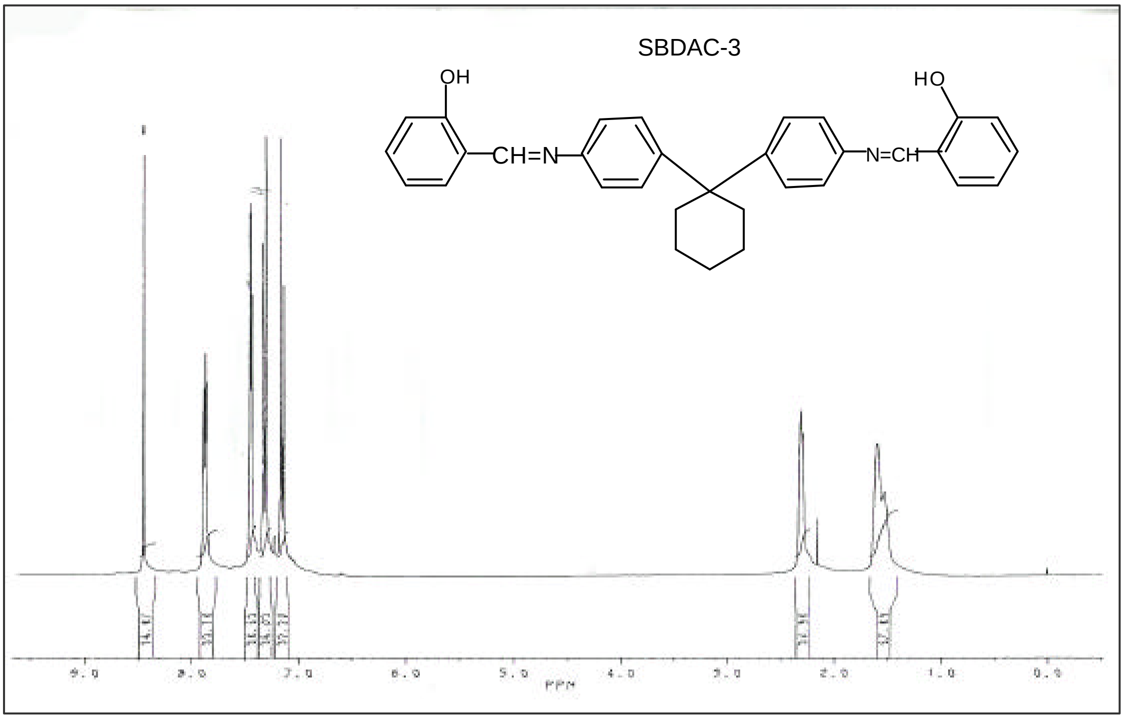
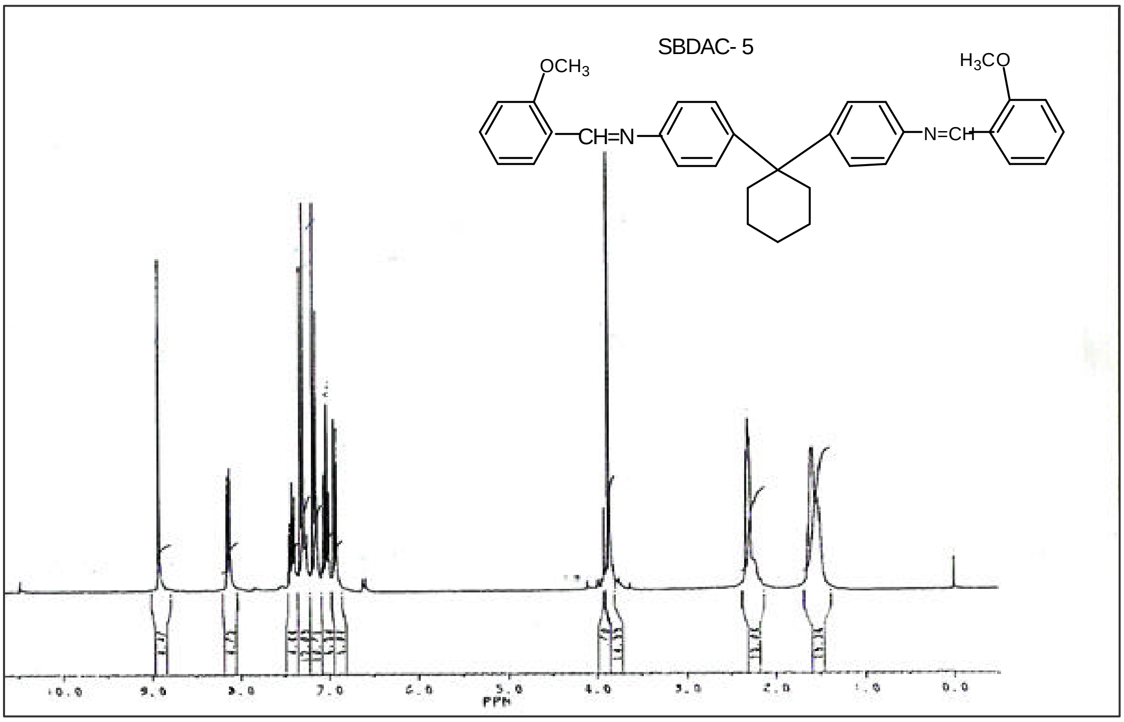


Fig.- 3.11: ^{1}H NMR spectra of SBDAC-2 and SBDAC-3 in $CDCl_3$



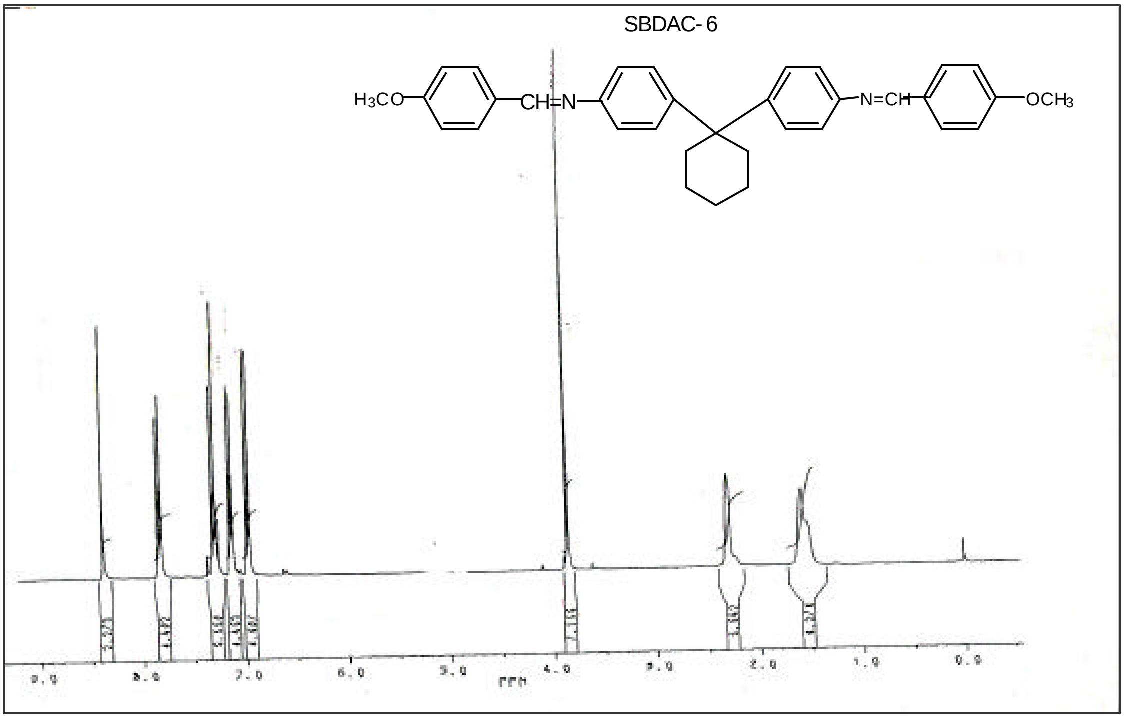


Fig.- 3.12: ^{1}H NMR spectra of SBDAC-5 and SBDAC-6 in $CDCl_3$

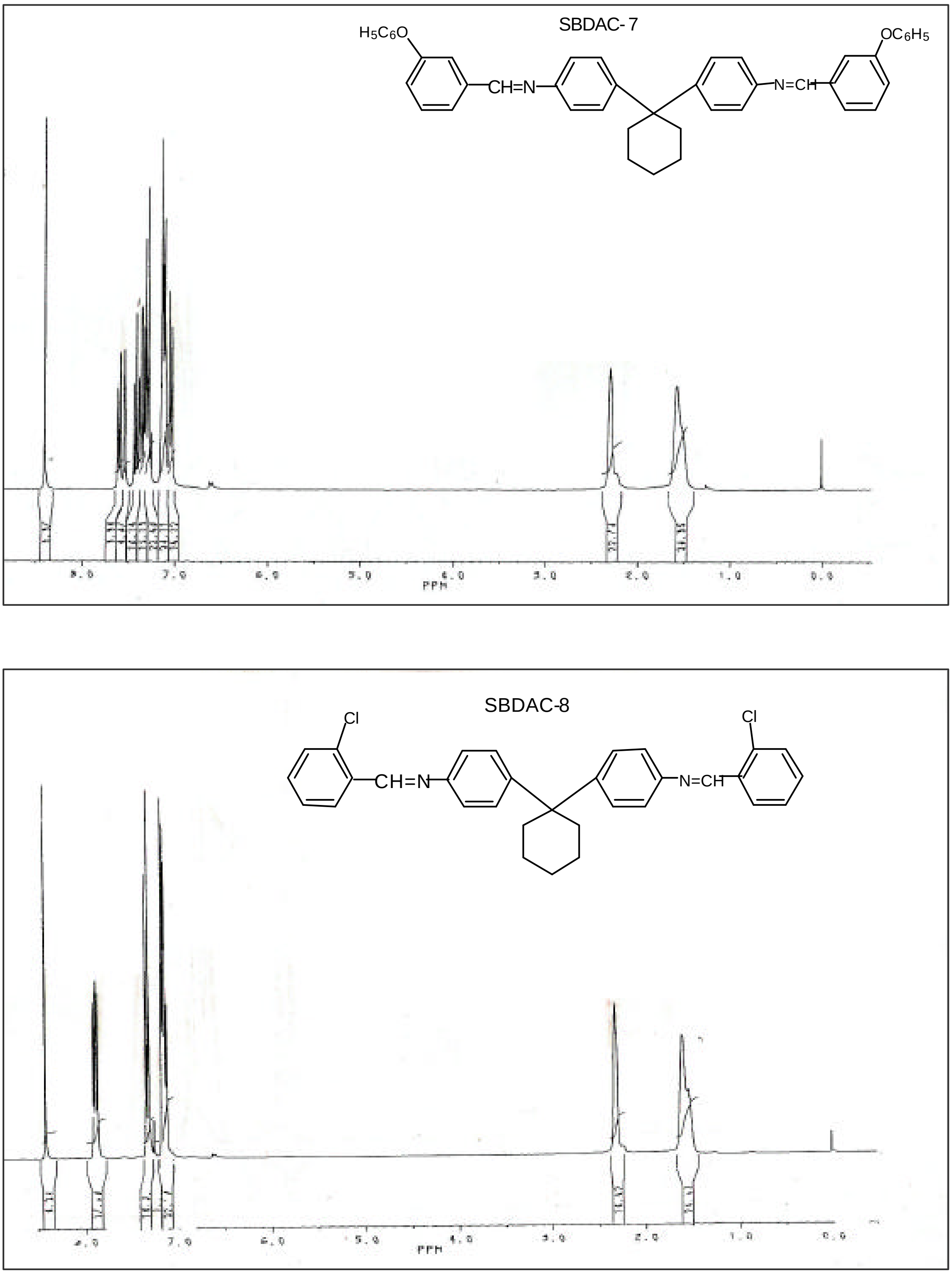


Fig.- 3.13: ^{1}H NMR spectra of SBDAC-7 and SBDAC-8 in $CDCl_3$

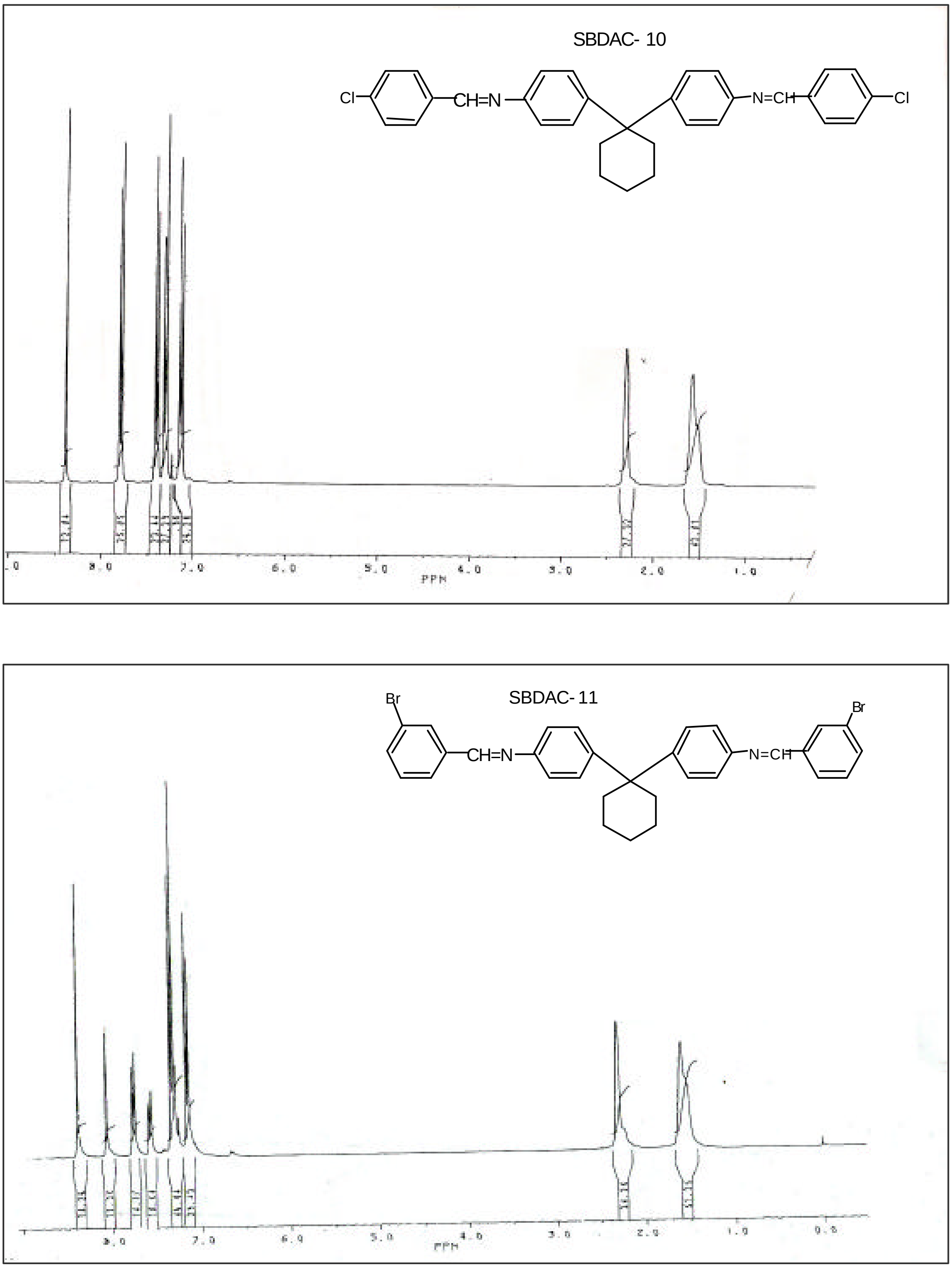


Fig.- 3.14: ^{1}H NMR spectra of SBDAC-10 and SBDAC-11 in $CDCl_3$.

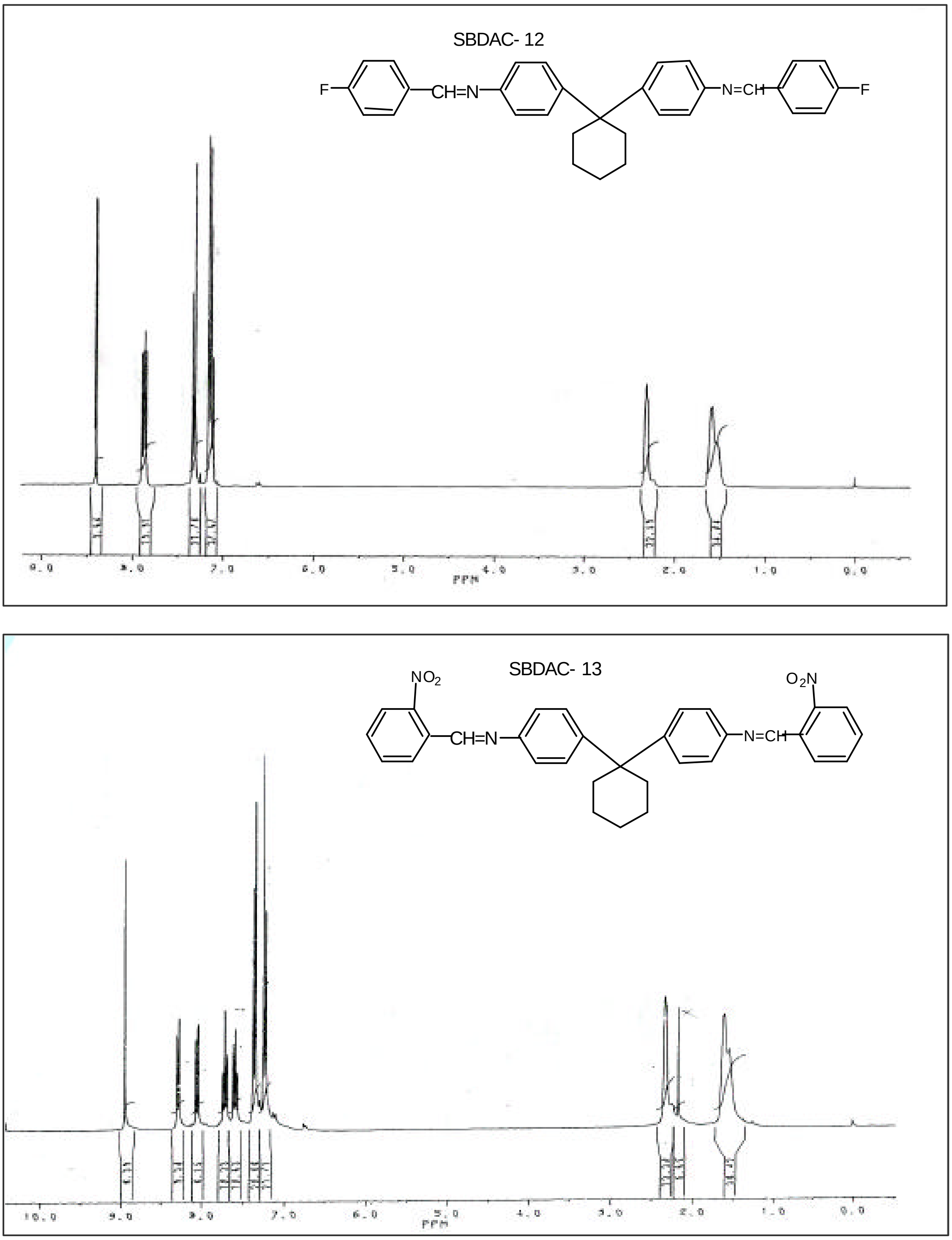


Fig.- 3.15: ^{1}H NMR spectra of SBDAC-12 and SBDAC-13 in $CDCl_3$

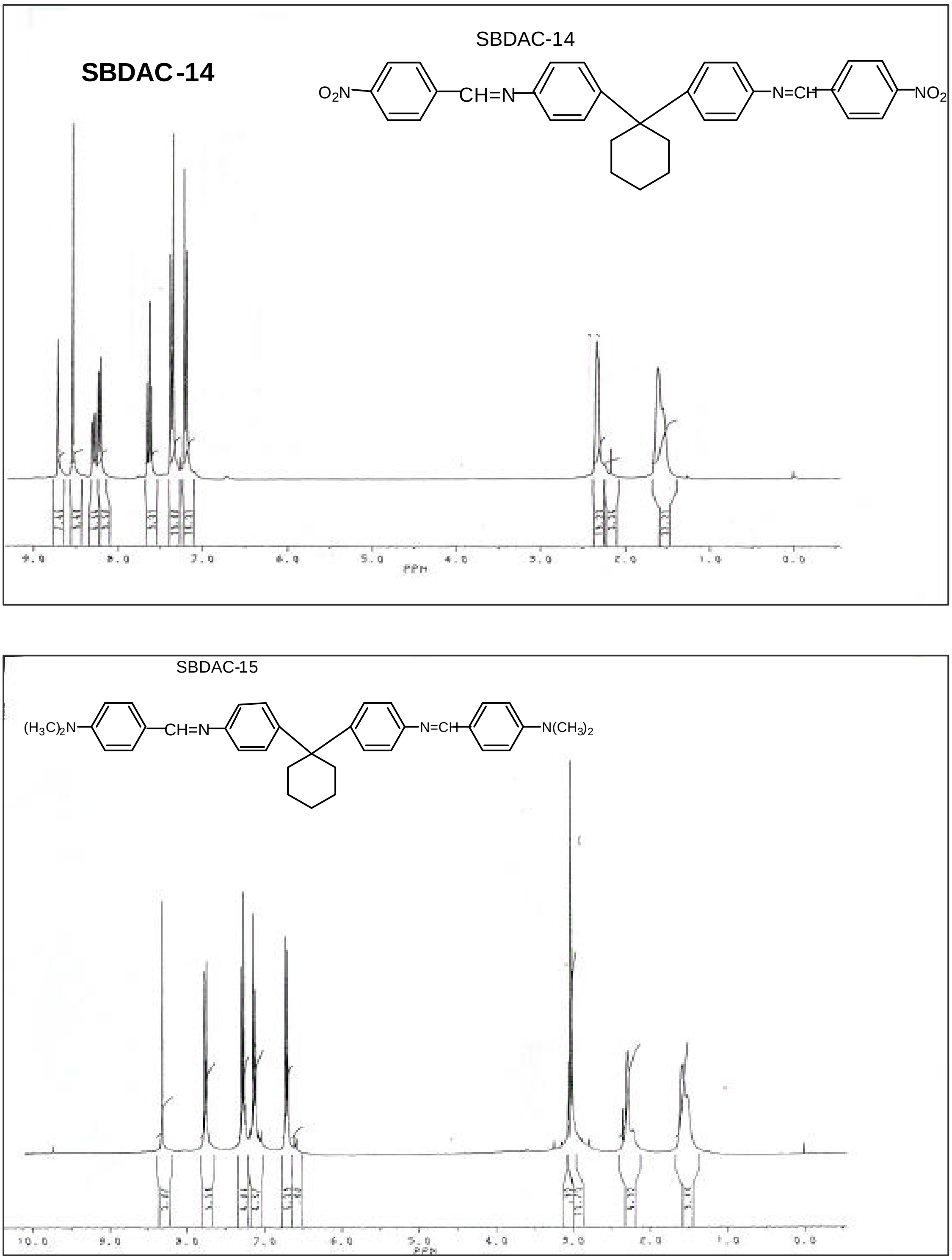


Fig.- 3.16: ^{1}H NMR spectra of SBDAC-14 and SBDAC-15 in $CDCl_3$.

Table -3.9: ^{1}H NMR chemical shift and coupling constants of DAC, SBDAC-1 to 16

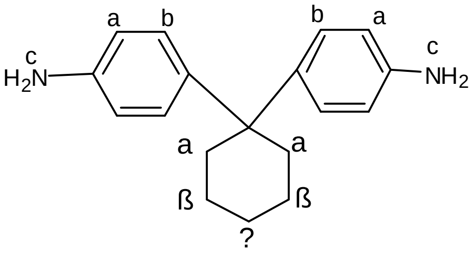
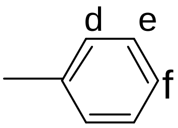
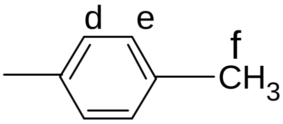
Sample	**NMR chemical shifts, ppm**
DAC 	1.517 (6H, s, ß + ?, -CH_2), 2.153 (4H, s, a, - CH_2) 3.475 (4H, s, c, -NH_2) 6.578 – 6.540 (4H, m, Ar - H_b, J=7.9) 7.016 – 6.997 (4H, m , Ar- H_a, J=8.66 & 8.7) 7.21 ($CDCl_3$).
SBDAC-1 	1.581 (6H, s, ß + ?, -CH_2-), 2.304 (4H, s, a, - CH_2) 7.162 – 7.135 (4H, d, Ar - H_b, J=10.9) 7.326 – 7.298 (4H, d, Ar- H_a, J=8.4) 7.452 – 7.403 (6H, m, Ar- H_{e+f}, J=6.5 & 2.7) 7.896- 7.856 (4H, m, Ar- H_d, J=7.4 & 5.4), 8.446 ($2H_C$ s, -CH=N-)
SBDAC-2 	1.578 (6H, s, ß + ?, -CH_2 -), 2.297 (4H, s, a, - CH_2-) 2.387 (4H, s, f, -CH_3), 7.148- 7.120 (4H, d, Ar - H_b, J=8.3) 7.312-7.231 (8H, m, Ar-H_{d+e}, J=8.1 & 8.3) 7.776-7.749 (4H, d, Ar- H_a, J=8.1) 8.408 ($2H_C$ s, -CH=N-)

Table -3.9: Conti. …..

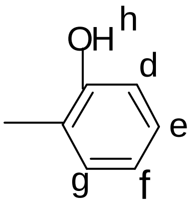
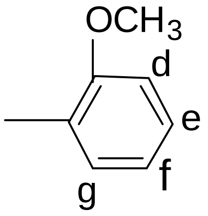
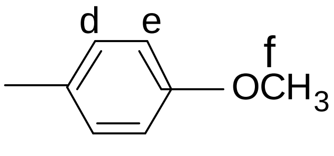
Sample	NMR chemical shifts, ppm
SBDAC-3 	1.59 (6H, s, ß + ?, -CH$_2$-), 2.301 (4H, s, a, - CH$_2$-) 6.936 -6.883 (2H, dd , Ar- H$_f$, J=8.3) 7.016-6.966 (2H,dd, Ar-H$_f$, J= 8.7) 7.222-7.187 (4H,d, Ar-H$_b$, J= 9.1) 7.371-7.319 (8H, m, Ar-H (a+e+g),J=7.1 & 8.7) 8.578 (2H$_C$, s, -CH=N-), 13.365 (2H, s, Ar-OH (h))
SBDAC-5 	1.594 (6H, s, ß + ?, -CH$_2$ -), 2.303 (4H, s, a, - CH$_2$ -) 3.898 (6H, s, -OCH$_3$), 6.962-6.913 (2H, d,Ar-H$_d$, J=8.4) 7.046-6.998 (2H, t,Ar-H$_f$, J=7.4 & 7.7) 7.171-7.143 (4H,d, Ar-H$_b$, J= 8.5), 7.245 (CDCl$_3$), 7.317-7.267 (4H,d, Ar-H$_a$, J= 9) 7.441-7.367 (2H, m, Ar-H$_e$, J=8.4& 8.7) 8.147-8.114 (2H, d, Ar-H$_g$, J=9.6), 8.916 (2H$_C$ s, -CH=N-)
SBDAC-6 	1.580 (6H, s, ß + ?, -CH$_2$-), 2.300 (4H, s, a, - CH$_2$-) 3.856 (6H$_f$, s, -OCH$_3$), 6.98-6.95 (4H,d, Ar-H$_b$, J= 8.7) 7.146-7.177 (4H,d, Ar-H$_d$, J= 8.7) 7.313-7.284 (4H,d, Ar-Ha, J= 8.7) 7.843-7.815 (4H,d, Ar-He, J= 8.7), 8.385 (2H$_C$ s, -CH=N-)

Table -3.9 Conti……

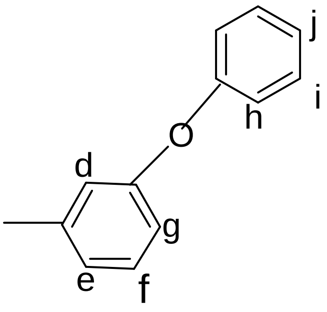
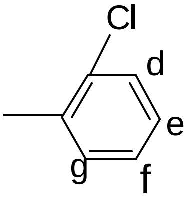
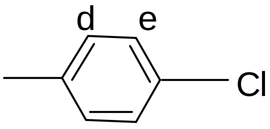
Sample	**NMR chemical shifts, ppm**
SBDAC-7 	1.568 (6H, s, ß + ?, -CH$_2$-), 2.289 (4H, s, a, - CH$_2$-) 7.05-7.024 (4H,d, Ar-H$_h$, J= 7.7) 7.147-7.094 (8H, m, Ar- H$_{g+i+j}$) 7.244 ($CDCl_3$), 7.312-7.275 (4H,d, Ar-H$_b$, J= 5.9) 7.347-7.321 (4H,d, Ar-H$_a$, J= 9.9) 7.4343-7.374 (2H, d, Ar-H$_f$, J=8) 7.541-7.534 (2H, d, Ar-H$_d$, J=1.8) 7.608-7.582 (2H, d, Ar-H$_e$, J=7.5), 8.397 (2H$_C$ s, -CH=N-)
SBDAC-8 	1.547 (6H, s, ß + ?, -CH$_2$-), 2.246 (4H, s, a, - CH$_2$-) 7.167-7.075 (8H,m, Ar-H$_{b+e+f}$, J= 8.4, 8.59) 7.245 ($CDCl_3$), 7.326-7.245 (4H, d, Ar- H$_{d+g}$,J= 8.54) 7.894-7.847 (4H, m, Ar-H$_a$, J=5.6 &6.77) 8.477 (2H, s, -CH=N-)
SBDAC-10 	1.575 (6H s, ß + ?, -CH$_2$-), 2.296 (4H s, a, - CH$_2$-), 7.151 – 7.122 (4H, d, Ar-H$_b$ J=8.7) 7.238 ($CDCl_3$), 7.322-7.294 (4H, d, Ar-H$_d$ J=8.4) 7.477-7.389 (4H, d, Ar-H$_e$ J=8.4) 7.806-7.777 (4H, d, Ar-H$_a$ J=8.3) 8.389 (2H, s, -CH=N-)

Table -3.9 Conti…..

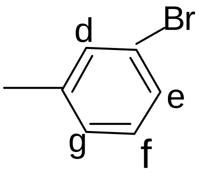
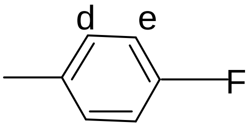
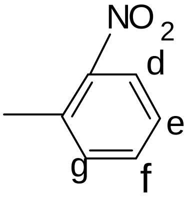
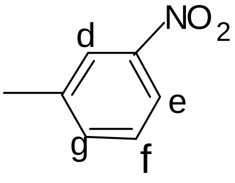
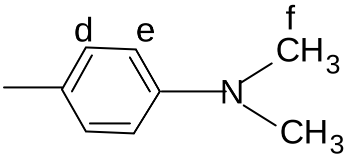
Sample	NMR chemical shifts, ppm
SBDAC-11  	1.583 (6H, s, ß + ?, $-CH_2-$), 2.306 (4H, s, a, $- CH_2-$) 7.169-7.130 (4H,d, Ar-H_b, J= 8.5) 7.244 ($CDCl_3$), 7.333-7.280 (6H, t, Ar- H_{a+f} ,J= 7.5, 8.3) 7.679-7.652 (2H, d, Ar-H_f, J=8.1) 7.764-7.738 (2H, d, Ar-H_g, J=7.8) 8.060 (2H, s, Ar-H_d,), 8.397 (2H s, -CH=N-)
SBDAC-12  	1.591 (6H, s, ß + ?, $-CH_2-$), 2.304 (4H, s, a, $- CH_2-$), 7.156 – 7.098 (8H, m, Ar-H_{b+d}, J=8.7) 7.334-7.299(4H, d, Ar-H_a J=8.5) 7.899-7.834 (4H, m, Ar-H_e J=8.1) 8.405 (2H, s, -CH=N-)
SBDAC-13  	1.611 (6H, s, ß + ?, $-CH_2-$), 2.329 (4H, s, a, $- CH_2-$) 7.294 -7.286 (4H,d, Ar-H_b, J= 8.5) 7.244 ($CDCl_3$), 7.373-7.344 (2H, d, Ar- H_a ,J= 8.5) 7.617-7.561 (2H, m, Ar-H_e, J=8.4) 7.738-7.688 (2H, m, Ar-H_f, J=7.5) 8.066 -8.035 (2H, d, Ar-H_g, J=9.4), 8.298 -8.270 (2H, d, Ar-H_d, J=8.5), 8.942 (2H, s, -CH=N-)

Table -3.9 Conti……

Sample	NMR chemical shifts, ppm
SBDAC-14  	1.599 (6H, s, ß + ?, -CH_2-), 2.329 (4H, s, a, - CH_2-) 7.211-7.183 (4H,d, Ar-H_b, J= 8.4) 7.292 ($CDCl_3$), 7.372-7.343 (4H, d, Ar- H_a, J= 8.6) 7.647-7.597 (2H, t, Ar-H_f, J=7.4 ,7.7) 8.224 - 8.196 (2H, d, Ar-H_g, J=8.3) 8.296- 8.267 (2H, d, Ar-H_e, J=7.9), 8.529 (2H, s, Ar-H_d,), 8.705 (2H, s, -CH=N-)
SBDAC-15  	1.575 (6H, s, ß + ?, -CH_2-), 2.291 (4H, s, a, - CH_2-), 3.019 (12H, s, H_f) 6.722-6.693 (4H, d, Ar-H_b J=8.7) 7.137-7.109 (4H, d, Ar-H_e, J=8.5) 7.238 ($CDCl_3$), 7.291-7.263 (4H, d, Ar-H_d, J=8.4) 7.766-7.737 (4H, d, Ar-H_a, J=8.7) 8.314 (2H, s, -CH=N-)

SECTION- 3: MASS SPECTRAL ANALYSIS OF DIAMINE AND SCHIFF BASES

This section of the thesis describes mass spectral analysis of diamine and SBDAC-1 to 16.

Mass spectrometry is used by organic chemists to characterize organic molecules in two principal ways:

1) To measure exact molecular weights, and from this, exact molecular formulae can be determined.
2) To indicate within a molecule the points at which it prefers to fragments, from this, the presence of certain structural units in the organic compound can be recognized.

The commonly used technique for obtaining the mass spectrum of an organic compound is electron impact (EI) technique. Other techniques are chemical ionization (CI), the fields desorption and fast atom bombardment (FAB) is used for organic compounds, while electrospray ionization (ESI) and matrix assisted laser desorption ionization (MALDI) are used for large biopolymers.

Mass spectra of DAC and SBDAC – 1 to 16 except - 11 were scanned on a Shimadzu GC - MS – QP 2010 Spectrometer by using E.I. (0.7kV) detector. The ion source temperature was 220^{0}C and interface temperature was 240^{0}C.

Ionization of a molecule by electron impact (EI)

A neutral sample of an organic molecule (M) is bombarded with high energy electrons. Energy of electrons is around 8-13 electron volts (eV), which is greater than the ionization energy for most compounds. One electron impact, the molecules are energized sufficiently to eject an electron. This process leads to the formation of a radical-cation symbolized more accurately by ($M^{+\cdot}$) but oftenly written as M^+ for simplification, which is called the molecular ion.

The molecular ion represents the intact molecule which has the same weight as the starting molecule (M), because weight loss of electron is negligible.

$$M \quad + \quad \bar{e} \quad \longrightarrow \quad M^{+\cdot} \quad + \quad 2\,\bar{e}$$

Neutral molecule
High energy electron
Radical cation (Molecular ion)

Fragmentation of molecular ion

The molecular ion $M^{+\cdot}$ undergoes fragmentation process in which free radicals or neutral molecules are lost from the molecular ion. The general tendency for fragmentation is to give the most stable fragments. There are two major types of fragmentations. In the first a neutral molecule (e.g. H_2O, $-C_2H_4$, CO, HCl, HCN, H_2S…etc.) is eliminated. The loss of a neutral molecule gives a new fragment, whose mass number has the same as, odd or evenness as the parent.

The second fragmentation process involves a separation into the ion part and radical part and this process involves a variety of homolytic-heterolytic cleavages and rearrangement reaction. Thus, studies of fragmentation process provide various information regarding structure of molecular ion and molecule.

The base peak, the mass spectrum and ratio of mass to charge (m/z)

The graphical representation of the mass spectrum of a compound is constructed by plotting mass/charge (m/z) ratio versus relative abundance or percentage of base peak. The most intense peak in the spectrum is assigned as the base peak. The base peak is assigned the arbitrary intensity value of 100, while all other peaks are given their proportionate values. The common practice is to represent spectra of organic compounds in the form of bar graph.

The molecular ion (M^+) peak has usually the highest m/z values in the group of peaks of M+1, M+2, M-1, M-2. Generally molecular ion peak have same mass as the molecular weight of original compound. M+1 and M+2 peaks are isotopes peaks. The intensity of M+1 peak in mass spectra is used to know the number of carbon as well as nitrogen atoms. In the absence of nitrogen, the maximum number of carbon atoms can be calculated by dividing the relative intensity of M+1 peak by 1.1. But, when nitrogen atom is present, number of carbon atoms can be calculated by subtracting amount 0.4 X number of nitrogen atoms from the measured relative intensity of the M+1 peak. When the M+2 peak of the ion looks larger than the M+1 peak, the compound might contain S, Cl, or Br.

When a compound contains two Cl, Br, S or Si, proton from the M+2 is likely to enhance the intensity of the M+1 peak. In the case of halogen atoms like chlorine and bromine, there are two isotopes with substantial natural abundance, which can lead to some distinctive patterns of peaks (spaced at intervals of two mass units) near to the molecular ion peak. Thus, the recognition of halogenated compounds from the characteristic patterns of these peaks can be done. Therefore a compound, which contains two chlorine or two bromine atoms or one chlorine or one bromine atom will display a distinct M+4 peak in addition of M+2 peak.

The number of nitrogen atoms present can be deduced with the help of nitrogen rule. When a molecule or ion contains an odd number of nitrogen atoms it will have an odd numerical value for the molecular weight. On the other hand when the number of nitrogen atoms are even or zero, the molecular weight will be even numbered. The rule applies to the organic compound containing C, H, N, O, S, P, B, Si and halogens.

DAC and SBDAC-1 to 16 contain two nitrogen atoms. According to nitrogen rule all compounds show even molecular weight except SBDAC-11. In other words, in the case of species with either zero or an even number of nitrogen, odd electrons will have an even mass number and even electron ions will have an odd mass number.

A general view of fragmentation

The molecular ion, (though it may be law abundance) gives highly useful information about the identity of an organic compound. Fragmentation pattern, i.e., the break-up process of the molecular ion into small ions (fragmentations or daughter ions) give further information about the structure of the compound. All fragment ions are, however, not of equal significance to assign the structure of a compound. The following points provide useful guidelines to understand fragmentation pattern and mass spectra of DAC and SBDAC -1 to 16 (Figs3.17 to 3.33)

1) The molecular ion peak is the most important in the mass spectrum of a compound and gives exact molecular weight.
2) Odd electron ions are generally more significant than even electron ions of similar mass.
3) Ions of high mass normally give more useful information than those of lower mass, since they are likely to have been formed via a simple rational fragmentation.
4) The meta stable ions provide useful information on the nature of the fragmentation process.
5) The intensities of fragmented ions in the mass spectrum reflect on the stability of the ions, and the energy relationships of the bonds broken and formed during the reactions leading to the ions.
6) All the molecular ions (M^+) contain cyclohexane rings, so that extensive decomposition takes place to give a series of fragment ions separated by 14 mass units. Thus, the mass spectra of DAC and SBDAC-1 to 16 show fragment ions $M^{+\cdot}$-CH_2, $M^{+\cdot}$-$2CH_{2,}$, $M^{+\cdot}$-$3CH_2$, $M^{+\cdot}$-$4CH_2$, $M^{+\cdot}$-$5CH_2$. But from all these fragments $M^{+\cdot}$-$3CH_2$ (M^+-42) is found more stable and intense.
7) All the mass spectra shows fragments of phenyl cations at m/z=77 due to loss of electron from substituted phenyl cation after loss of, C and C_2H_2 give ions m/z=65 and 51, respectively.

Mass spectral analysis

Mass spectral fragments of DAC and SBDAC -1 to SBDAC -16 are reported in Table 3.10. The molecular ion peaks M^+ , $(M\ -1)^+$ and some of the main fragments are reported in Table 3.11. An attempt is made to assign each fragment mentioned in Table 3.11 through Scheme – II. Pyrolysis of compound is a complex process and involves a variety of reactions such as ionization , decomposition, branching, cross-linking and rearrangement. Upon loss of electron results molecular ion, while loss of azomethine proton gives $(M\text{-}1)^+$ ion peak in the mass spectrum. $(M\text{-}1)^+$ ion undergoes further fragmentation to give fragments 1 and 2. Fragment -1 further undergoes fragmentation to give fragments 3 and 4. Similarly fragment - 2 produces fragments - 4 and 6, while fragment - 3 produces fragments 5, 6 and 7. In case of SBDAC-4, fragment 4 further decomposes into fragment $C_7H_6O^+$ (m/e = 106) and nitrogen radical. Besides main fragments, many more fragments are possible due to above mentioned possible reactions. At the end all fragments are converted into low molecular mass gaseous products. Thus , mass spectral data supported the structure of the diamine and schiff bases.

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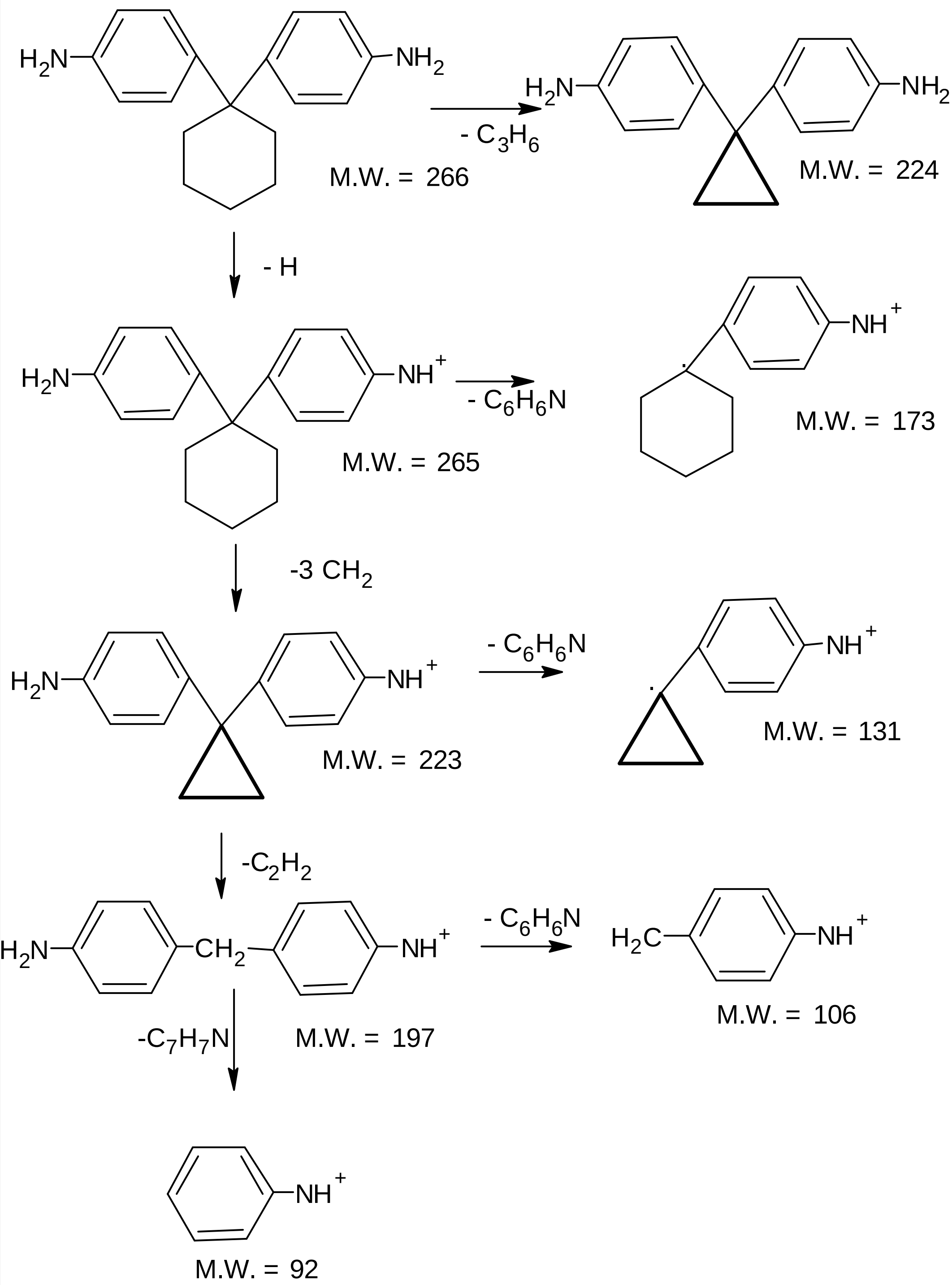
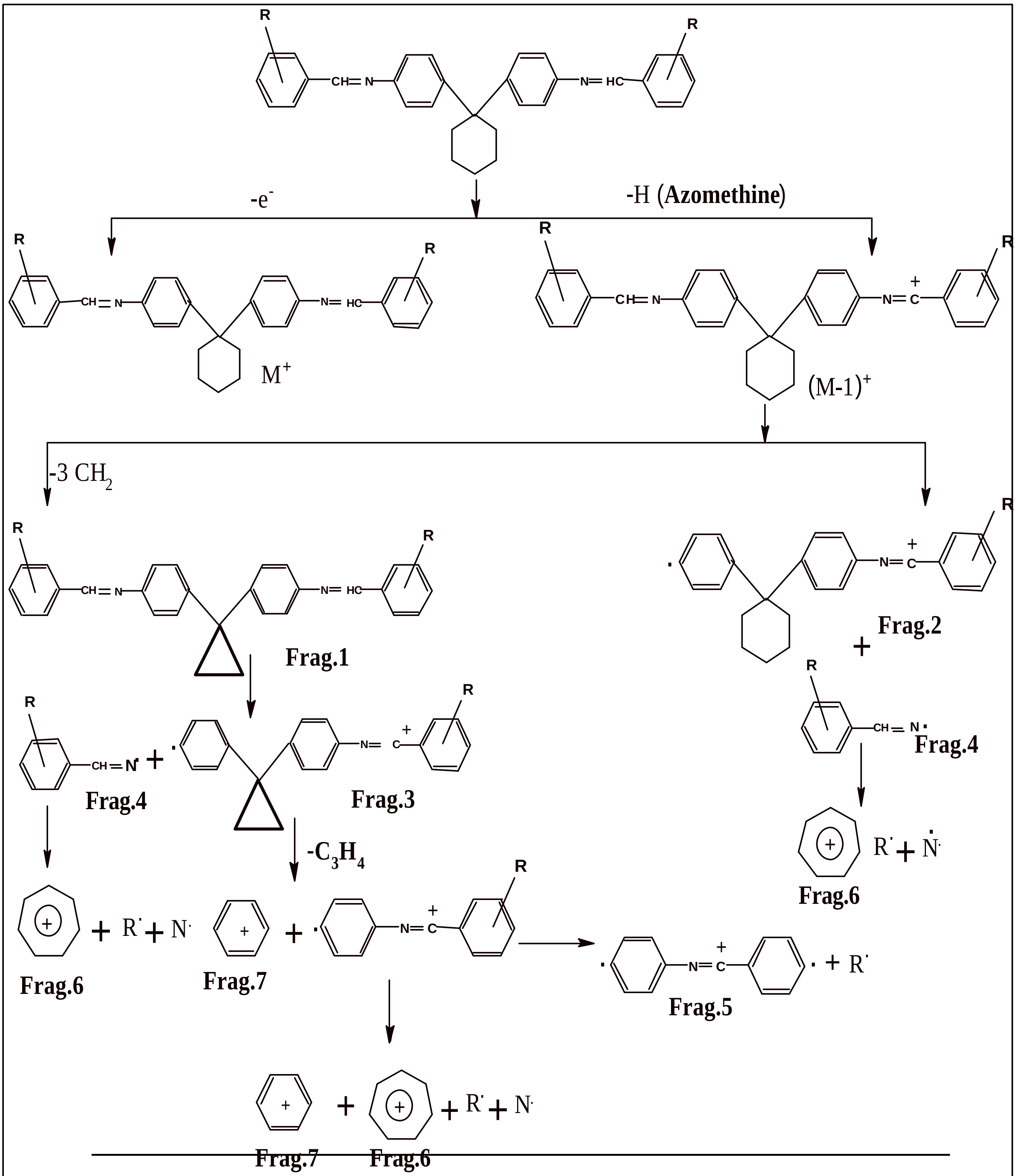
13 R.M. Silverstein and F.X. Webster "Spectrometric identification of organic compounds ", sixth edition, John wiley and sons, New York, 1996.

14 P.S. Kalsi, "Spectroscopy of Organic Compounds." 5th edition, New age international, Ltd., New-Delhi, 2003.



SCHEME- I

Fragmentation of DAC



SCHEME II

Fragmentation scheme

Table 3.10: Important mass spectral fragments of DAC and SBDAC-1 to 16

Compd.	m/z
DAC	268, 267,266, 265, 224, 223, 197, 195, 144, 130, 106, 92, 77, 65.
SBDAC- 1	444, 443, 442, 441, 400, 399, 386, 373, 338, 295, 282, 218, 194, 181, 180, 178, 165, 147, 129, 115, 104, 91, 77 .
SBDAC -2	472, 471, 470, 469, 428, 427, 401, 352, 335, 310, 309, 296, 232, 220, 208,194, 178, 165, 154, 115, 105, 91, 77 .
SBDAC -3	477, 476, 475, 474, 432, 431, 405, 355, 354, 337, 312,299, 238, 237, 210, 196, 178, 165, 152, 128, 115, 102, 91, 77, 65, 51, 41.
SBDAC -4	477, 474, 475, 474, 431, 412, 371, 370,355, 327, 311, 301, 250, 234, 210, 207, 194, 180, 163, 144, 130, 115, 106, 77, 65, 45.
SBDAC -5	504, 503, 502, 459, 433, 384,368, 341, 315, 301, 266, 254, 234, 224, 223, 207, 195, 178, 165, 130,119, 106, 91,77.
SBDAC -6	504, 503, 502, 459, 433, 384, 351, 341, 266, 265, 250, 224, 223, 207, 195, 165, 119, 106, 91, 77, 44 .
SBDAC-7	628, 627, 626, 607, 583, 570,557, 446,430, 403, 374, 354, 314, 313, 298, 286, 272, 250, 228, 191, 181, 165, 141, 129, 115, 104, 91, 77, 65, 51.
SBDAC-8	478, 435, 422. 409, 369, 356, 339, 326, 313, 300, 286, 279, 252, 239, 236, 212, 198, 191, 178, 156, 143, 129, 115, 109, 91, 77, 65.

Table 3.10 Conti….

Schiff base	m/e
SBDAC -9	510, 467, 454, 441, 385, 372, 342, 329, 316, 302, 280, 266, 252, 240, 228, 214, 204, 191, 178, 165, 152, 129,115, 109, 91, 77, 65.
SBDAC -10	478, 435, 422, 409, 356, 339, 313, 309, 239, 236,212, 198, 191, 178, 156, 143, 129, 95, 77 , 44.
SBDAC -11	600, 560, 557, 533, 531, 513, 431, 418, 387, 375, 360, 348, 310, 298, 286, 272, 259, 231, 218, 204, 191, 178, 165, 152, 129, 115, 102, 91, 77, 69, 51.
SBDAC -12	478, 435, 422, 409, 369, 356, 339, 326, 313, 300, 286, 279, 239, 236, 212, 198, 191, 178, 156, 143, 129, 115, 109, 95, 77.
SBDAC -13	533, 532, 531, 517, 501, 489, 474, 441, 425, 400, 391, 383, 370, 356, 342, 324, 307, 289, 279, 267, 257, 239, 220, 205, 192, 179, 167, 149, 136, 107
SBDAC -14	532, 531, 515, 490, 489, 463, 459, 442, 412, 399, 383, 367, 356, 340, 327, 308, 293, 266, 263, 239, 225, 217, 204, 191, 178, 165, 147, 129, 115, 103, 91, 77, 65, 55.
SBDAC -15	528, 513, 499, 485, 470, 459, 443, 430, 409, 397, 381, 363, 337, 322, 305, 275, 264, 235, 221, 207, 182, 168, 157, 147,134, 122, 107, 91, 77, 65, 42.
SBDAC-16	490, 468, 448, 447,425, 406, 404, 378, 377, 360, 354, 336, 335,320, 309, 307, 290, 285, 266, 265, 242, 224, 223,204, 195, 174, 167, 148, 130, 117, 106, 91, 77.

Table – 3.11 **Molecular ion(M^+), $(M-1)^+$ peaks and some important fragments of SBDAC-1 to 16**

Schiff base	M^+	$(M-1)^+$	Frag-1	Frag-2	Frag-3	Frag-4	Frag-5	Frag-6	Fag-7
SBDAC-1	442	441	399	338	296	104	178	91	77
SBDAC-2	470	469	427	352	309	118	178	91	77
SBDAC-3	474	473	431	355	311	120	178	91	77
SBDAC-4	474	473	431	355	311	106	178	91	77
SBDAC-5	502	501	459	368	325	119 (-CH3)	178	91	77
SBDAC-6	502	501	459	368	325	119 (-CH3)	178	91	77
SBDAC-7	626	625	583	430	387	196	178	91	77
SBDAC-8	511 (-Cl)	510 (-Cl)	469 (-Cl)	372	339 (-Cl)	139	178	91	77

Table -3.11 Conti ……

Schiff base	M+	(M-1)+	Frag-1	Frag-2	Frag-3	Frag-4	Frag-5	Frag-6	Fag-7
SBDAC-9	511	510	468	372	329	139	178	91	77
SBDAC-10	511	510	468 (-Cl)	372 (-Cl)	329 (-Cl)	139	178	91	77
SBDAC-11	600	599	558	417	375	183	178	91	77
SBDAC-12	478	477	436	280	314	122	178	91	77
SBDAC-13	532	531	490	383	341	149	178	91	77
SBDAC-14	532	531	490	383	341	149	178	91	77
SBDAC-15	528	527	486	381	380	147	178	91	77
SBDAC-16	490	-	448	364	318	130	178	91	77

Molecular ion peak M $^+$ **(M-1) $^+$: Due to loss of azomethine proton**

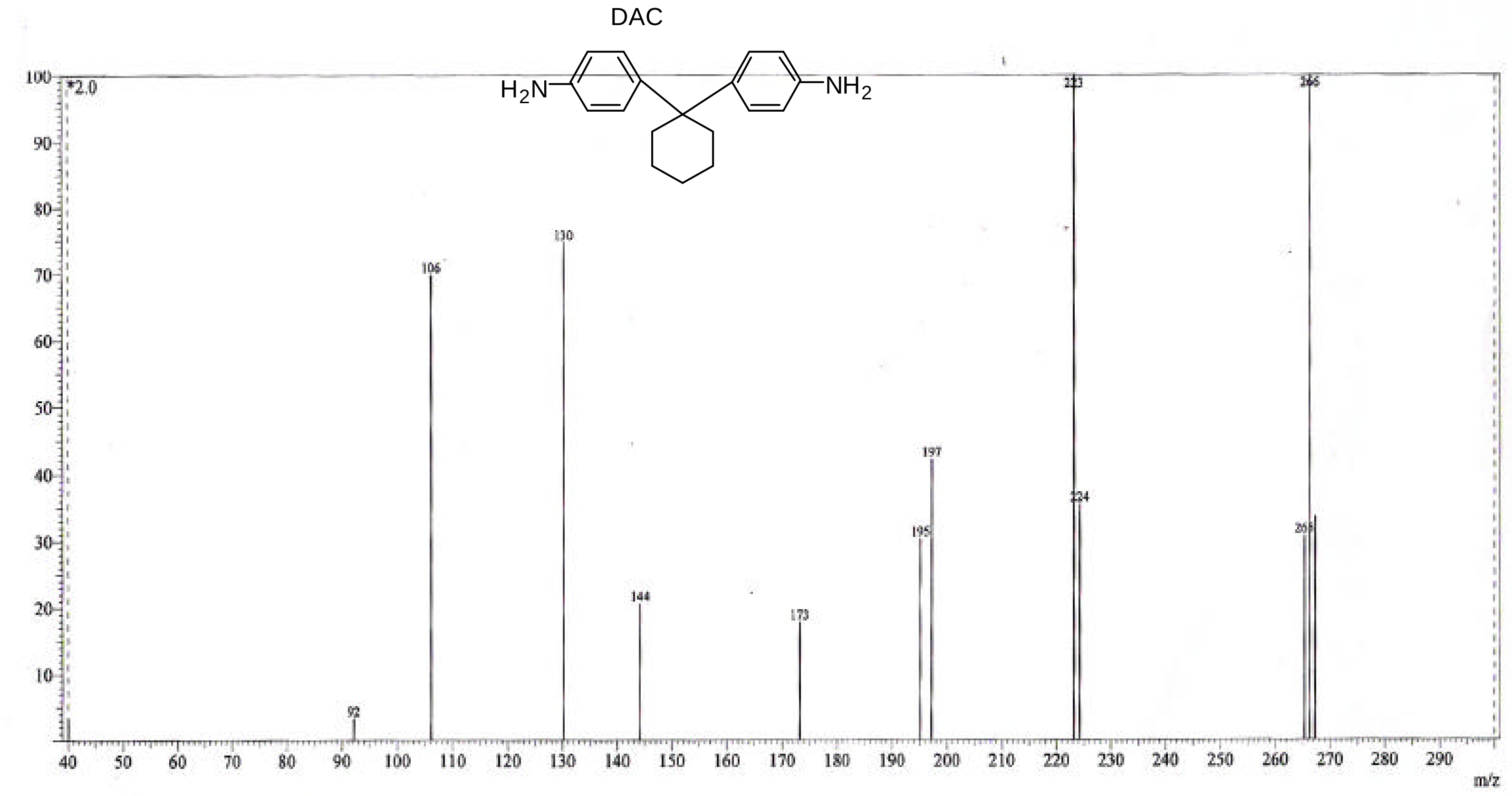


Fig.- 3.17 : Mass Spectrum (E.I.) of DAC

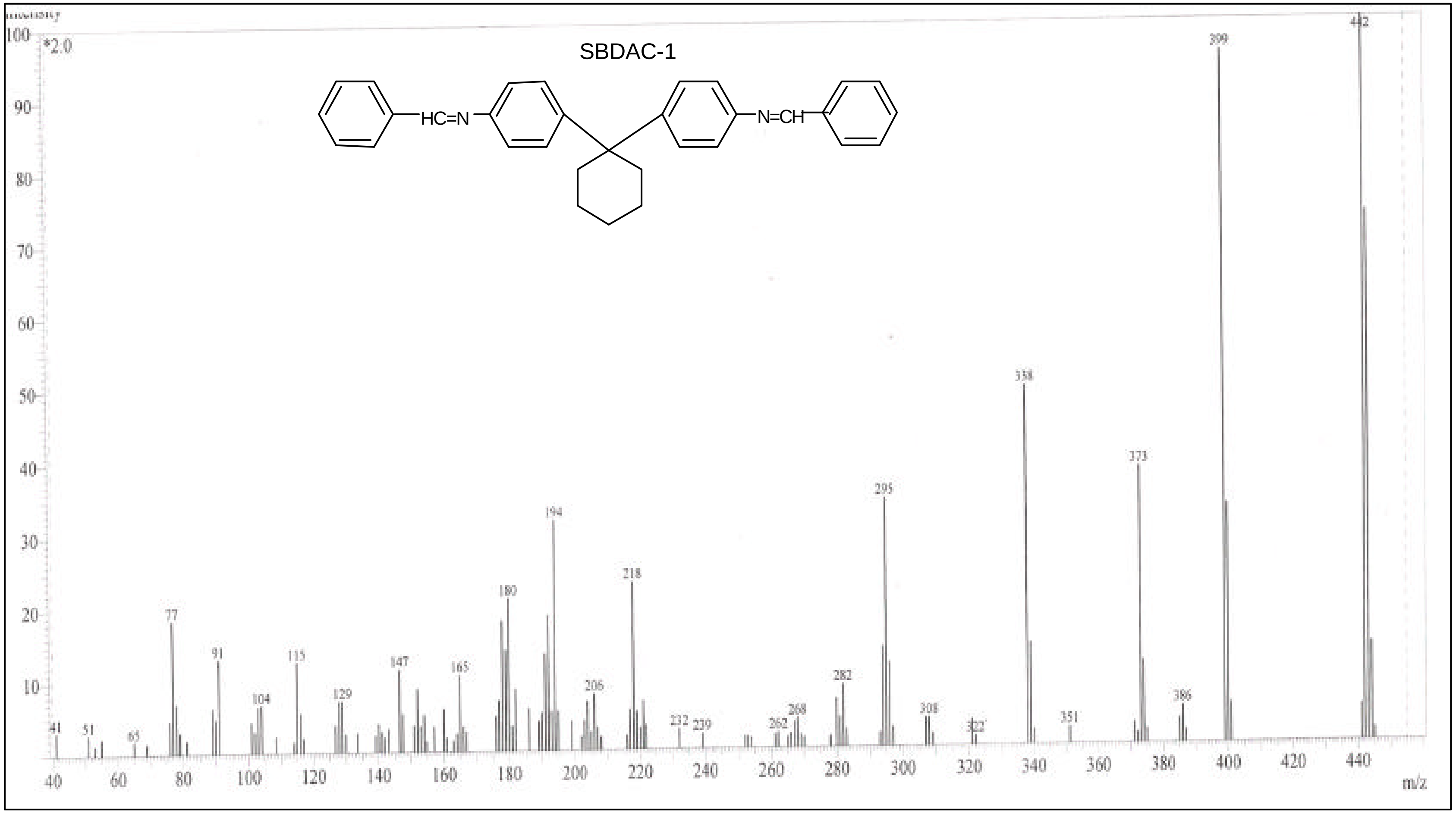


Fig.- 3.18 : **Mass Spectrum (E.I.) of SBDAC-1**

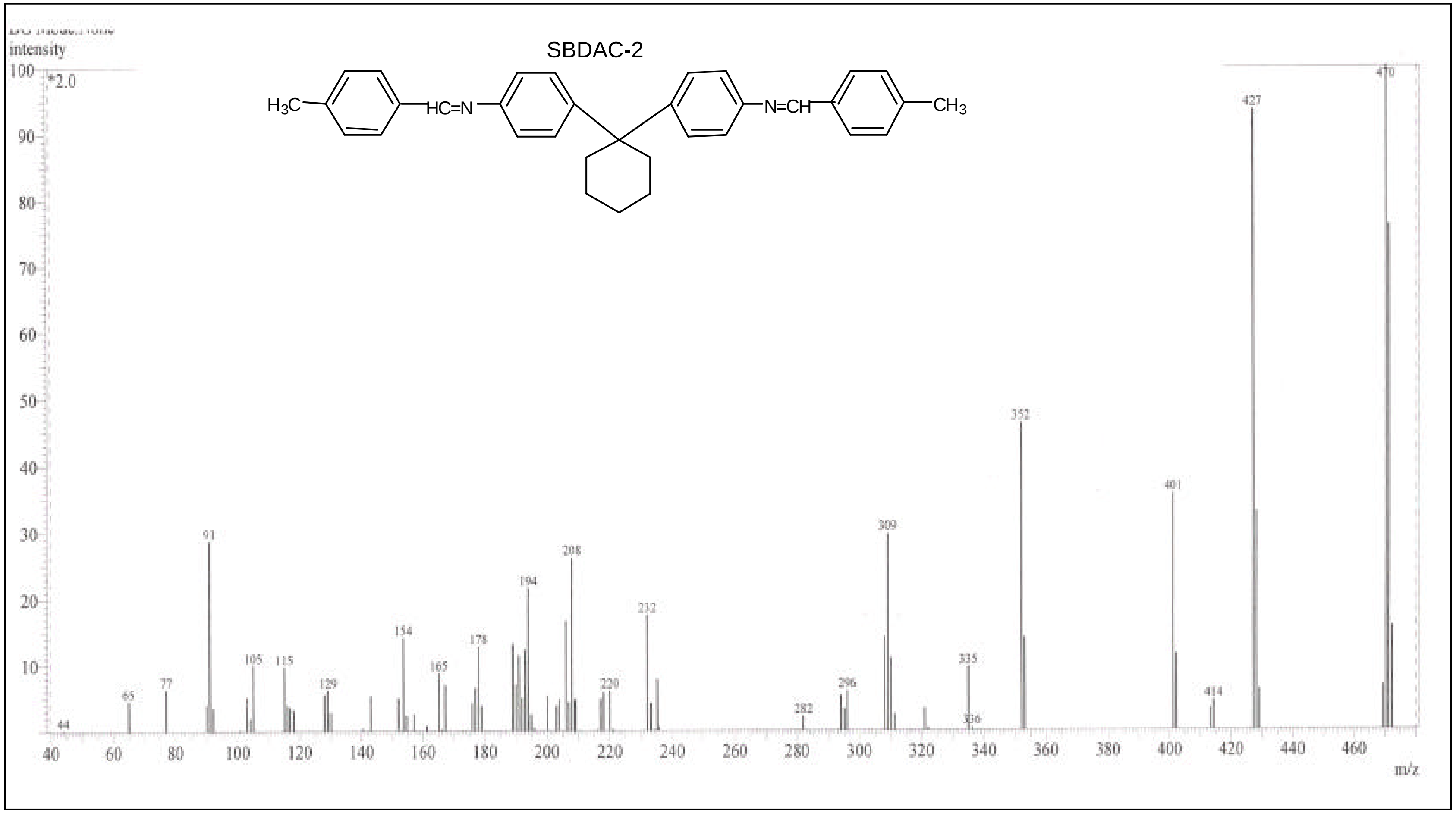


Fig.- 3.19 : Mass Spectrum (E.I.) of SBDAC-2

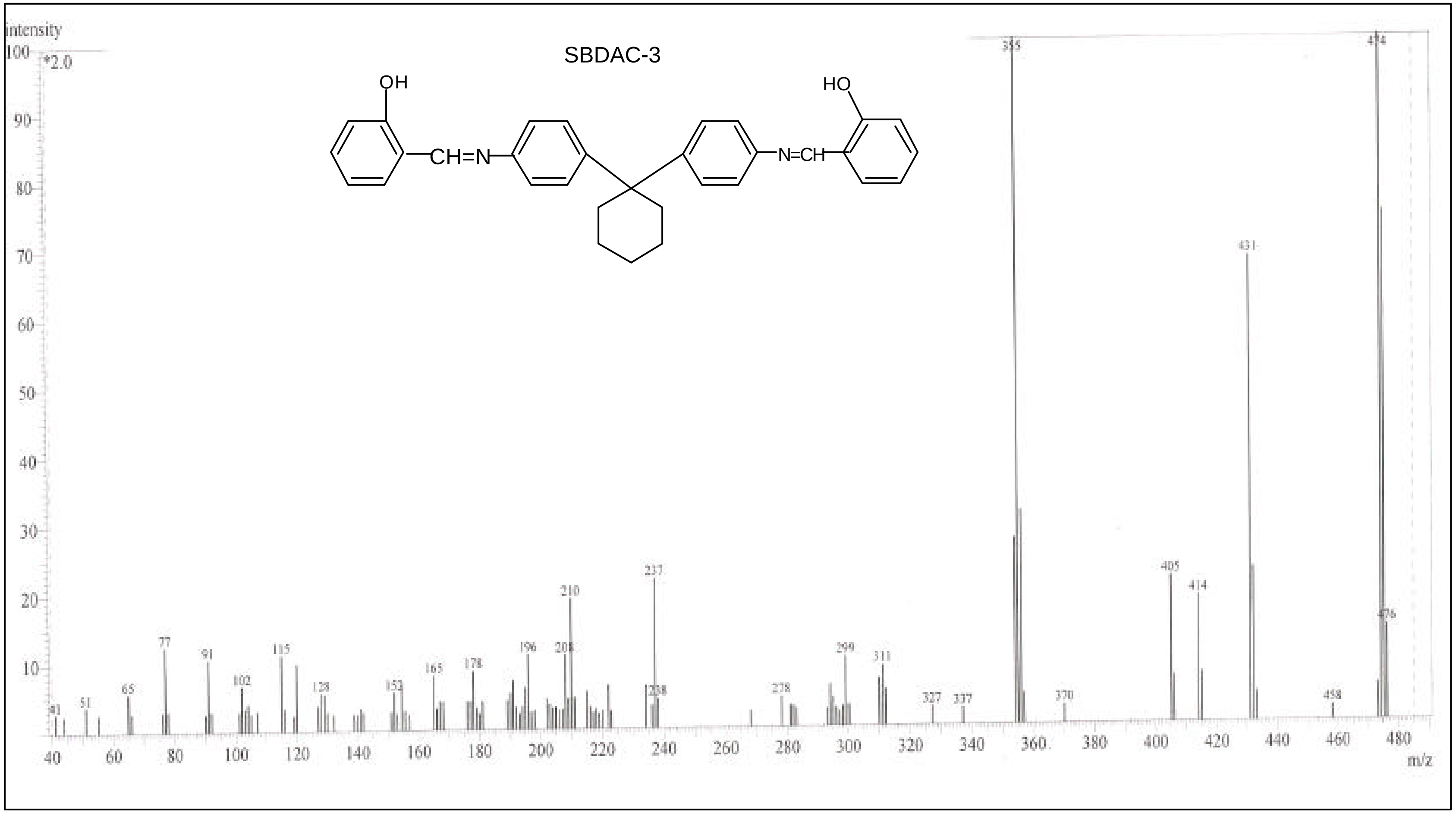


Fig.- 3.20 : Mass Spectrum(E.I.) of SBDAC-3

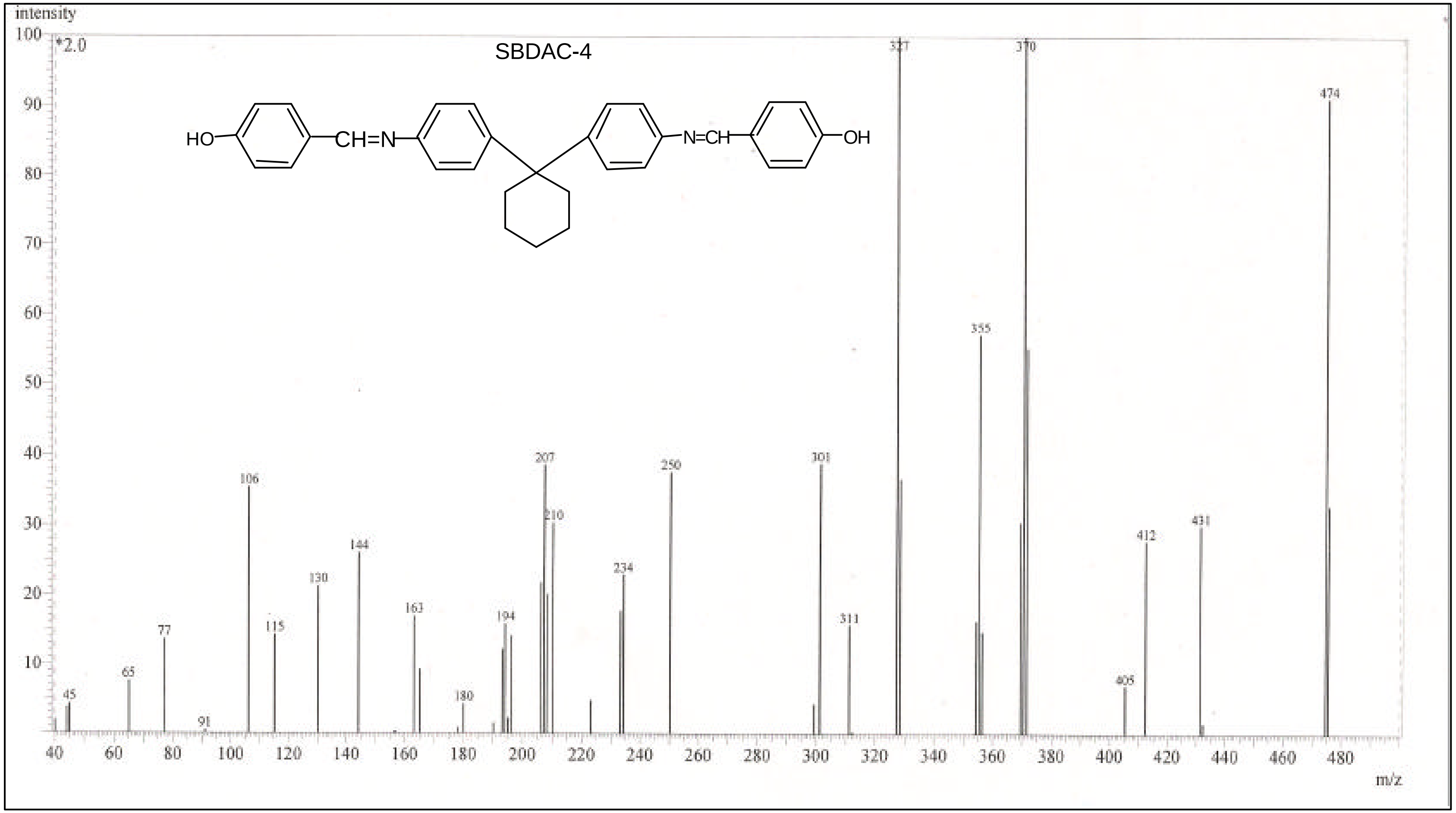


Fig.- 3.21 : Mass Spectrum (E.I.) of SBDAC-4

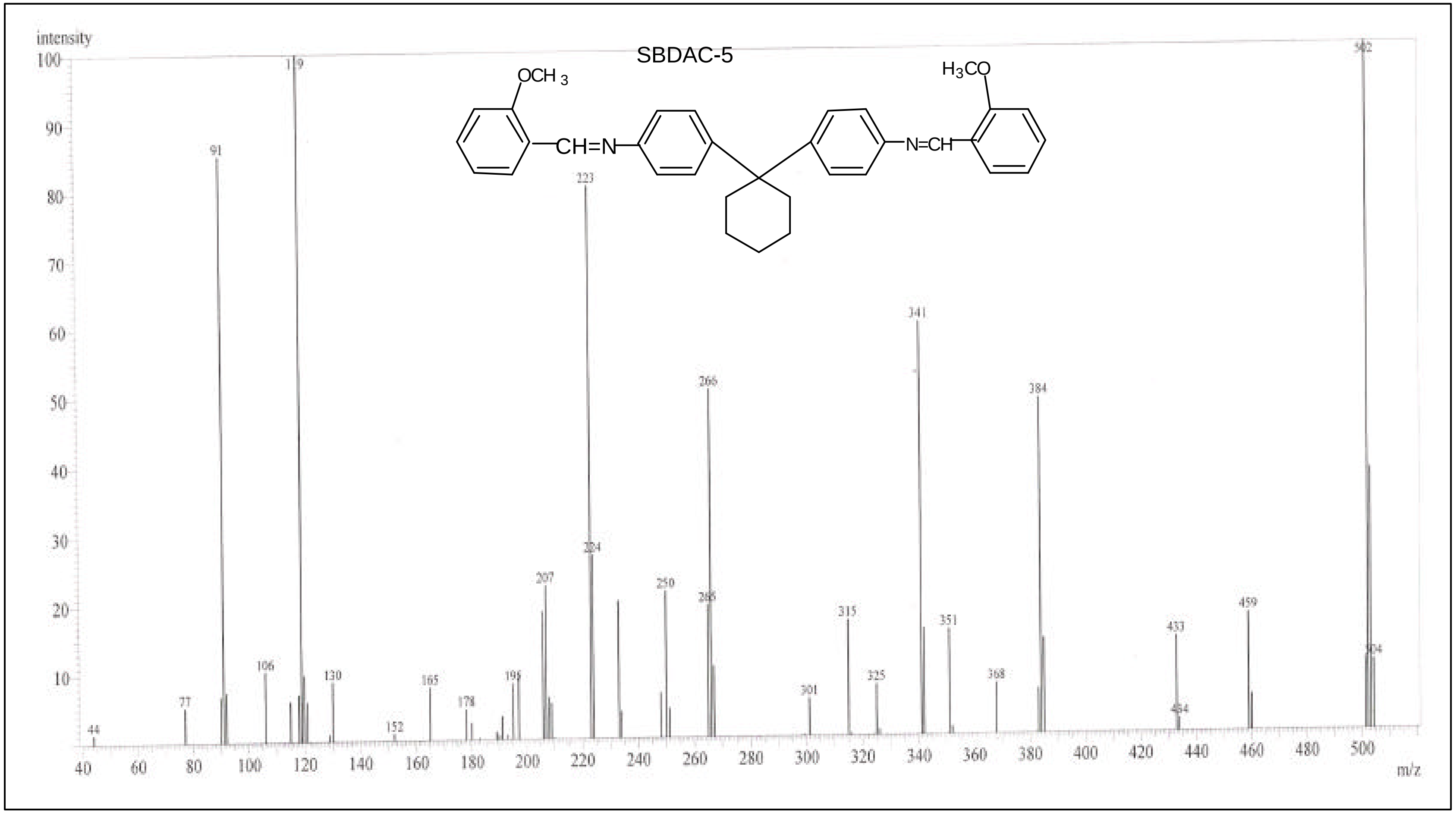


Fig.- 3.22 : Mass Spectrum (E.I.) of SBDAC-5

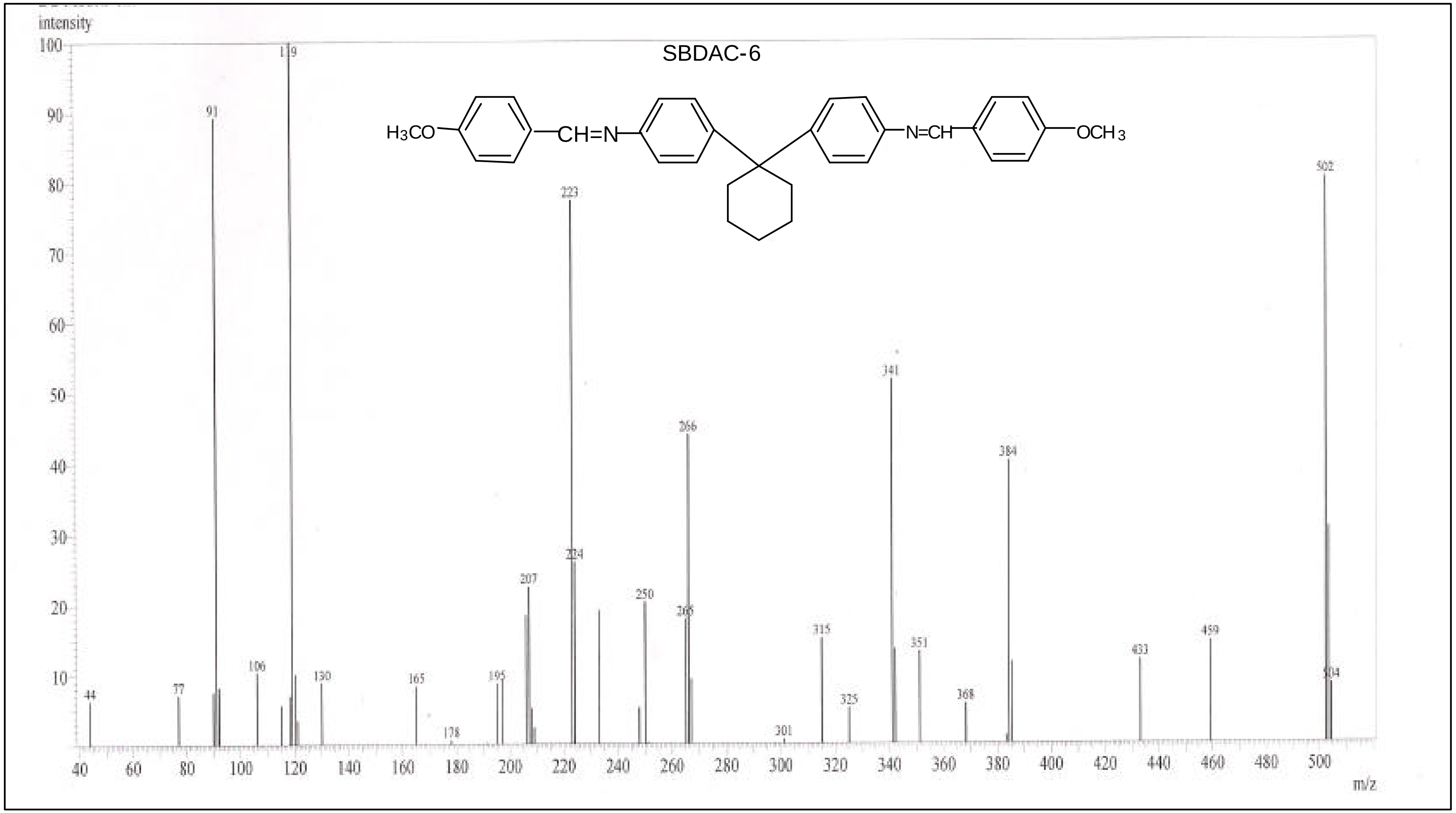


Fig.- 3.23 : Mass Spectrum (E.I.) of SBDAC-6

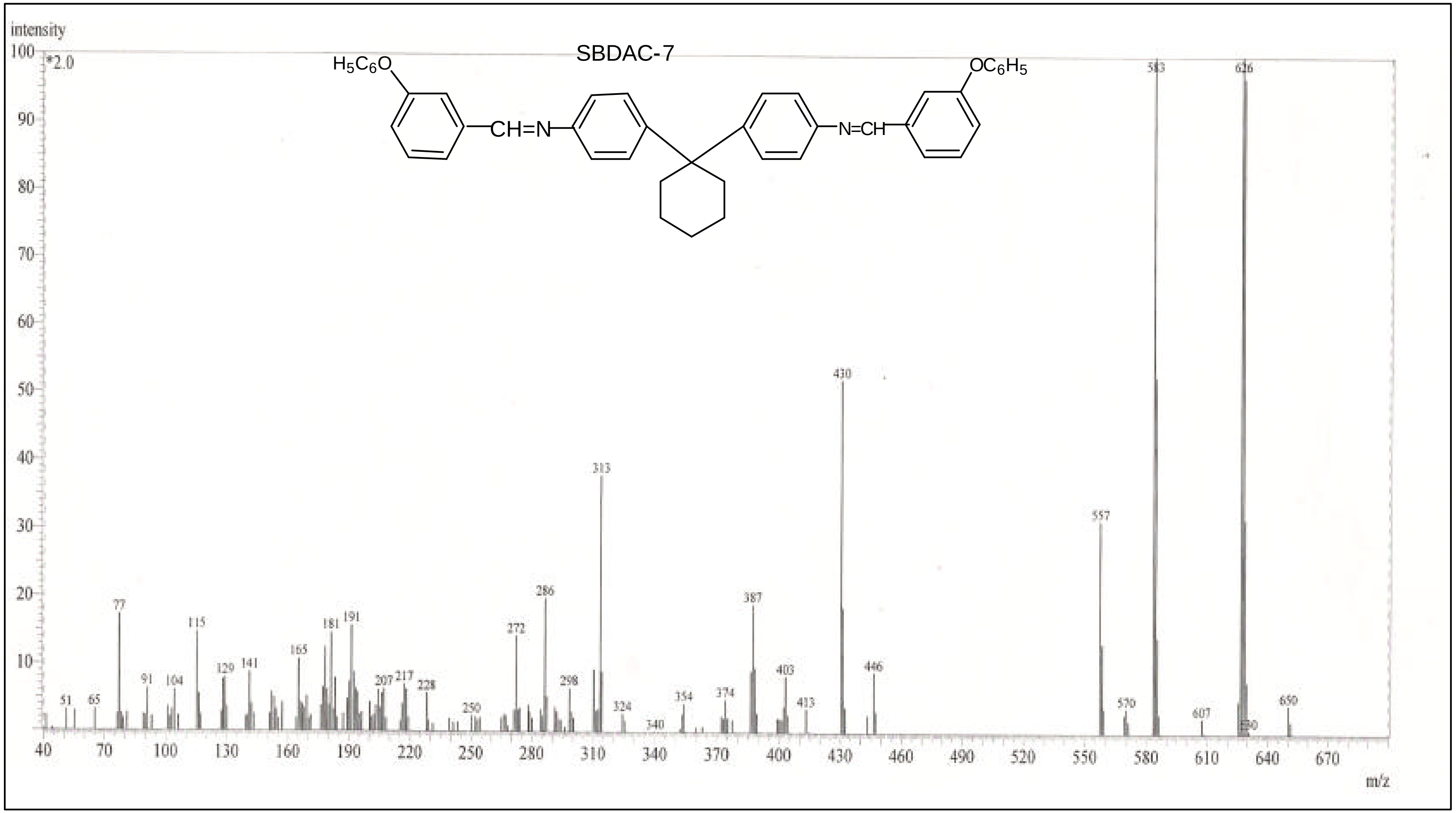


Fig.- 3.24 : Mass Spectrum (E.I.) of SBDAC-7

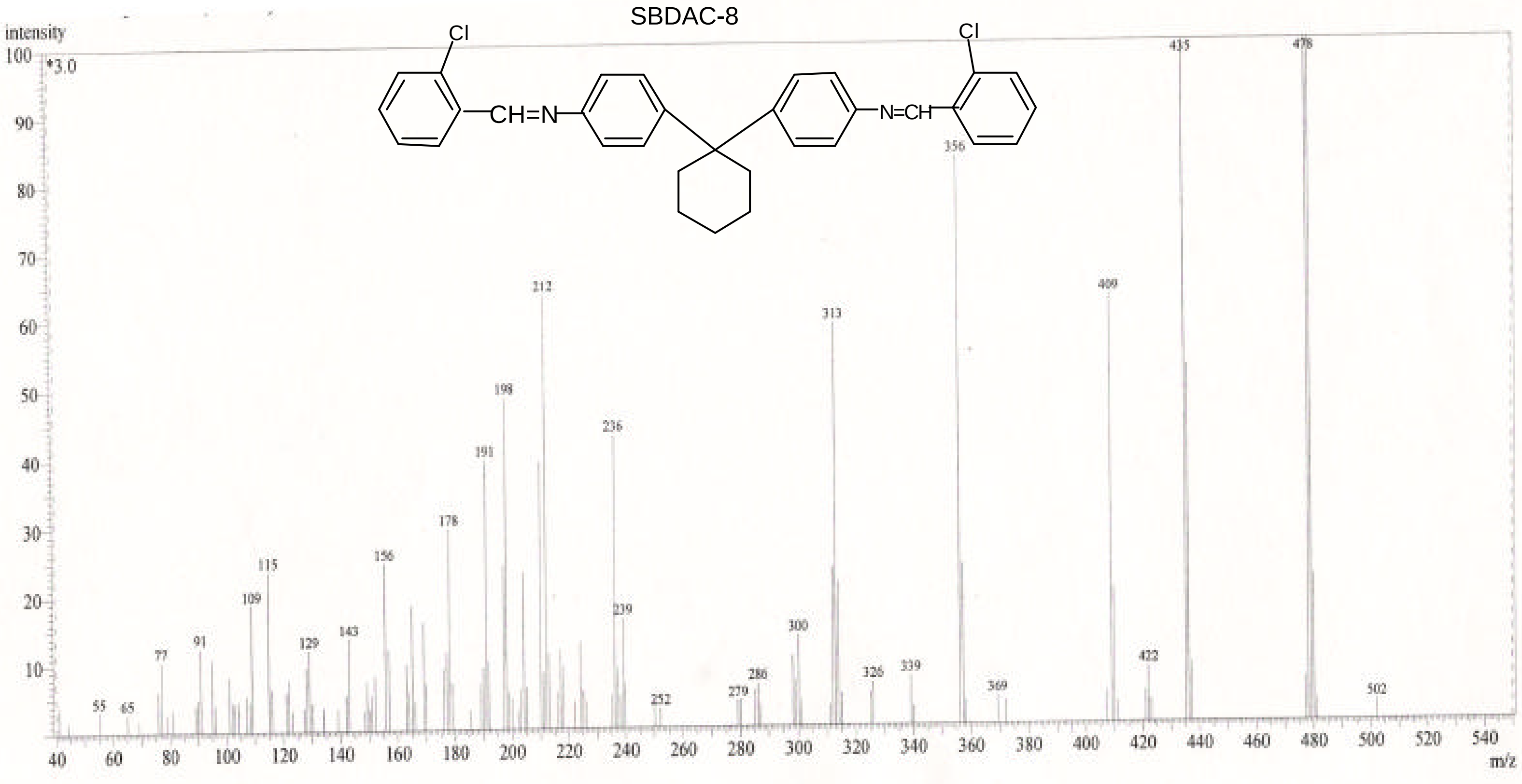


Fig.- 3.25 : Mass Spectrum (E.I.) of SBDAC-8

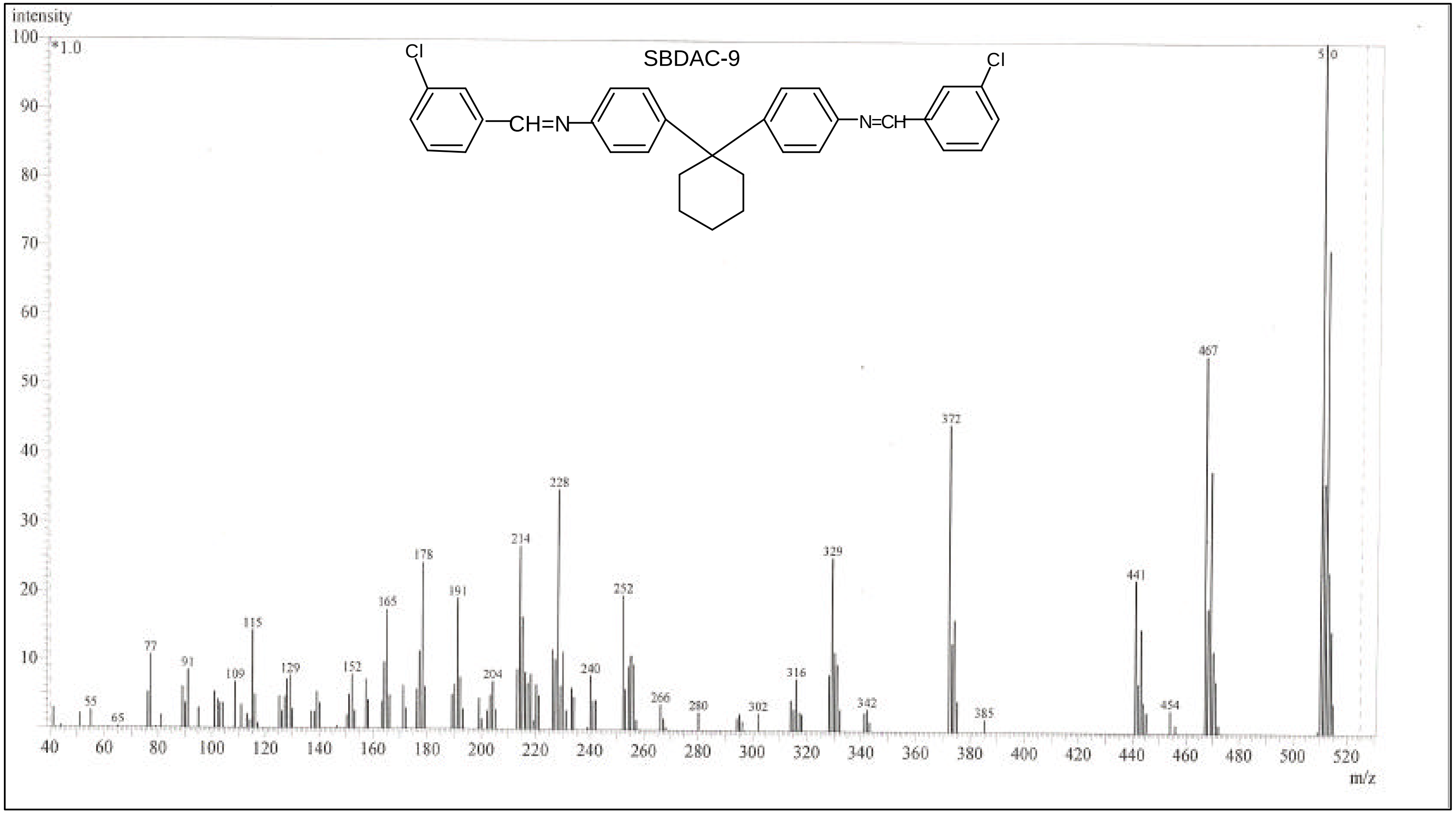


Fig.- 3.26 : Mass Spectrum of(E.I.) SBDAC-9

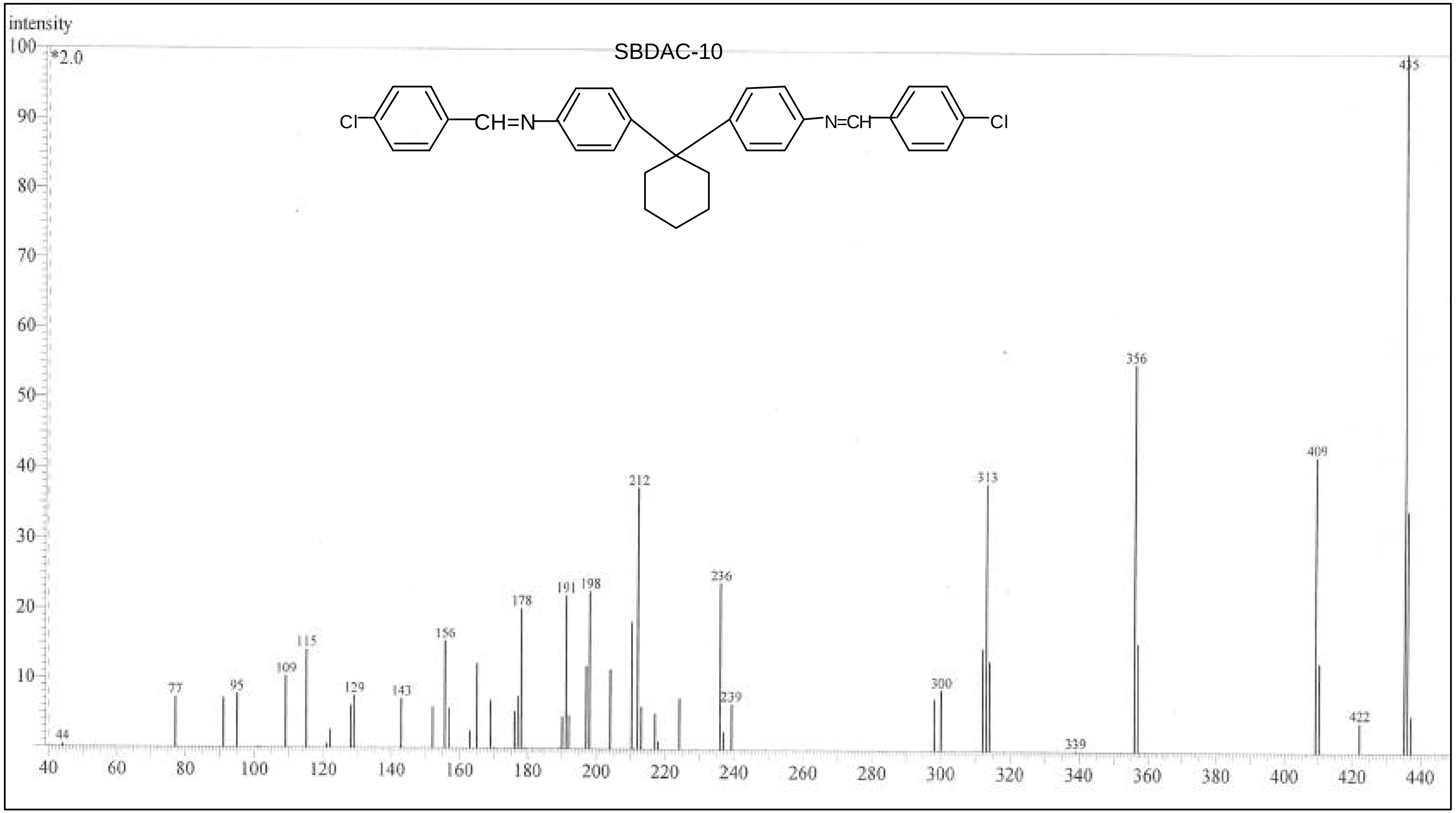


Fig.- 3.27 : Mass Spectrum(E.I.) of SBDAC-10

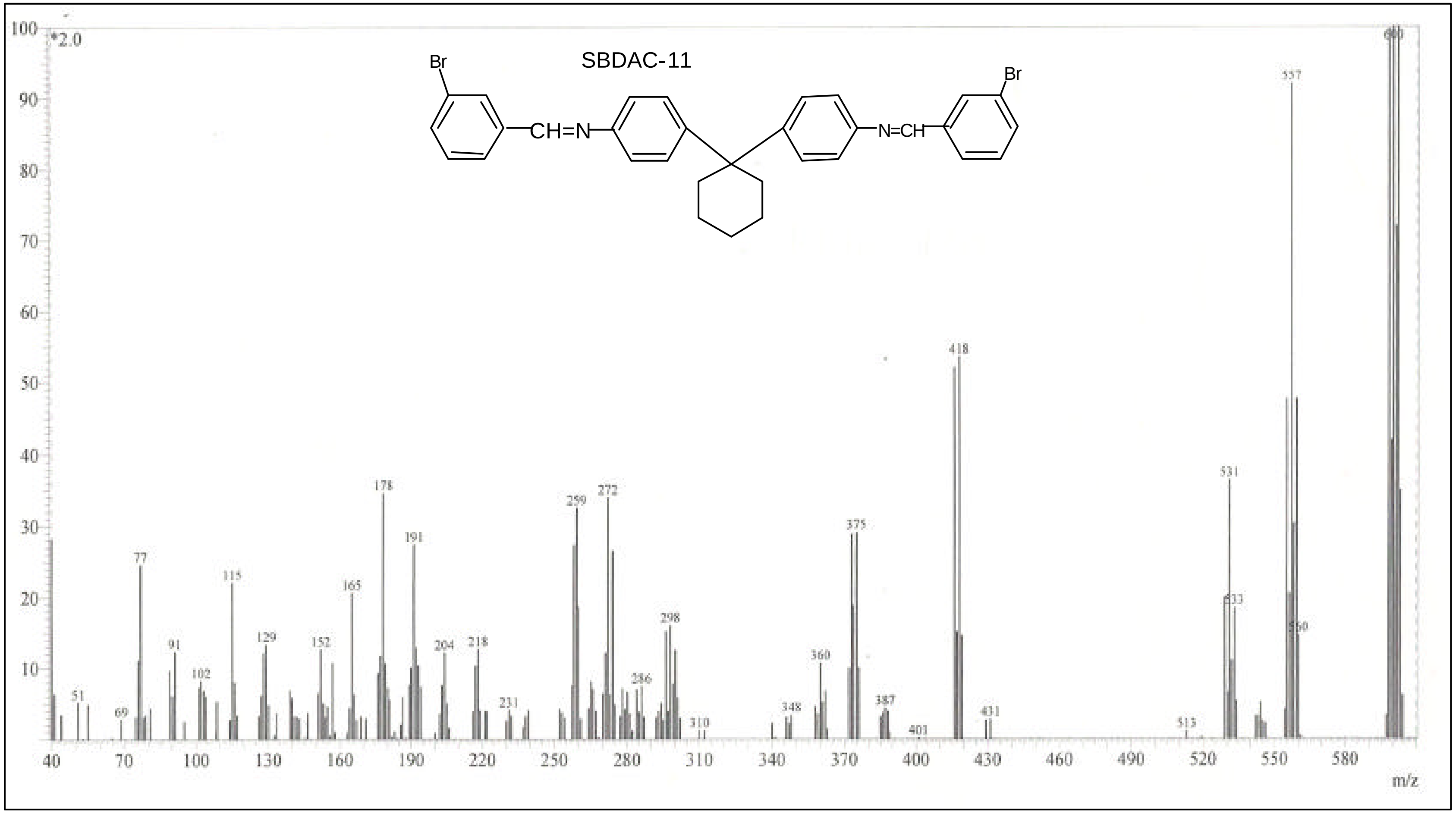


Fig.- 3.28 : Mass Spectrum(E.I.) of SBDAC-11

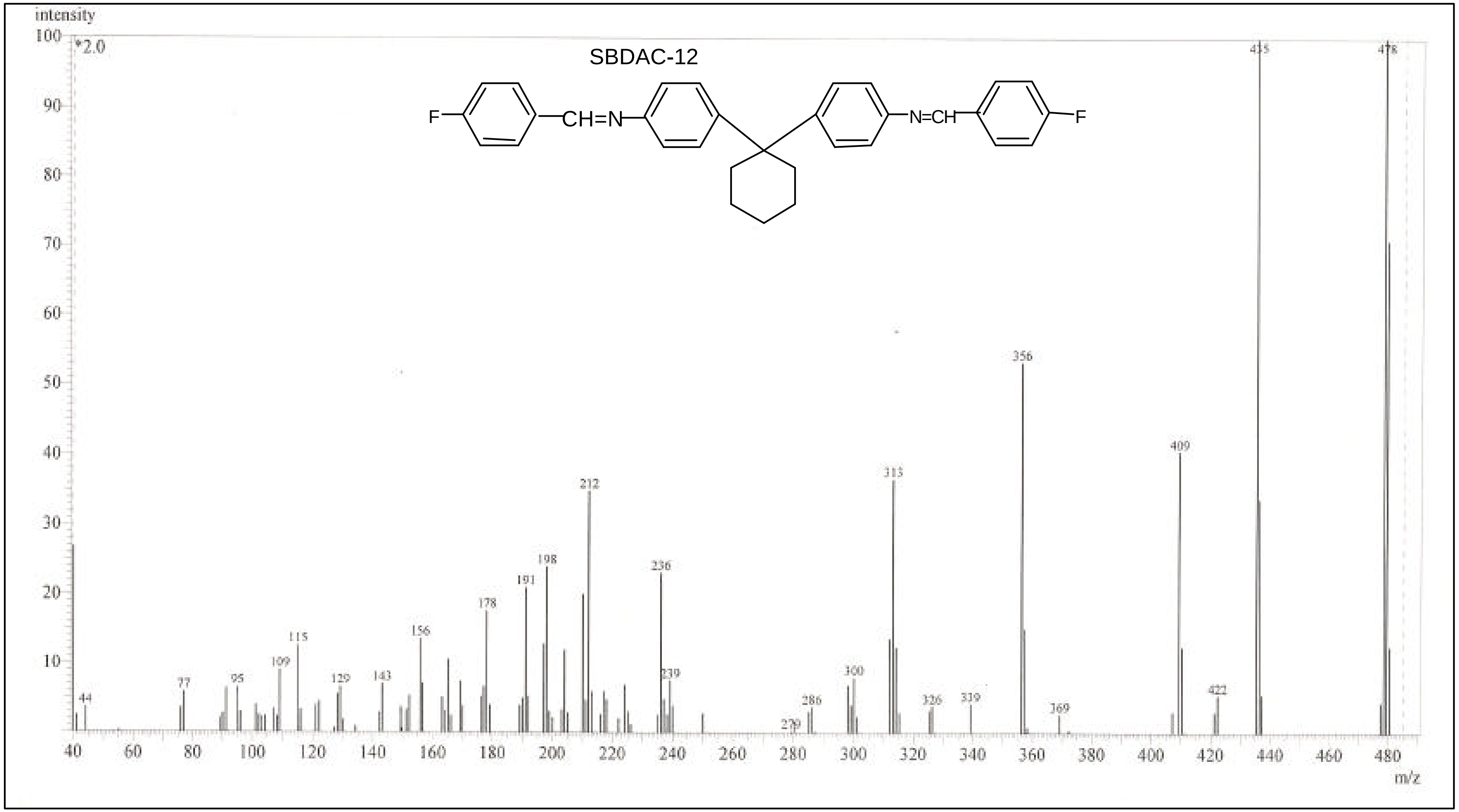


Fig.- 3.29 : Mass Spectrum(E.I.) of SBDAC-12

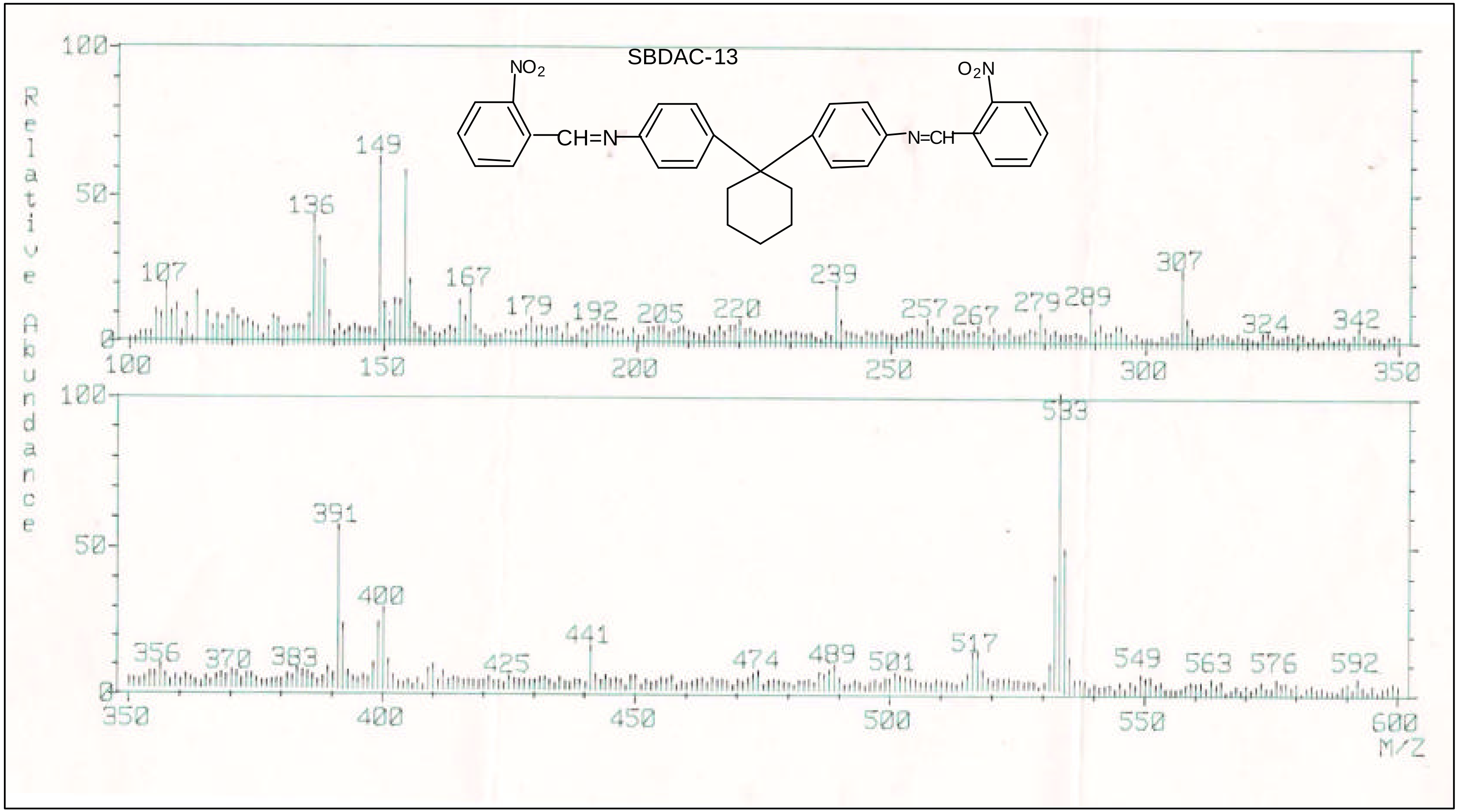


Fig.- 3.30 : Mass Spectrum(E.I.) of SBDAC-13

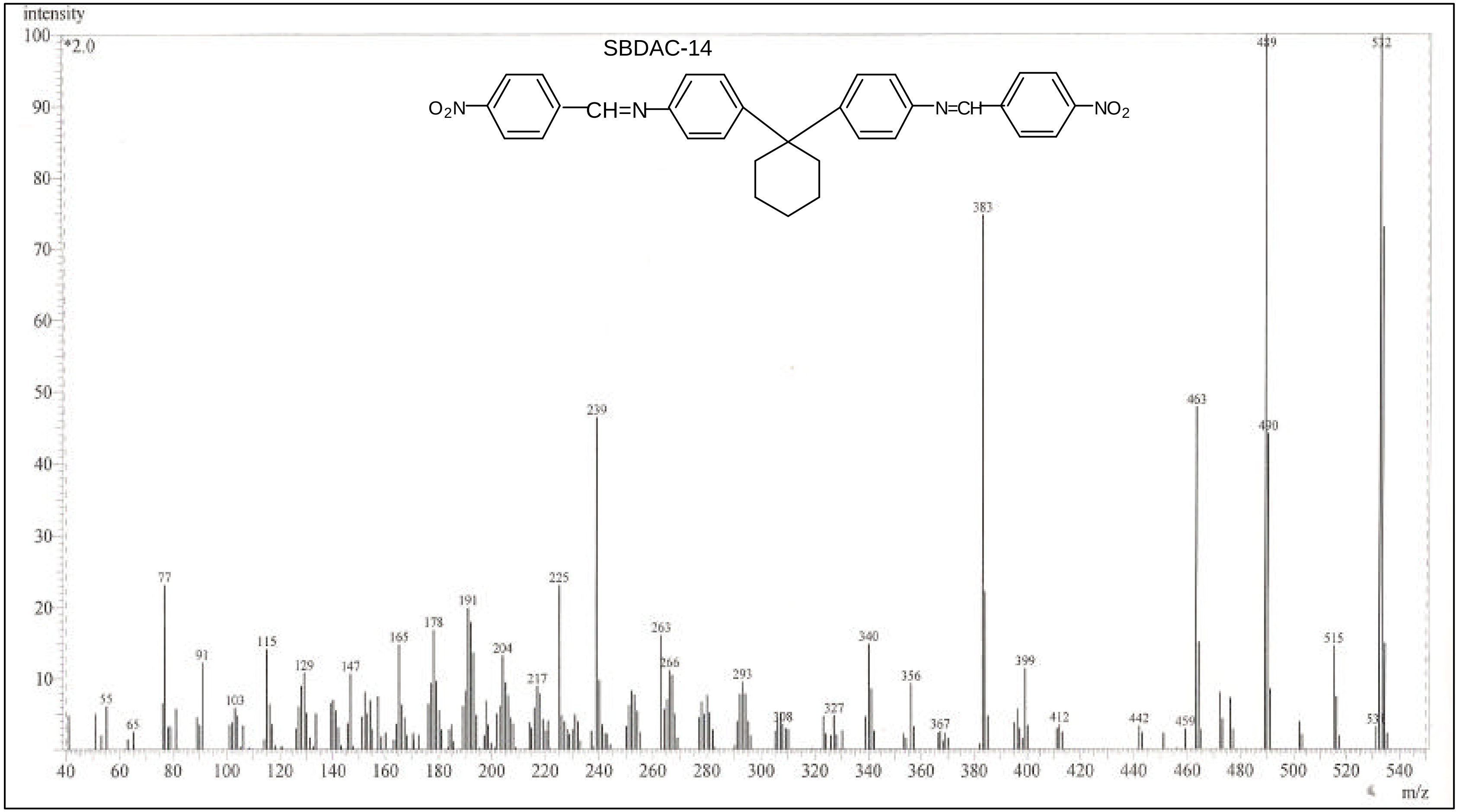


Fig.- 3.31 : Mass Spectrum(E.I.) of SBDAC-14

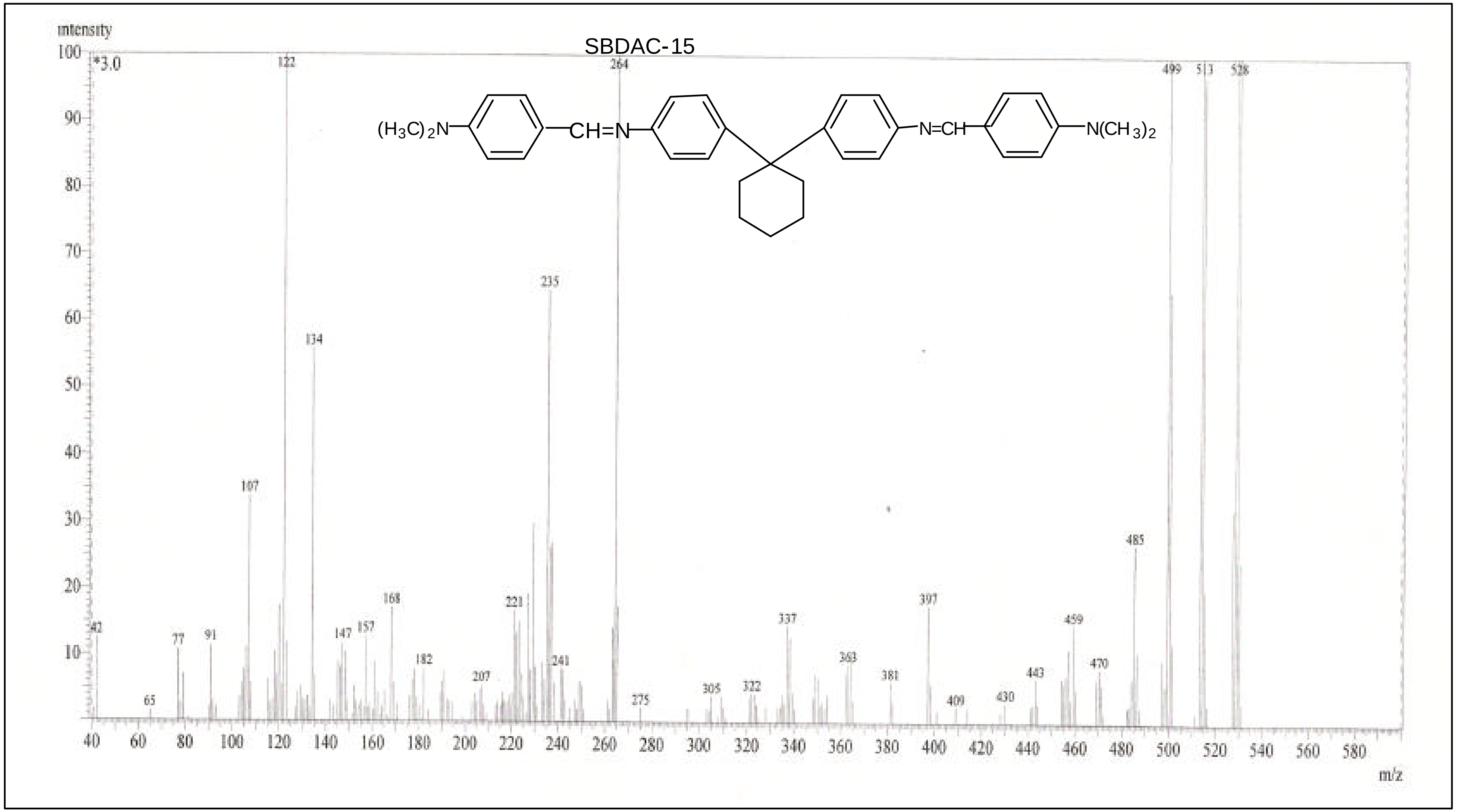


Fig.- 3.32 : Mass Spectrum(E.I.) of SBDAC-15

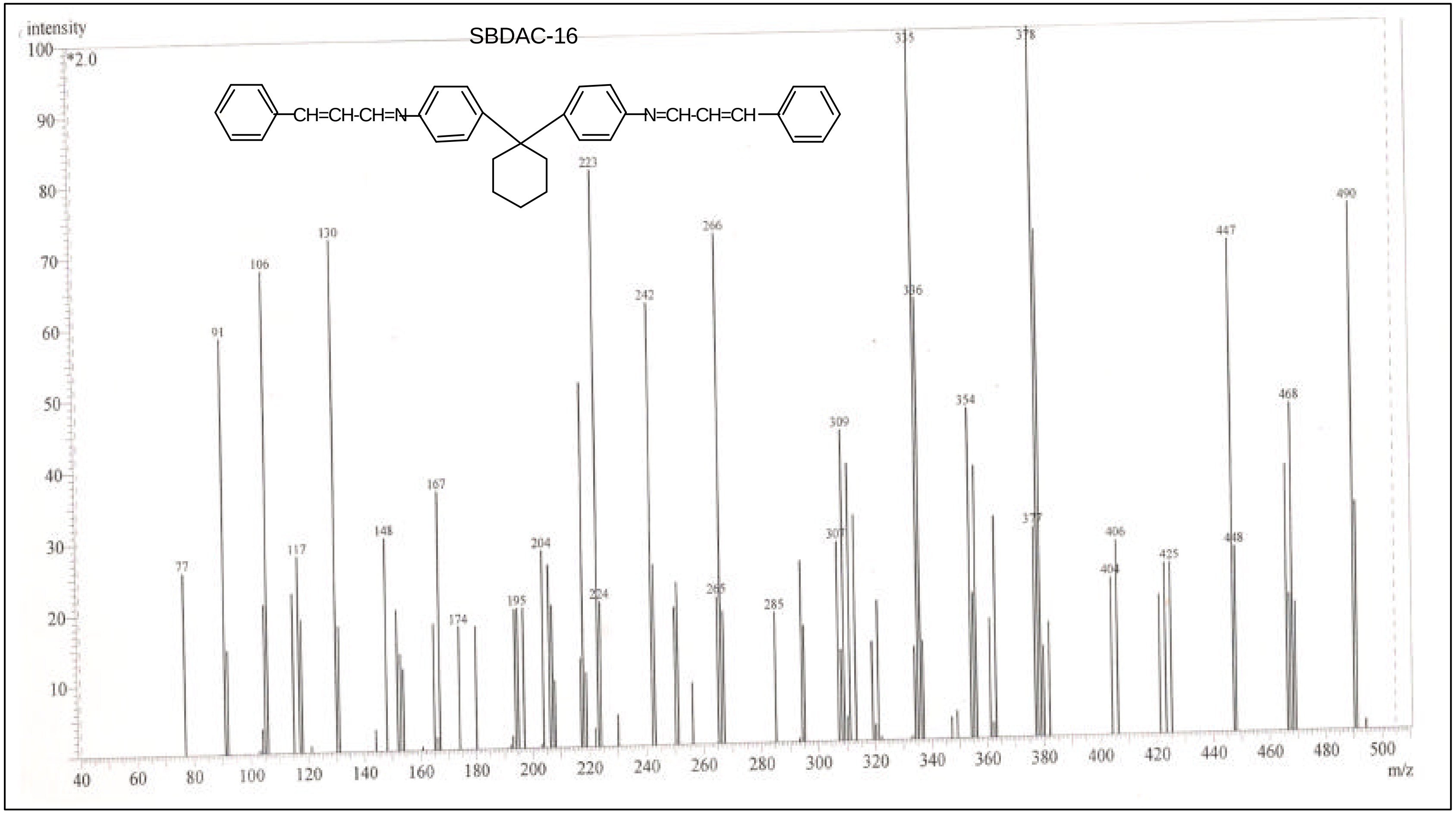


Fig.- 3.33 : Mass Spectrum(E.I.) of SBDAC-16

SECTION – 5: DENSITY MEASUREMENTS

This section of the thesis describes density measurements.

The density is an additive property and depends on intrinsic volume and molecular weight of the compound. In order to determine densities of schiff bases by specific volume method, a series of schiff base solutions were prepared in DMF and benzene at room temperature (~38^0C). Densities of solutions were determined by usual method and are reported in Table 3.10. Experimental densities are fitted to following equation:

$$\frac{1}{W_1 r_{12}} = \frac{1}{r_1} + \frac{W_2}{W_1 r_2} \qquad \text{... 3.2}$$

Where W_1 and W_2 are weight fractions of solvent and schiff bases, respectively $?_1$, $?_2$ and $?_{12}$ are the densities of solvent, schiff bases and solution, respectively. The least square densities along with correlation coefficient (?) are reported in Table 3.10 from which it is clear that density of a given schiff base is different in DMF and benzene .Eqn. 3.2 is valid only for ideal solution and for non ideal solution it may differ from actual value because of molecular interactions.

Discrepancy in experimental densities is mainly due to solvolysis. Schiff bases and solvents are structurally dissimilar. Schiff bases are polar compounds. .Azomethine, phenyl and other substituents groups of schiff bases interact with solvent molecules. Dipole- dipole interaction of the opposite type favors solvolysis, while of the same type disrupts the solvent structure formed around solute molecule and as a consequence both apparent molecular weight and volume of the molecule will change. Overall density of the solute will be decided by the predominant factor, i.e., apparent weight or volume. Thus, molecular interactions in the given solvent -solute system at a given temperature govern the density.

Table 3.10 Density of SBDAC-1 to 16 derived according to specific volume method.

Concen., mol/lit	Density, g cm^{-3}		Density, g cm^{-3}	
	Benzene	DMF	Benzene	DMF
	SBDAC-1		SBDAC-2	
0.01	0.818	0.944	0.820	0.944
0.02	0.821	0.946	0.825	0.947
0.04	0.826	0.948	0.829	0.949
0.06	0.829	0.951	0.831	0.952
0.08	0.833	0.952	0.835	0.954
0.1	0.836	0.954	0.838	0.956
	?$_{2}$ = 1.472 ? =0.996	?$_{2}$ = 1.249 ? =0.999	?$_{2}$ = 1.349 ? =0.993	?$_{2}$ = 1.294 ? =0.999
	SBDAC-3		SBDAC-4	
0.01	0.941	0.944	0.941	0.945
0.02	0.947	0.945	0.947	0.947
0.04	0.956	0.947	0.956	0.949
0.06	0.993	0.949	0.993	0.951
0.08	1.025	0.951	1.025	0.954
0.1	1.037	0.953	1.037	0.956
	?$_{2}$ = 1.358 ? =0.995	?$_{2}$ = 1.193 ? =1.000	?$_{2}$ = 1.358 ? =0.996	?$_{2}$ = 1.259 ? =0.999

Table 3.1 Continue…

Concen., mol/lit	Density, g cm $^{-3}$		Density, g cm $^{-3}$	
	Benzene	DMF	Benzene	DMF
	SBDAC-5		SBDAC-6	
0.01	0.835	0.944	0.825	0.949
0.02	0.837	0.946	0.827	0.953
0.04	0.840	0.949	0.835	0.956
0.06	0.845	0.955	0.839	0.959
0.08	0.848	0.959	0.842	0.962
0.1	0.85	0.963	0.849	0.963
	?$_{2\,=}$ 1.272 ? =0.998	?$_{2\,=}$ 1.652 ? =0.998	?$_{2\,=}$ 1.701 ? =0.990	?$_{2\,=}$ 1.356 ? =0.996
	SBDAC-7		SBDAC-8	
0.01	0.835	0.951	0.834	0.950
0.02	0.838	0.954	0.840	0.954
0.04	0.841	0.959	0.842	0.957
0.06	0.846	0.962	0.843	0.96
0.08	0.850	0.964	0.844	0.962
0.1	0.855 ?$_{2\,=}$ 1.275 ? =0.999	0.967 ?$_{2\,=}$ 1.308 ? =0.998	0.847 ?$_{2\,=}$ 1.079 ? =0.992	0.964 ?$_{2\,=}$ 1.331 ? =0.996

Table 3.1 Continue…

Concen., mol/lit	Density, g cm $^{-3}$		Density, g cm $^{-3}$	
	Benzene	DMF	Benzene	DMF
	SBDAC-9		SBDAC-10	
0.01	0.825	0.949	0.831	0.952
0.02	0.828	0.952	0.833	0.956
0.04	0.833	0.956	0.839	0.959
0.06	0.836	0.96	0.841	0.961
0.08	0.839	0.963	0.845	0.963
0.1	0.844	0.966	0.847	0.964
	?$_{2}$ = 1.354 ? =0.998	?$_{2}$ = 1.491 ? =0.998	?$_{2}$ = 1.280 ? =0.996	?$_{2}$ = 1.258 ? =0.996
	SBDAC-11		SBDAC-12	
0.01	0.833	0.953	0.813	0.950
0.02	0.834	0.957	0.818	0.954
0.04	0.839	0.96	0.822	0.956
0.06	0.843	0.964	0.83	0.959
0.08	0.847	0.967	0.834	0.963
0.1	0.851	0.969	0.838	0.965
	?$_{2}$ = 1.262 ? =0.999	?$_{2}$ = 1.337 ? =0.998	?$_{2}$ = 1.921 ? =0.985	?$_{2}$ = 1.425 ? =0.997

Table 3.1 Continue…

Concen., mol/lit	Density, g cm $^{-3}$		Density, g cm $^{-3}$	
	Benzene	DMF	Benzene	DMF
	SBDAC-13		SBDAC-14	
0.01	0.824	0.954	0.822	0.956
0.02	0.827	0.957	0.826	0.958
0.04	0.832	0.961	0.831	0.961
0.06	0.838	0.963	0.836	0.964
0.08	0.844	0.965	0.842	0.966
0.1	0.85	0.968	0.849	0.969
	$?_2 =$ 1.790 ? =0.999	$?_2 =$ 1.312 ? =0.998	$?_2 =$ 1.793 ? =0.999	$?_2 =$ 1.298 ? =0.999
	SBDAC-15		SBDAC-16	
0.01	0.823	0.95	0.822	0.953
0.02	0.826	0.953	0.827	0.955
0.04	0.829	0.957	0.832	0.957
0.06	0.832	0.96	0.836	0.959
0.08	0.841	0.963	0.843	0.962
0.1	0.848	0.965	0.848	0.963
	$?_2 =$ 1.665 ? =0.978	$?_2 =$ 1.377 ? =0.998	$?_2 =$ 1.665 ? =0.978	$?_2 =$ 1.229 ? =0.999

SECTION – 6: Refractive index measurements.

Refractive index is a property of the material and is extremely useful in chemical analysis and process control. The determination of the oil content of oil-bearing seeds is an interesting application of refractometry. It is a convenient and precise tool to determining the sulfur content of rubber [15]**.** It is also applicable in the determination of the efficiency of distillation columns. Refractive-index measurements are useful for the control of manufacturing processes such as in the fermentation industries, in dyestuffs and in the canning and preservation of foods, and also useful for identification or assaying some solid, liquid or constituent of a solution. It also offers a positive means for the identification of crystalline substances [16]. Molar refraction is of great importance for the calculation of dipole moment.

Refractive index is also an additive property. In the present work efforts have been made to determine the refractive index of schiff bases. R.I. measurements were made on pyknometer and Abbe refractometer. R. I. of schiff base solutions is determined at room temperature (~38^0C) and discussed in light of structural aspects. The molar refractions (M_{RD}) of pure liquid solutions can be determined according to Lorentz and Lorenz equation.

$$\left(M_{R_D}\right) = \frac{n^2 - 1}{n^2 + 2} . \frac{M}{?} \quad \text{... 3.3} \qquad \left(M_{R_D}\right)_{12} = \frac{n_{12}^2 - 1}{n_{12}^2 + 2} . \frac{X_1M_1 + X_2M_2}{?_{12}} \quad \text{... 3.4}$$

Where n_{12} and $?_{12}$ are R.I. and density of the solutions, respectively X_1 and X_2 are molar refractions of solvent and solute respectively. M_1 and M_2 are molecular weight of solvent and solute, respectively. From the density and refractive index data on SBDAC-1 to 16 solutions in benzene and DMF at 38^0C, the molar refraction of schiff bases at specified compositions were determined according Eqn. 3.3 and Eqn.3.4 and were plotted against concentration of solute. From the least square analysis the values of molar refractions were determined from the intercepts (Table-3.1).

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15 A.T. Mc-Phenson and A.D. Cummings, J. Research Natl. Bur. Standards, **14**, 553 (1935).

16 F.E. Wright, J. Am. Chem. Soc., **38**, 1647 (1916).

Table 3.13 Refractive index and molar refractions data of SBDAC-1 to 16

Conc., mol/lit	Benzene			DMF		
	?, gcm^{-3}	R.I.	M_{R_D}	?, gcm^{-3}	R.I.	M_{R_D}
	SBDAC-1			SBDAC-1		
0.01	0.818	1.512	26.942	0.944	1.556	24.986
0.02	0.821	1.535	27.985	0.946	1.563	25.290
0.04	0.826	1.556	28.996	0.948	1.585	26.248
0.06	0.829	1.582	30.287	0.951	1.602	26.992
0.08	0.833	1.609	31.573	0.952	1.623	27.939
0.1	0.36	1.644	33.216	0.954	1.653	29.175
	M_{R_D} = 681.27C + 26.418 ? =0.998			M_{R_D} = 573.51C + 24.43 ? =0.997		
	SBDAC-2			SBDAC-2		
0.01	0.821	1.523	27.337	0.944	1.512	23.331
0.02	0.825	1.548	28.430	0.947	1.535	24.231
0.04	0.829	1.572	29.615	0.949	1.564	25.476
880.06	0.831	1.598	30.954	0.952	1.598	26.866
0.08	0.835	1.623	32.170	0.954	1.623	27.947
0.1	0.838	1.645	33.297	0.956	1.644	28.881
	M_{R_D} = 660.64 C + 26.990 ? =0.997			M_{R_D} = 770.42C + 22.975 ? = 0.996		
	SBDAC-3			SBDAC-3		
0.01	0.823	1.534	27.750	0.944	1.543	24.509
0.02	0.832	1.556	28.532	0.945	1.568	25.519
0.04	0.846	1.584	29.511	0.947	1.596	26.713
0.06	0.868	1.617	30.361	0.949	1.631	28.150
0.08	0.884	1.649	31.332	0.951	1.642	28.727
0.1	0.899	1.682	32.329	0.953	1.664	29.697
	M_{R_D} = 544.72C + 27.374 ? = 0.998			M_{R_D} = 701.46 C + 24.345 ? = 0.988		

Tables 3.13 Conti……

Conc., mol/lit	Benzene			DMF		
	?, gcm^{-3}	R.I.	M_{R_D}	?, gcm^{-3}	R.I.	M_{R_D}
	SBDAC-4			SBDAC-4		
0.01	0.823	1.533	27.707	0.944	1.541	24.434
0.02	0.832	1.545	28.064	0.947	1.568	25.465
0.04	0.846	1.586	29.593	0.949	1.588	26.365
0.06	0.868	1.618	30.400	0.951	1.615	27.518
0.08	0.884	1.634	30.755	0.954	1.634	28.350
0.1	0.899	1.658	31.435	0.956	1.659	29.424
	M_{R_D} = 466.31 C + 27.437 ? = 0.979			M_{R_D} = 662.86C + 24.217 ? = 0.995		
	SBDAC-5			SBDAC-5		
0.01	0.835	1.573	29.002	0.944	1.595	26.429
0.02	0.837	1.604	30.367	0.948	1.614	27.117
0.04	0.840	1.632	31.728	0.949	1.642	28.329
0.06	0.845	1.654	32.766	0.955	1.683	29.826
0.08	0.848	1.672	33.726	0.959	1.701	30.584
0.1	0.850	1.709	35.469	0.963	1.716	31.241
	M_{R_D} =638.02C + 28.797 ? = 0.991			M_{R_D} = 690.67C + 26.106 ? = 0.989		
	SBDAC-6			SBDAC-6		
0.01	0.825	1.572	29.314	0.949	1.589	26.073
0.02	0.827	1.591	30.201	0.953	1.604	26.619
0.04	0.835	1.628	31.761	0.956	1.632	27.769
0.06	0.839	1.649	32.809	0.959	1.644	28.356
0.08	0.842	1.673	34.016	0.962	1.668	29.362
0.1	0.849	1.709	35.512	0.963	1.699	30.668
	M_{R_D} = 686.25 C + 28.854 ? =0.997			M_{R_D} = 614.20C + 25.646 ? = 0.996		

Tables 3.13 Conti……

Conc., mol/lit	Benzene			DMF		
	?, gcm-^{3}	R.I.	M_{R_D}	?, gcm-^{3}	R.I.	M_{R_D}
	SBDAC-7			SBDAC-7		
0.01	0.835	1.571	28.965	0.944	1.575	25.736
0.02	0.838	1.592	29.937	0.947	1.596	26.571
0.04	0.841	1.616	31.246	0.949	1.614	27.484
0.06	0.846	1.639	32.443	0.952	1.631	28.338
0.08	0.850	1.652	33.283	0.954	1.652	29.374
0.1	0.855	1.674	34.451	0.956	1.654	29.741
	M_{R_D} = 602.11C +28.718 ? = 0.994			M_{R_D} = 547.20C + 25.612 ? = 0.988		
	SBDAC-8			SBDAC-8		
0.01	0.834	1.561	28.539	0.950	1.512	23.193
0.02	0.840	1.570	28.869	0.954	1.535	24.073
0.04	0.842	1.592	30.042	0.957	1.564	25.030
0.06	0.843	1.602	30.763	0.960	1.598	26.707
0.08	0.845	1.616	31.622	0.962	1.623	27.804
0.1	0.847	1.628	32.408	0.964	1.644	28.759
	M_{R_D} = 446.37C + 28.159 ? = 0.997			M_{R_D} = 776.69C + 22.818 ? = 0.996		
	SBDAC-9			SBDAC-9		
0.01	0.825	1.532	27.609	0.949	1.542	24.351
0.02	0.828	1.546	28.271	0.952	1.568	25.350
0.04	0.833	1.564	29.193	0.956	1.593	26.391
0.06	0.836	1.585	30.316	0.960	1.632	27.921
0.08	0.839	1.592	30.852	0.963	1.656	28.938
0.1	0.844	1.617	32.073	0.966	1.689	30.259
	M_{R_D} = 488.37C + 27.277 ? = 0.996			M_{R_D} = 806.7C + 23.926 ? = 0.998		

Tables 3.13 Conti……

Conc., mol/lit	Benzene			DMF		
	?, gcm-^{3}	R.I.	M_{R_D}	?, gcm-^{3}	R.I.	M_{R_D}
	SBDAC-10			SBDAC-10		
0.01	0.831	1.546	28.001	0.950	1.532	23.951
0.02	0.833	1.562	28.778	0.954	1.564	25.150
0.04	0.839	1.589	30.027	0.957	1.595	26.435
0.06	0.841	1.602	30.839	0.960	1.618	27.425
0.08	0.845	1.628	32.115	0.962	1.637	28.302
0.1	0.847	1.631	32.531	0.964	1.664	29.462
	M_{R_D} = 523.74C + 27.780 ? = 0.995			M_{R_D} = 725.39C + 23.840 ? =0.990		
	SBDAC-11			SBDAC-11		
0.01	0.828	1.546	28.142	0.953	1.512	23.141
0.02	0.834	1.562	28.809	0.957	1.535	24.040
0.04	0.839	1.589	30.167	0.960	1.564	25.319
0.06	0.843	1.602	30.979	0.964	1.598	26.745
0.08	0.847	1.628	32.338	0.967	1.623	27.868
0.1	0.851	1.641	33.166	0.969	1.644	28.881
	M_{R_D} = 570.69C + 27.749 ? = 0.996			M_{R_D} = 795.65C + 22.76 ? = 0.996		
	SBDAC-12			SBDAC-12		
0.01	0.813	1.502	26.673	0.950	1.523	23.603
0.02	0.818	1.523	27.586	0.954	1.548	24.542
0.04	0.822	1.546	28.76	0.956	1.572	25.590
0.06	0.830	1.557	29.261	0.959	1.595	26.570
0.08	0.834	1.564	29.735	0.963	1.614	27.374
0.1	0.838	1.576	30.428	0.965	1.632	28.200
	M_{R_D} = 396.59 C + 26.747 ? = 0.972			M_{R_D} = 623.88C + 23.452 ? = 0.992		

Tables 3.13 Conti……

Conc., mol/lit	Benzene			DMF		
	?, gcm^{-3}	R.I.	M_{R_D}	?, gcm^{-3}	R.I.	M_{R_D}
	SBDAC-13			SBDAC-13		
0.01	0.824	1.609	30.896	0.954	1.556	24.746
0.02	0.827	1.623	31.539	0.957	1.584	25.808
0.04	0.832	1.656	33.053	0.961	1.613	26.989
0.06	0.838	1.689	34.508	0.963	1.646	28.359
0.08	0.844	1.703	35.212	0.965	1.682	29.823
0.1	0.850	1.725	36.224	0.968	1.712	31.040
	M_{R_D} = 615.58C + 30.502 ? = 0.992			M_{R_D} = 864.93C + 24.287 ? = 0.998		
	SBDAC-14			SBDAC-14		
0.01	0.822	1.604	30.767	0.956	1.542	24.178
0.02	0.826	1.623	31.577	0.958	1.573	25.383
0.04	0.831	1.647	32.735	0.961	1.604	26.669
0.06	0.836	1.665	33.649	0.964	1.638	28.050
0.08	0.842	1.692	34.872	0.966	1.671	29.415
0.1	0.849	1.714	35.847	0.969	1.698	30.535
	M_{R_D} = 569C + 30.398 ? = 0.998			M_{R_D} = 870.44C + 23.846 ? = 0.996		
	SBDAC-15			SBDAC-15		
0.01	0.823	1.523	27.291	0.950	1.514	23.274
0.02	0.826	1.546	28.353	0.953	1.534	24.070
0.04	0.829	1.558	29.106	0.957	1.558	25.100
0.06	0.832	1.592	30.805	0.960	1.592	26.518
0.08	0.841	1.612	31.671	0.963	1.601	27.021
0.1	0.848	1.624	32.275	0.965	1.623	28.030
	M_{R_D} = 572.1C + 27.053 ? =0.998			M_{R_D} = 652.88C + 23.015 ? = 0.991		

Tables 3.13 Conti……

Conc., mol/lit	Benzene			DMF		
	?, gcm-^{3}	R.I.	M_{R_D}	?, gcm-^{3}	R.I.	M_{R_D}
	SBDAC-16			SBDAC-16		
0.01	0.822	1.542	28.138	0.953	1.512	23.116
0.02	0.827	1.563	29.019	0.955	1.535	24.039
0.04	0.832	1.586	30.133	0.957	1.564	25.286
0.06	0.836	1.602	30.988	0.959	1.598	26.706
0.08	0.843	1.612	31.478	0.962	1.623	27.764
0.1	0.848	1.623	30.089	0.963	1.644	28.737
	M_{R_D} = 437.24C + 28.130 ? =0.979			M_{R_D} = 782C +22.767 ? =0.996		

SECTION-7: ANTIBACTERIAL AND ANTIFUNGAL ACTIVITY OF SYMMETRIC DOUBLE SCHIFF BASES

Schiff bases possess some unique characteristics, which exert a profound influence on biological activities. All of the sixteen schiff bases, standard drugs and solvent DMF have been screened for their microbial activity against Escherichia coli, Bacillus megaterium, Proteus vulgaris, Staphylococcus aureus and Aspergillus niger by cup plate method [17-18].

In order to grow different microorganisms, the nutrient agar media was prepared according to reported method .

Peptone (bacteriological)	0.5 g
Meat extract	0.5 g
Sodium chloride	0.5 g
Agar	0.5 g
Distilled water	100 ml

The ingredients were mixed together and heated on a low flame till fully dissolved. The pH of the media was adjusted to 7.5. The media was cooled to 50°C and was poured in 15ml lots in sterilized petri dishes and allowed to harden. Surface seeding of the hardened plates was done with different microorganisms namely Escherichia coli, Bacillus megaterium, Proteus Vulgaris, Staphylococcus aureus, Aspergillus niger.

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17 A.L.Bary, “The Antimicrobic susceptibility test, principles and practices.” Illus Lea and Febiger, Philadelphia, pp 180-193, 1976

18 R.Chuickshank, J.P.Duigd, D.P.Marmom and R.H.A.Swain, “Medical Microbiology” Churchill-Livingstone, Edinburgh, London. Vol 2, 1975

Table-3.14: A comparative zone of inhibition in mm for standard drugs and schiff bases samples

Sample	Zone of inhibition				
	E.coli	B. mega	B. sub.	P.vulgeris	A. niger
SBDAC-1	8	9	9	9	12
SBDAC-2	10	8	10	9	14
SBDAC-3	9	11	9	10	15
SBDAC-4	9	10	9	9	15
SBDAC-5	10	9	12	11	18
SBDAC-6	11	10	12	10	18
SBDAC-7	8	9	8	8	17
SBDAC-8	11	10	12	9	16
SBDAC-9	10	10	12	11	17
SBDAC-10	11	10	12	11	16
SBDAC-11	12	9	11	10	15
SBDAC-12	8	9	10	9	14
SBDAC-13	9	9	11	10	15
SBDAC-14	9	9	10	11	16
SBDAC-15	8	10	9	10	16
SBDAC-16	7	9	8	9	12
Amoxicillin	18	19	22	22	18
Amoxicillin	17	21	19	23	20
Ciprofloxacin	22	20	21	24	19
Erythromycin	19	20	22	24	18

The plates were incubated at 37^{o}C for 24h. Sterile cups were punched and loaded with 0.1ml (50µg) of each sample solution and DMF control. The plates were further incubated for 24h at 37^{o}C and zones of inhibition of the bacterial growth were measured in diameter (mm) and reported in Table-3.14.
From which, it is clear that SBDAC-1 to SBDAC-16 showed moderate antibacterial activity as compared to standard drugs like amoxicillin, ampicillin, ciprofloxacin and erythromycin, while they possess good to comparable antifungal activity except SBDAC -1, which showed moderate antifungal activity in comparison with standard drugs.

CHAPTER–4

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THERMAL ANALYSIS OF DIAMINE AND SYMMETRIC DOUBLE SCHIFF BASES

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INTRODUCTION

During last few years, the method of thermal analysis have been widely accepted in analytical chemistry to study industrially important products such as polymers, pharmaceuticals, metals, minerals, alloys , clays and various complex in inorganic chemistry. Several thermal methods have been recognized, which differ in the measured properties and temperature programs [1]. This chapter of the thesis describes the thermal analysis of diamines and schiff bases.

Yi et. al [2] have reported the thermal stabilities of the polyimide derived from 1,1' bis (4-amino phenyl) cyclohexane and its derivatives with PMDA,BTDA and HFDA. The thermal stabilities of polyimides were evaluated by thermogravimetric analysis (TGA) as well as differential scanning calorimetry (DSC) under nitrogen atmosphere. These polyimides exhibited excellent thermal stabilities. They are stable up to 500 ^{0}C and the residual weight at 800 ^{0}C were above 30%. The glass transition temperatures (T_gs) measured by DSC (290–372) ^{0}C. They have found that the T_gs were increased with number of methyl substituents in 1,1' bis (4-amino phenyl) cyclohexane because of the increasing restriction on the main chain rotation motion.

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[1] G. Chatawal and S. Anand .” Instrumental methods of chemical analysis “2nd Edn., 1984.

[2] M. H. Yi, W. Huang, M. Y. Jin and K. Y. Choi ”Synthesis and characterization of soluble polyimides from 1,1’ bis(4-amino phenyl)cyclohexane derivatives”., Macromolecules,**30**, 5660, 1997.

Patel et. al [3] have reported thermal study of schiff base and its metal complexes derived from terephthalaldehyde and o-amino phenol with various metal ions. They have reported that all chelates showed a loss in weight corresponding to two water molecules in the range of 150 to 180^0C. The TG curves indicated that above 180^0C decomposition of schiff base with partial evaporation. In the temperature range of 180 to 450^0C, the schiff base molecules are lost and finally products were converted into metal oxides.

Bi and Fan [4] have reported thermal study of schiff base complexes. Unsymmetric tetradentate schiff base ligand was synthesized using 5-chloro -2-hydroxy benzophenone, o-phenylene diamine and salicylaldehyde. Five metal complexes of this ligand ML xH_2O [M=Cu(II), Ni(II), Zn(II), Mn(II) and Co(II)] have been prepared. The DTA-TG curves of the complexes shown that Cu (II) complex give a one stage decomposition pattern due to loss of the ligand molecule. Other complexes decomposed in two steps. The first decomposition step corresponds to the loss of water molecule. The second step corresponds to the loss of ligand molecule. (They have suggested that the loss of water molecule at low temperature is because of water of crystallization.) In all cases, the final products were metal oxides. The total weight loss is in agreement with the composition of the complexes.

Mishra et al. [5] have reported physico-chemical and thermal study of bioactive schiff base and its complexes. Complexes of schiff base salicylidene-2-amino phenol (SAPh) with Co (II), Ni (II) and Cu (II) were synthesized according to reported procedure. Thermal study of $[\text{Ni SAPh} (H_2O)_3]\cdot 2H_2O$ complex has been done. The TGA curve of complex showed decomposition starting between 70-110^0C (obs. 10% wt loss). This weight loss is due to lattice

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3 . N.H. Patel, K.M. Patel, K.N. Patel and M.N. Patel, “Coordination chain polymers of some transition metals with schiff base”, Synth. React. Inorg. Met-Org. Chem., **31**, 1031, 2001.

4. C. Bi and Y. Fan, “Synthesis and characterization of metal complexes with unsymmetric tetradentate schiff base ligand”, Synth. React. Inorg. Met-Org. Chem., **34**, 687, 2004.

5. A P. Mishra, M. Khare and S. K. Gautam, “Synthesis, physico-chemical characterization and antibacterial studies of some bioactive schiff bases and their metal chelates.” Synth. React. Inorg. Met. Org. Chem. 32, 1485, 2002.

water molecules, further weight loss due to three coordinating water molecules observed from 110 to 240^{0}C. (15% wt. loss obs.)The thermal degradation of the schiff base in metal chelates began on heating above240^{0}C and pyrolysis curve showed two steps, the first between 240-320^{0}C and second from 320-550^{0}C. An almost horizontal thermal curve is observed above 550^{0}C. The percentage weight of the residue in this horizontal region was 24% due to nickel oxides

Panchal et. al [6] have reported thermogravimetric analysis of lanthanide coordination polymers with the schiff base N,N'-di (o- hydroxy phenyl) terephthalaldehyde. The weight loss was measured from ambient temperature up to 800^{0}C at a rate of 10^{0}C/min in N_2 atmosphere. It has been observed that in the range of 35-105^{0}C, the loss in weight for all coordinating polymers was due to two lattice water molecules. In the temperature range 350-400^{0}C the compounds to loose nitrate ion. The temperature range 400-800^{0}C the schiff base molecules were lost. The compositions of the final products were determined by the observed weight loss in thermo gravimetric analysis.

The thermal studies throw light on molecular architecture of compounds, such as degree of polymerization, orientation, crystal perfection, percentage crystallinity, the extent of chain branching, strength of various bonds holding together molecules, on the kinetic of degradation, the effects of time, temperature, pressure, etc. and on the rates and products of degradation. On practical side, thermal analysis not only explains the behavior of compound under conditions of high temperatures but also help in selecting the right kind of material for the specific uses where high temperatures are encountered.

It also suggests the design and synthesis of new materials for specific requirements in chemical technology such as high temperature resistant synthetic and natural fibers, transportation industries, electrical and electronic instruments, appliances, etc.

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[6] P.K.Panchal, N.H. Patel and M.N. Patel, "Synthesis and characterization of coordination polymers of trivalent lanthanides with a schiff base." Synth. React. Inorg. Met. Org. Nanometal Chem. 35, 107, 2005.

Effect of various operating parameters

1. Atmosphere

The atmosphere associated with any thermal analysis which composed of gases that are introduced from outside and are evolved from the samples.

The presence or absence of such gases may have a strong influence on the results. These gases may react with the sample or with each other, and change the reaction mechanism or product composition. Inert atmosphere and vacuum will influence decomposition processes. In vacuum, primary decomposition of gases will tend to be pumped away from the sample before the molecules collide with the surface and undergo secondary reactions. When these molecules collide with inert gas molecules, they may undergo homogeneous reaction or may be reflected back to the sample surface and react there.

2. Container geometry

The container geometry influences the gaseous environment and heat transfer to the samples. Even with a flowing gaseous atmosphere, a deep narrow container limits the contact between the samples surface and gas, whereas a shallow, broad container will promote the contact.

3. Container material

It is reasonable to expect that in some cases the container material reacts with material to be tested or some of the products.

4. Sample size

Two major effects are associated with the sample size, namely surface and bulk effects. In carrying out degradation studies, it is customary to reduce fil particle size until the rate of decomposition becomes independent of size.

5. Rate of heating

In the case where only kinetic considerations are significant, and increase in the rate of temperature rise causes the process to be displayed to a higher temperature because the sample will have been at the lower temperature for a shorter length of time. The rate of change of the measured parameters will also be greater for faster heating.

Differential scanning calorimetry (DSC) and Differential thermal analysis (DTA)

Physical transformation [7] such as glass transition, cold crystallization, crystallization from melt, crystalline disorientation, and melting can be studied by differential scanning calorimetry (DSC) and differential thermal analysis (DTA). DSC is a method where by the energy necessary to establish a zero temperature difference between a substance and a reference material is recorded as a function of temperature or time.

When an endothermic transition occurs, the energy input to the sample in order to maintain a zero temperature difference, because this energy input is precisely equivalent in magnitude to the energy absorbed during the transition in direct calorimetric measurement. DSC provides useful informations about crystallinity, stability of crystallites, glass transition temperature, cross linking, kinetic parameters such as the activation energy, the kinetic order and heat of polymerization, etc.

DTA is more versatile and gives data of more fundamental nature than TGA. This technique involves recording of difference in temperature between a substance and reference material against either time or temperature as the two specimens are subjected to identical temperature regimes in an environment heated or cooled at a programmed heating rate. Any transition, which the sample undergoes, results in absorption or liberation of energy by the sample with a corresponding deviation of its temperature from that of the reference.

In DTA, as soon as the sample reaches the temperature of the change of its state (chemical or physical), the differential signal appears as a peak. The number, position, shape and nature (exothermic or endothermic) of the DTA peaks give information about glass transition temperature, crystalline rearrangement, melting, curing, degradation , decomposition of chemical substance, etc.

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7. E. Heisenberg; Cellulose Chemie, **12**, 159, (1931); C. A. **25**, 59823, 1931.

Thermo gravimetric analysis (TGA)

Different substances decompose over different ranges of temperature yielding different proportion of volatile and residues. Thermo gravimetry is useful analytical technique for recording weight loss of a test sample as a function of temperature, which may be used for understanding the chemical nature of the substance. Thus, the weight of a substance in an environment heated or cooled at a controlled rate is recorded as a function of time or temperature.

There are three types of thermogravimetry

1. Static or isothermal thermogravimetry
2. Quasistatic thermogravimetry and
3. Dynamic thermogravimetry

Most of the studies of chemical substances are generally carried out with dynamic thermogravimetry. Normally the sample starts losing weight at a very slow rate up to a particular temperature and there after, the rate of loss becomes large over a narrow range of temperature. After this temperature, the loss in weight levels off. TGA curves are characteristic for a given substance because of unique sequence of physico-chemical reactions, which occur over definite temperature ranges. The change in weight is a result of the rupture and/or formation of various physical and chemical bonds at elevated temperatures that lead to evaluation of volatile products in the formation of heavier reaction products. Pyrolysis of many substances yields TG curves.

The weight of the sample decreases slowly as reaction begins and then decreases rapidly over a comparatively narrow range of temperature and finally levels off as the reaction is completed. The shape of the curve depends on the kinetic parameters: reaction order n, frequency factor A and activation energy E_a. The values of these parameters have been shown to be of major importance to elucidate the mechanism in degradation [8, 9].

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8 D. W. Levi, L. Reich and H. T. Lee; Polymer Eng. Sci., **5**, 135, 1965.

9 H. L. Friedman; U. S. Dept. Com., Office. Tech., 24 PP (1959); cf. C. A. **55**, 26, 511, 1961.

Reich and Levi [10] have described several temperature characteristics for qualitative assessment of relative thermal stability of polymers:

1. Initial decomposition temperature (T_0)
2. Temperature for 10% weight loss (T_{10})
3. Temperature for maximum rate of decomposition (T_{max})
4. Half volatilization temperature (T_s)
5. Differential decomposition temperature and
6. Integral procedural decomposition temperature (IPDT)

With dynamic heating T_0 and T_{10} are some of the main criteria of the thermal stability of a given substance.

For the estimation of kinetic parameters from TG traces, several so called exact methods have been proposed. All these methods involve two important assumptions that thermal and diffusion barriers are negligible and that Arrhenius equation is valid. Since small quantities of materials are employed in TG studies, thermal and diffusion barriers would be negligible. Since the shape of any TG curve is dependent on the nature of apparatus and the way in which it is used. Most kinetic treatments are based on relationship of the type:

$$\frac{dC}{dt} = kf(C) \qquad \ldots(4.1)$$

where C = Degree of conversion, t = time, k = rate constant, f(C) = a temperature independent function of C.

The constant k is generally assumed to have the Arrhenius form

$$k = A\, e^{-Ea/RT} \qquad \ldots(4.2)$$

C is defined as the conversion with respect to initial material

$$C = 1 - \frac{W}{W_0} \qquad \ldots(4.3)$$

Where W_0 = Initial weight of the material and W = weight of the material at any time.

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10. Reich and D. W. Levi; Macromol. Rev. Eds. Peterlin Goodman Wiley Interscience, New York, 173, 1968.

The residual weight fraction is given by

$$\frac{W}{W_0} = (1 - C)$$

and the rate of conversions is given by

$$\frac{dC}{dt} = -\left(1/W_0\right)\frac{dW}{dt} \qquad \text{…(4.4)}$$

For homogeneous kinetics, the conversion would be assumed to have the form

$$f(C) = (1 - C)^n \qquad \text{…(4.5)}$$

where n = order of the reaction.

Upon substituting Eqns. (4.2) and (4.5) into Eqn. (4.1)

$$\frac{dC}{dt} = A\ e^{-Ea/RT}\,(1–C)^n$$

OR

$$\frac{dC}{dT} = \left(\frac{A}{b}\right)(e^{-Ea/RT)}\ (1\text{-}C)^n \qquad \text{… (4.6)}$$

where b = Rate of heating.

Methods of single heating rate

1. Freeman – Carroll [11] and Anderson-Freeman method [12]

Freeman-Carroll developed the following relation to analyze TGA data at a single heating rate :

$$\frac{\Delta \ln (dC/dt)}{\Delta \ln (1 - C)} = n - \frac{E_a}{R}\left[\frac{\Delta(1/T)}{\Delta \ln(1-C)}\right] \qquad \text{… (4.7)}$$

A Plot of L.H.S. against $\frac{\Delta(1/T)}{\Delta \ln(1-C)}$ for equal interval of Δ(1/T) would yield a straight line with slope equal to $-E_a/R$ and the intercept equal to n. Using Eqn. (4.7) Anderson-Freeman derived Eqn. (4.8):

$$\Delta ln\left(\frac{dC}{dt}\right) = n\Delta ln(1 - C) - \frac{E_a}{R}\Delta\frac{1}{T} \qquad \text{..(4.8)}$$

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[11] E. S. Freeman and B. Carroll; J. Phys. Chem., **62**, 394, 1958.

[12] D. A. Anderson and E. S. Freeman; J. Polym. Sci., **54**, 253, 1961

According to Eqn. (4.8), the plot of $\Delta ln\left(dC/dt\right)$ against $\Delta \ln\left(1-C\right)$ for equal intervals of $\Delta\frac{1}{T}$ would be a straight line with slope equal to n and the intercept equal to $-(E_a/R)\Delta\frac{1}{T}$

2. Sharp-Wentworth method [13]

For a first order process (n=1), Sharp-Wentworth derived following relation to analyze TGA data:

$$\log\left[\frac{dC/dt}{1-C}\right]=\log\left(A/b\right)-\frac{E_a}{2.303R}\cdot\frac{1}{T} \qquad ..(4.9)$$

The plot of log $\left(\frac{dC/dt}{1-C}\right)$ against 1/T would be a straight line, with slope equal to $-(E_a/2.303\,R)$ and intercept equal to $\log\left(A/b\right)$.

3. Chatterjee method [14]

Chatterjee developed the following relation for the determination of n from TG curves based on weight units.

$$n=\frac{\log\left(-\frac{dW}{dt}\right)_1-\log\left(-\frac{dW}{dt}\right)_2}{\log W_1-\log W_2} \qquad …(4.10)$$

where W_1 and W_2 are the sample weight

4. Horowitz and Metzger method [15]

The value of E_a can be determined from a single TG curve according to Horowitz and Metzger:

$$\ln\left[\ln(1-C)^{-1}\right]=\frac{Ea}{RTs^2}\theta \qquad …(4.11)$$

where Ts = Temperature at which the rate of decomposition is maximum and q = T – Ts. The frequency factor A and entropy change ΔS can be determined respectively according to Eqns. (4.12) and (4.13).

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13 J. H. Sharp and S. A. Wentworth; Anal. Chem., **41**, 2060, 1969.

14 P. K. Chatterjee; J. Polym. Sci., **A-3**, 4253, 1965.

15 H. H. Horowitz and G. Metzger; Ana. Chem., **35**, 1464, 1963.

$$\ln E - \ln \left(RT_S^2\right) = \ln A - \ln \beta - \frac{E}{RT_S} \qquad \ldots(4.12)$$

$$A = \frac{k_b T}{h} e^{\Delta S/R} \qquad \ldots(4.13)$$

Where k_b is Boltzmann constant

Uses of multiple heating rates

(1) Anderson [16] method

Anderson [16] and Friedman [17] have developed the methods based on multiple heating rates. These methods are based on the fact that as the heating rates are increased, TG curves tend to shift to higher temperatures, since at lower temperature decomposition occurs for shorter times.

The relation is

$$\ln R_t = \ln A + n \ln (1 - C) - \frac{E_a}{RT} \qquad \ldots(4.14)$$

where $R_t = b\, dC/dt$

The plot of $\ln R_t$ against 1/T at various fixed degree of conversion would be a straight line with slope equal to –E/R at a fixed degree of conversion.

In order to evaluate the values of n and A, Eqn. (4.15) can be employed by considering 1/T = 1/To when $\ln R_t = 0$

$$\frac{E_a}{RT_0} = \ln A + n \ln (1 - C) \qquad \ldots(4.15)$$

According to Eqn (4.15), the plot of E_a/RT_0 against in (1-C) would be a straight line with slope equal to n and intercept equal to in A.

(2) Friedman method [17]

Friedman [17] has developed following Eqn. (4.16):

$$\ln\left(\frac{dC}{dt}\right) = \ln A + n \ln (1 - C) - \frac{E_a}{RT} \qquad \ldots(4.16)$$

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16 H. C. Anderson, J. Polym. Sci., **C6**, 175, 1964

17 H. L. Friedman, J. Polym. Sci., **C6**, 183, 1964.

According to Eqn. (4.16), the plot of ln dC/dt against 1/T at various values of fixed degree of conversion would be a straight line with slope equal to $-E_a/R$ and

$$Intercept = \ln A + n \ln(1-C) \qquad \text{… (4.17)}$$

The intercept obtained from the first graph can be plotted against in (1-C), the slope and the intercept of which yield the values of n and A, respectively.

(3) Ozawa method [18]

Ozawa has developed the following Eqn. 4.18:

$$\log \int_0^C \frac{dC}{(1-C)^n} \approx \log \frac{AE_a}{RT} - \log b - 2.315 - 0.4567\left(\frac{E_a}{RT}\right) \qquad \text{… (4.18)}$$

The plot of log b against 1/T would be a straight line for the fixed values of conversion; the slope is equal to $-0.4567(E_a/R)$.

EXPERIMENTAL

TG-thermograms of SBDAC-3, SBDAC-7, SBDAC-10, SBDAC-14, SBDAC-15 and SBDAC-16 were scanned on at the heating range of 10^0C/mm in nitrogen atmosphere over the temperature range from 35^0 to 800^0C.

RESULT AND DISCUSSION

Thermal analysis of material is very important in predicting their utility under various environment conditions, in understanding molecular architecture decomposition mechanisms and high temperature applications. Thermogravimetric analysis provides a means to estimate kinetic parameters of thermal decomposition reactions [19]. Thermal methods are based upon the relationship between temperature and some properties of a system such as mass, heat of reaction or volume, etc [20, 21].

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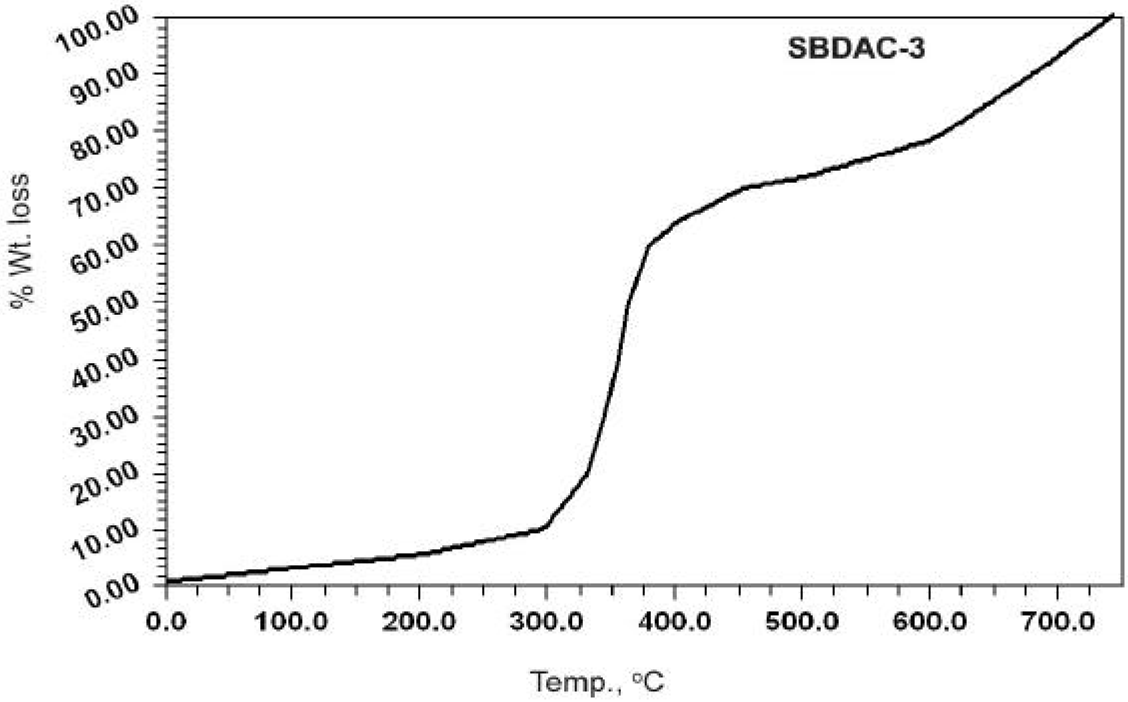
[18] T. Ozawa, Bull. Chem. Soc. Jap.,38, 1881, 1965.

[19] Jovan Mijovic, "Cure kinetics of neat vs reinforced epoxies", J. Appl. Polym. Sci. **31**, 1177-1187, 2003.

[20] W. W. Wendlant, "Thermal Methods of Analysis", 2^{nd} Ed. Wiley, New York, 1974; T. Meisel and K. Seytold, Crit. Rev. Ana. Chem. **12**, 267, 1981.

[21] R. C. Mackenizie, "Differential Thermal Analysis", Vol. 1&2, Academic Press, New York, 1970., W. W. Wendlant, Anal. Chem., **54**, 97R (1982); **56**, 250R, 1984.

TG-thermograms of SBDAC-3, SBDAC-7, SBDAC-10, SBDAC-14 SBDAC-15 and SBDAC-16 are presented in Figs 4.1-4.3, respectively. The initial decomposition temperature (IDT), temperature of 10 % weight loss (T_{10}), temperature of 50 % weight loss (T_{50}), final decomposition temperature (FDT), temperature of maximum weight loss (T_{max}) and the decomposition range are reported in Table 4.1 from which it is clear that schiff bases are thermally stable upto about 200-285^{0}C and involved two step decomposition. T_{max} is different for different schiff bases and it is varied between 333-380^{0}C and degradation pattern is quite different suggesting different degradation mechanism. The kinetic parameters such as energy of activation (E_a), frequency factor (A), and order of reaction (n) are determined according to Anderson-Freeman method [22] (Eqn. 4.8). The detail calculation for SBDAC-14, SBDAC-15 and SBDAC-16 are reported in Tables 4.2-4.4, respectively and the plots of $\vartriangle \ln \frac{dW}{dt}$ against ?lnW are presented in Figs. 4.4 to 4.8. The least square values of E, n and A along with correlation coefficients are reported in Table 4.5. The entropy change (?S*) is calculated at corresponding T_{max} and also included in Table 4.5.



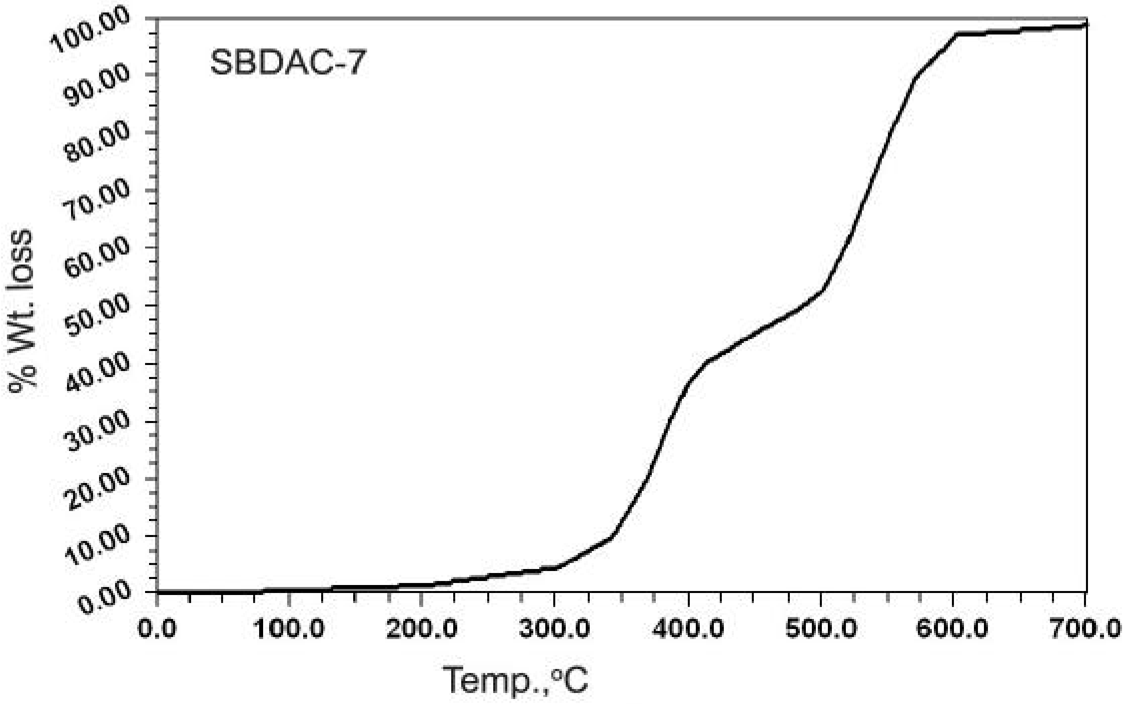
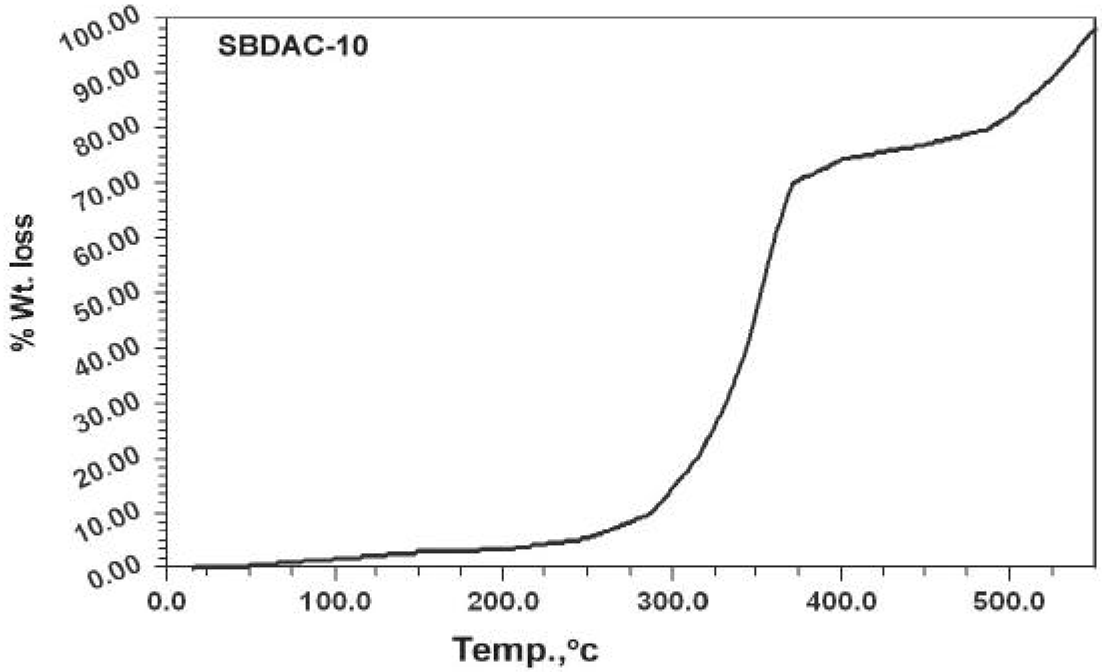


Fig.-4.1 TG thermograms of SBDAC- 3 and 7 at the heating rate of 10^oC/min in an N_2 atmosphere



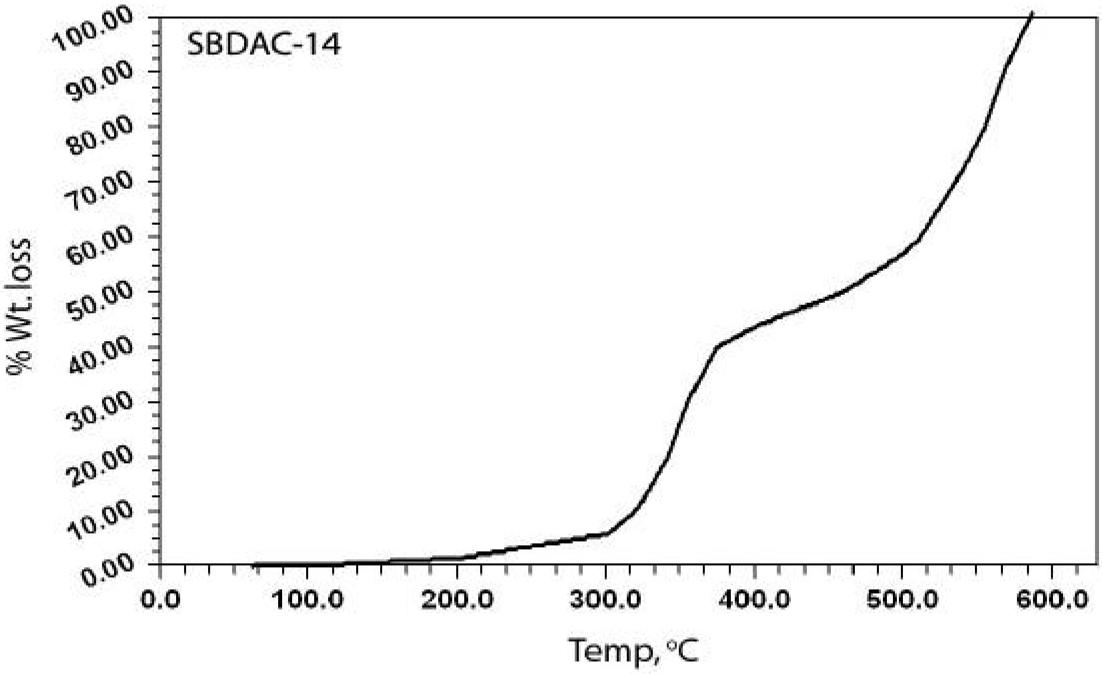
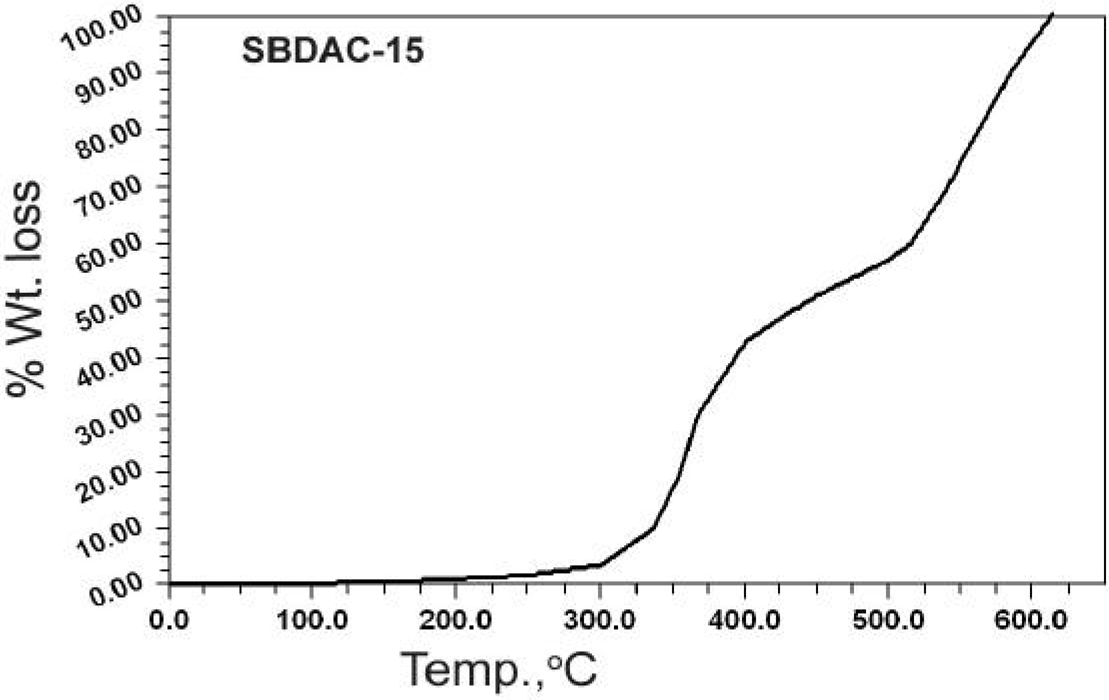


Fig.-4.2 TG thermograms of SBDAC- 10 and 14 at the heating rate of 10^{o}C/min in an N_2 atmosphere



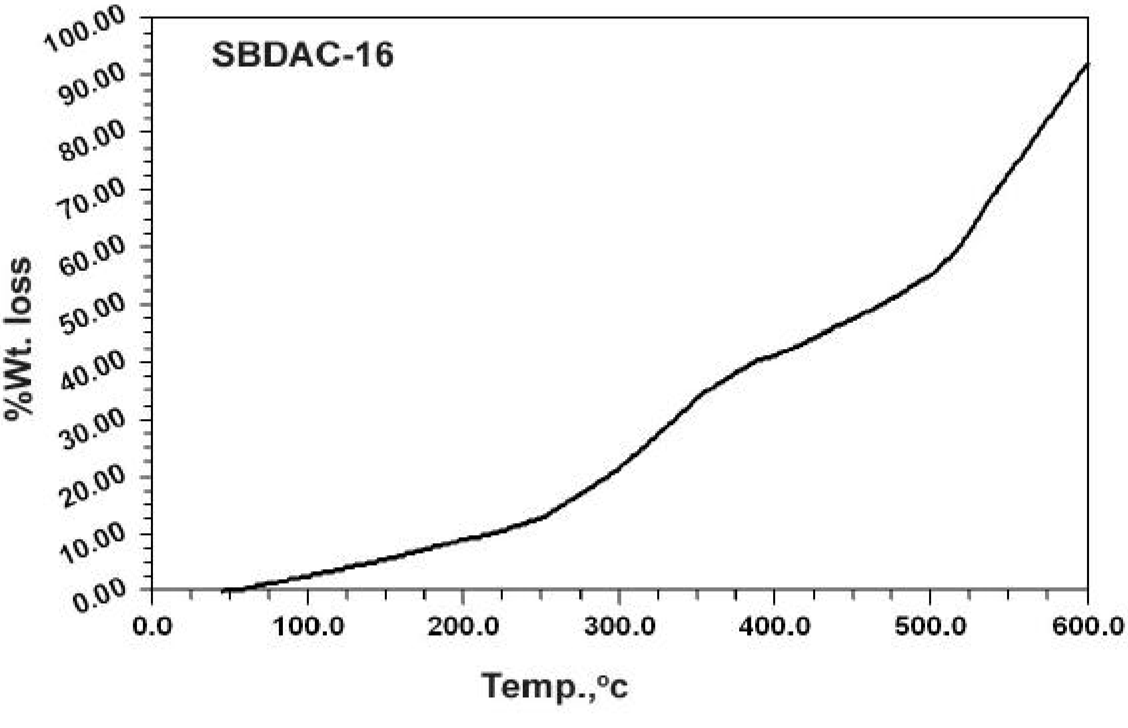


Fig.-4.3 TG thermograms of SBDAC-15 and 16 at the heating rate of 10°C/min in an N_2 atmosphere

Table-4.1: *TGA data of schiff bases.*

Schiffbases	IDT, °C	T_{10}, °C	T_{50} , °C	FDT. °C	Decompn. Temp,,°C	%Wt.loss	T_{max} °C
SBDAC-3	200.0	292.0	362.1	500.9 750	250-451 589-750	62.0 23.4	353.4 -
SBDAC-7	267.0	342.9	485.7	419.0 608	267-419 488-608	37.7 46.9	379.7 538.7
SBDAC-10	239.0	287.5	352.0	379 560	239-379 470-560	66.3 19.6	355.9 -
SBDAC-14	250.0	319.5	358.7	372 589	250-372 480-589	35.4 46.4	350.3 565.8
SBDAC-15	285.0	335.7	442.9	413 623	285-413 507-623	42.0 41.4	357.8 549.9
SBDAC-16	250.0	217.4	467.4	367 620	250-367 474-620	24.2 44.3	333.0 554.0

Table-4.2: The calculation scheme for SBDAC-14 by Anderson-Freeman method

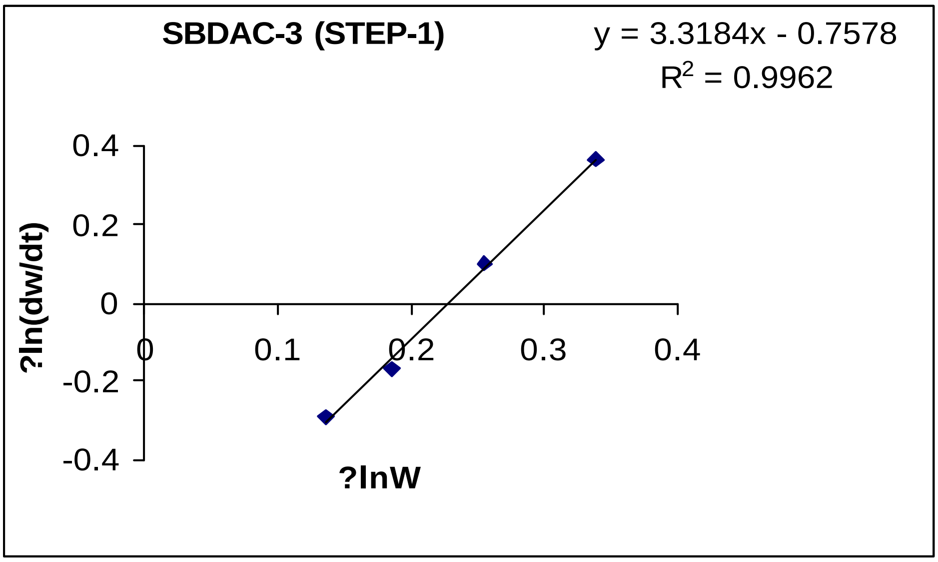
1/T	% wt. loss	dw/dt	Active Wt.	lnW	ln dw/dt	?lnW	?lndw/dt
STEP-1							
1.67	12.59	4.06	26.452	3.275	1.401	0.061	-0.131
1.66	14.16	4.63	24.881	3.214	1.533	0.074	-0.114
1.65	15.95	5.19	23.095	3.140	1.647	0.091	-0.095
1.64	17.95	5.71	21.092	3.049	1.742	0.111	-0.076
1.63	20.16	6.16	18.876	2.938	1.818	0.136	-0.055
1.62	22.57	6.51	16.472	2.802	1.873	0.168	-0.030
1.61	25.12	6.71	13.922	2.633	1.904	0.209	-0.003
1.60	27.75	6.73	11.291	2.424	1.907	0.264	0.032
1.59	30.37	6.52	8.671	2.160	1.875	0.340	0.076
1.58	32.87	6.04	6.169	1.820	1.798		
STEP-2							
1.220	76.21	5.214	23.79	3.169	1.651	0.086	-0.129
1.215	78.17	5.93	21.83	3.083	1.780	0.099	-0.125
1.210	80.22	6.721	19.78	2.985	1.905	0.114	-0.092
1.205	82.35	7.366	17.65	2.871	1.997	0.133	-0.043
1.200	84.55	7.687	15.45	2.738	2.040	0.163	0.012
1.195	86.88	7.593	13.12	2.574	2.027	0.191	0.066

Table-4.3: The calculation scheme for SBDAC-15 by Anderson-Freeman method

1/T	% wt. loss	dw/dt	Active Wt.	lnW	ln dw/dt	?lnW	?ln dw/dt
STEP-1							
1.65	10.58	2.91	34.52	3.542	1.068	0.040	-0.213
1.64	11.94	3.60	33.16	3.501	1.281	0.047	-0.207
1.63	13.46	4.43	31.64	3.454	1.488	0.055	-0.187
1.62	15.14	5.34	29.96	3.400	1.675	0.029	-0.159
1.61	15.99	6.26	29.11	3.371	1.834	0.110	-0.113
1.60	19.03	7.01	26.07	3.261	1.947	0.088	-0.057
1.59	21.23	7.42	23.87	3.173	2.004	0.103	0.001
1.58	23.57	7.41	21.53	3.069	2.003	0.121	0.055
1.57	26.03	7.01	19.07	2.948	1.947	0.141	0.097
1.56	28.54	6.36	16.56	2.807	1.850	0.164	0.124
1.55	31.04	5.62	14.06	2.643	1.726		
STEP-2							
1.235	68.61	4.08	31.39	3.446	1.406	0.047	-0.055
1.230	70.05	4.31	29.95	3.400	1.461	0.051	-0.054
1.225	71.54	4.55	28.46	3.348	1.515	0.055	-0.047
1.220	73.07	4.77	26.93	3.293	1.562	0.059	-0.039
1.215	74.62	4.96	25.38	3.234	1.601	0.064	-0.026
1.210	76.20	5.09	23.80	3.170	1.627	0.070	-0.016
1.205	77.80	5.17	22.20	3.100	1.643	0.075	0.002
1.200	79.40	5.16	20.60	3.025	1.641	0.081	0.014
1.195	81.01	5.09	18.99	2.944	1.627	0.089	0.028
1.190	82.62	4.95	17.38	2.855	1.599	0.097	0.035
1.185	84.22	4.78	15.78	2.759	1.564	0.106	0.052
1.180	85.81	4.54	14.19	2.653	1.513		

Table-4.4: The calculation scheme for SBDAC-16 by Anderson-Freeman method

1/T	% wt. loss	dw/dt	Active Wt.	lnW	ln dw/dt	?lnW	?lndw/dt
STEP-1							
1.78	19.48	1.84	17.47	2.860	0.610	0.036	-0.037
1.77	20.09	1.91	16.86	2.825	0.647	0.039	-0.031
1.76	20.73	1.97	16.22	2.786	0.678	0.042	-0.035
1.75	21.40	2.04	15.55	2.744	0.713	0.046	-0.034
1.74	22.10	2.11	14.85	2.698	0.747	0.051	-0.037
1.73	22.84	2.19	14.11	2.647	0.784	0.055	-0.031
1.72	23.60	2.26	13.35	2.592	0.815	0.062	-0.026
1.71	24.40	2.32	12.55	2.530	0.842	0.068	-0.030
1.70	25.22	2.39	11.73	2.462	0.871	0.078	-0.025
1.69	26.10	2.45	10.85	2.384	0.896	0.082	-0.020
1.68	26.95	2.50	10.00	2.303	0.916	0.093	-0.016
1.67	27.84	2.54	9.11	2.209	0.932	0.105	-0.008
1.66	28.75	2.56	8.20	2.104	0.940	0.118	-0.004
1.65	29.66	2.57	7.29	1.987	0.944	0.135	0.008
1.64	30.58	2.55	6.37	1.852	0.936	0.156	0.012
1.63	31.50	2.52	5.45	1.696	0.924		
STEP-2							
1.21	74.33	4.16	21.07	3.048	1.426	0.142	0.010
1.20	77.12	4.12	18.28	2.906	1.416	0.166	0.025
1.19	79.92	4.02	15.48	2.740	1.391	0.204	0.043
1.18	82.78	3.85	12.62	2.535	1.348	0.254	0.064
1.17	85.61	3.61	9.79	2.281	1.284	0.337	0.087
1.16	88.41	3.31	6.99	1.944	1.197	0.498	0.119
1.15	91.15	2.94	4.25	1.447	1.078		



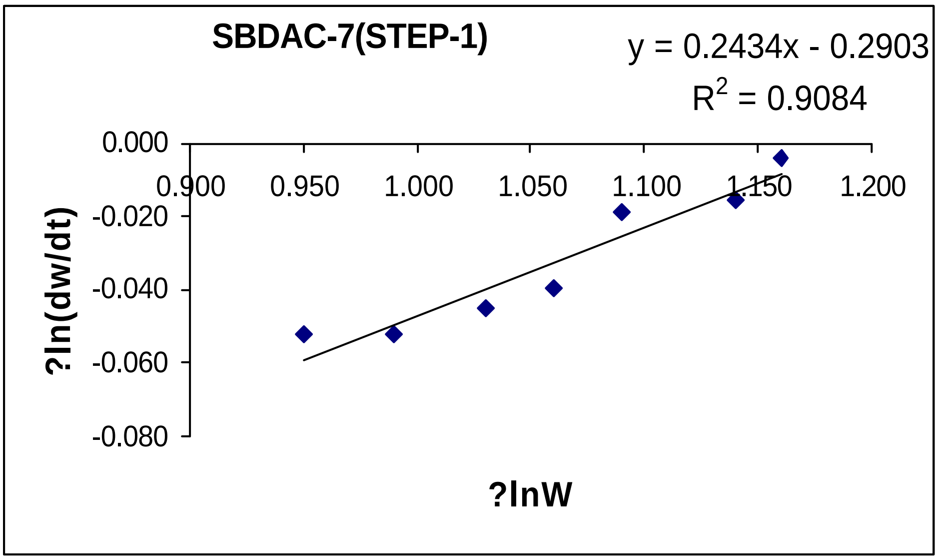
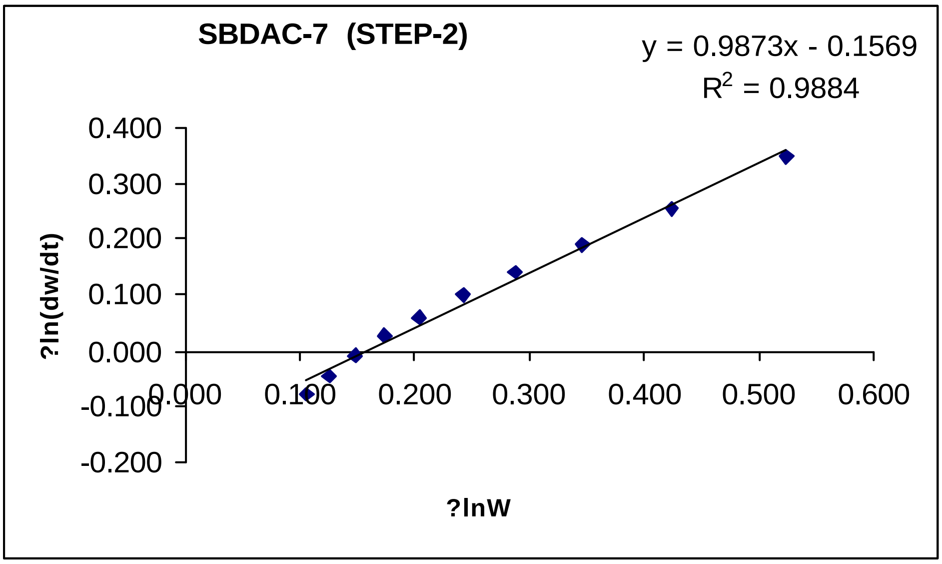


Fig.4.4 The Anderson–Freeman plots of SBDAC-3 and 7.



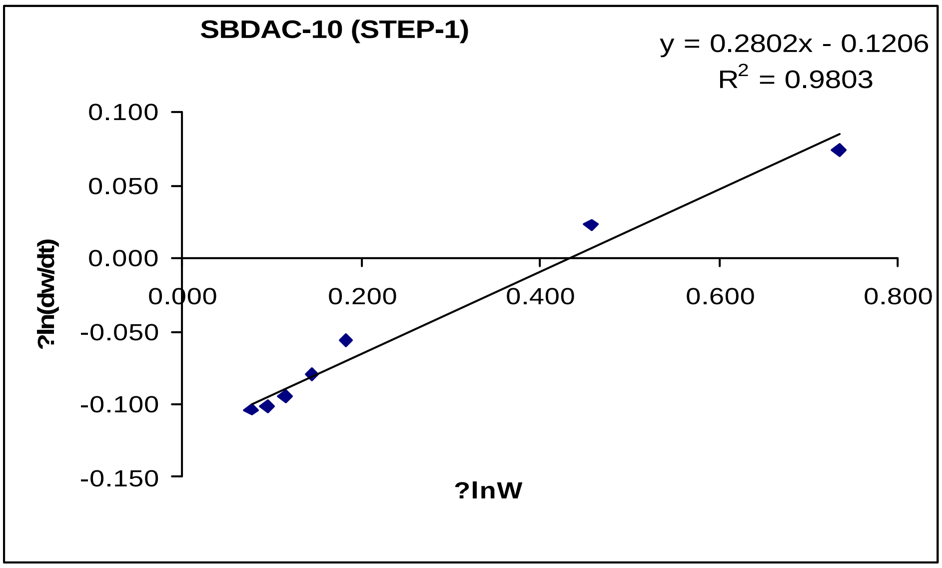
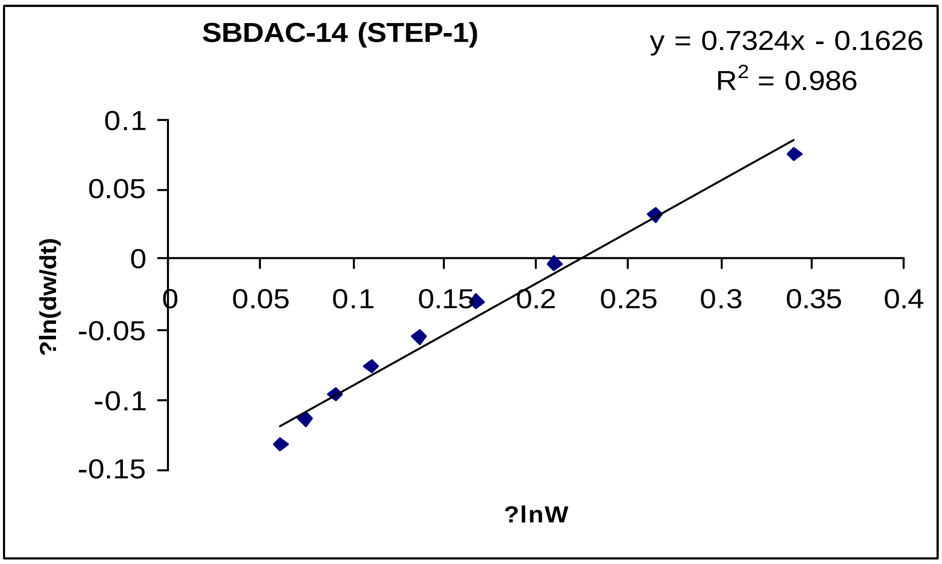


Fig.4.5 The Anderson- Freeman plots of SBDAC-7 and 10.



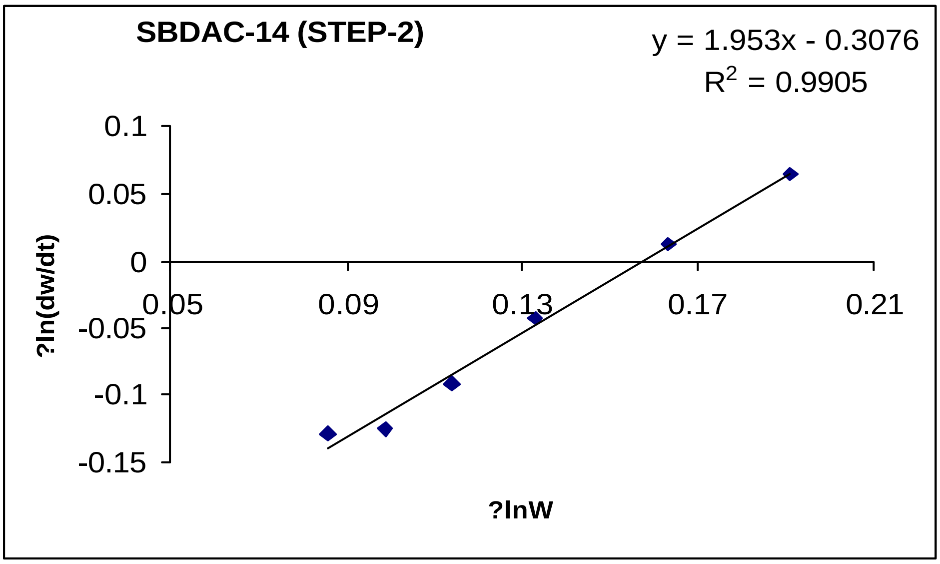
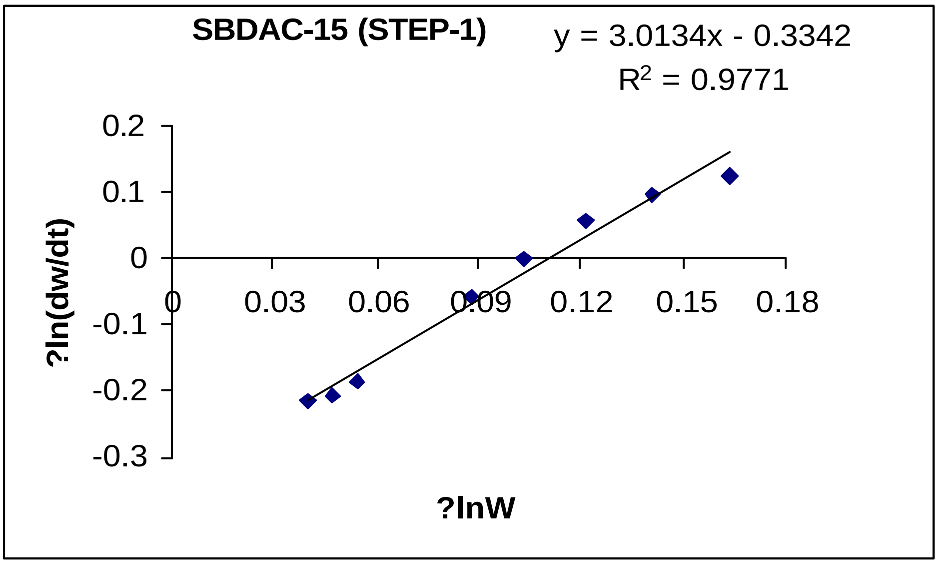


Fig.4.6 The Anderson- Freeman- plots of SBDAC-14.



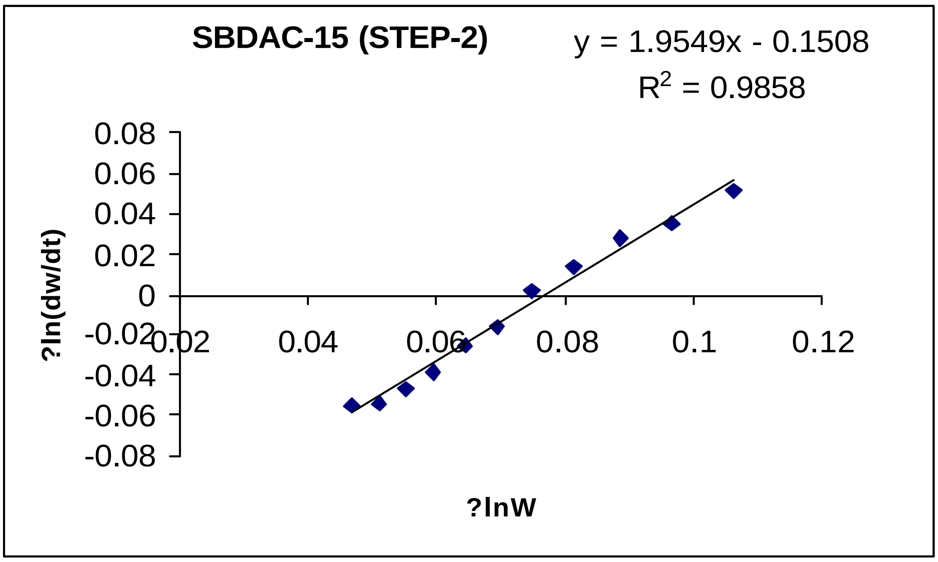
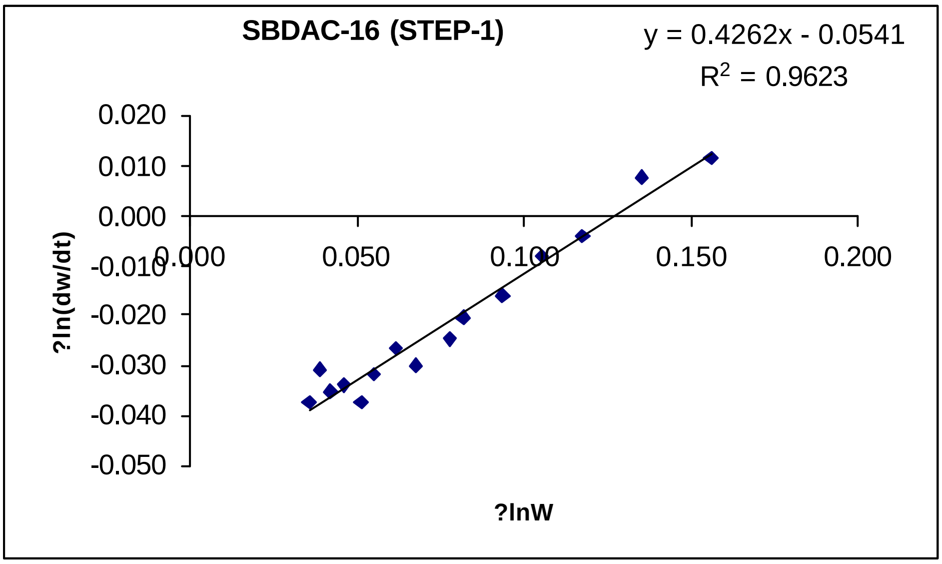


Fig.4.7 The Anderson -Freeman plots of SBDAC-15.



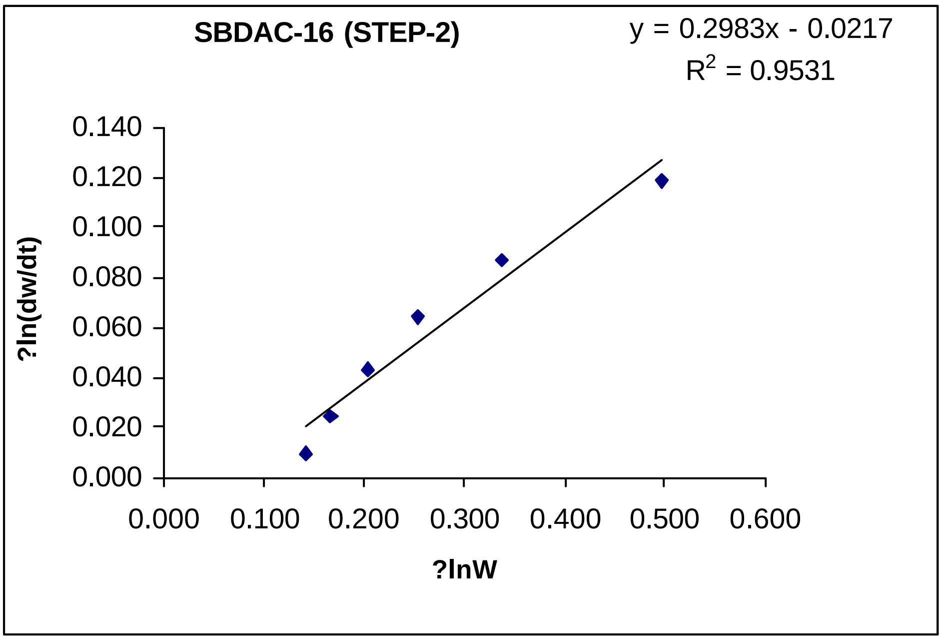


Fig.4.8 The Anderson -Freeman plots of SBDAC-16.

Table-4.5: The kinetic parameters of schiff bases derived according to Anderson- Freeman method

Schiff bases	**n**	**Ea, kJ**	**A, S^{-1}**	**?S***	**?**
SBDAC-3	3.32	315.02	$2.94X10^{24}$	217.4	0.998
SBDAC-7	0.24 0.99	482.70 130.05	$9.43x10^{36}$ $9.82x10^{5}$	456.4 -138.5	0.953 0.994
SBDAC-10	0.28	100.27	$1.08x10^{6}$	-135.7	0.990
SBDAC-14	0.73 1.95	135.19 255.74	$1.48x10^{9}$ $6.10x10^{13}$	-75.5 10.4	0.993 0.995
SBDAC-15	3.01 1.96	277.86 125.37	$1.41x10^{21}$ $3.36x10^{5}$	153.8 -147.6	0.989 0.993
SBDAC-16	0.42 0.30	449.80 180.40	$1.83x10^{1}$ $7.28x10^{-3}$	226.7 -294.3	0.981 0.976

Schiff bases either followed integral or fractional order degradation kinetics. Different magnitudes of kinetic parameters indicated different degradation mechanism. The large and positive values of ?S* suggested that the transition states are less ordered one, while negative values suggested ordered transition states [22, 23].

Azomethine and side substituents are weak points and hence selective degradation proceeds on heating. The degradation may result in the formation of free radicals, which may further undergo recombination and degrade at high temperature. The degradation process is a complex one and involves a variety of reactions such as fragmentation, branching, rearrangement, cross-linking, etc. Almost zero or small amount of residues suggested that schiff bases ultimately converted into small molecules as suggested in mass spectral analysis of these samples.

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CHAPTER – 5

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SOUNDVELOCITY AND ALLIED PARAMETERS OF SYMMETRIC DOUBLE SCHIFF BASES

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This chapter of the thesis describes the sound velocity, density and viscosity measurements of SBDAC-1 to 16 in different solvents such as chloroform (CF), dimethylformamide (DMF), tetrahydrofuran (THF) and 1,4-dioxane (DO) at three different temperatures: 30^o, 35^o, and 40^{o}C and evaluation of their acoustical parameters.

INTRODUCTION

In recent years, ultrasonic has become the subject of extensive research in different fields of science namely consumer industries, medical field, engineering, process industries, etc. [1]. It is also found most suitable to investigate various organic compounds (liquids), polymers, etc. Ultrasonic studies in aqueous and no aqueous electrolytic solutions have led to new insight into ion- solvent interactions and valuable informations about the ionic interactions and the nature and the strength of interactions [2].

Ultrasonic velocity offers a rapid non- destructive method for the characterization of materials. Elastic constants of an isotropic material can be determined ultrasonically when both longitudinal and transverse wave velocity are known. The measurements of ultrasonic velocity have been going on for the past several years. Some of the extensively used methods include light diffraction method; sing around method, the pulse echo superposition, the pulse echo overlap and the faster digital techniques using pulse echo method.

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Non-destructive testing of ultrasonic involves incorporation of physical principles for determining flaws, dimensional variations, micro structural features and the mechanical properties of worked materials without impairing their usefulness. The non-destructive applications of ultrasonic for determining structural integrity, micro structural features and mechanical properties of worked materials.

Ultrasonic non-destructive and evaluation(NDTE) plays a major role in the present day life assessment program of nuclear installation, chemical industries, gas pipe lines, etc. during preservice and in service inspection/conditions. Typical casting defects are non-metallic inclusions, porosity, shrinkage, cavities, cold shut, hot tear (shrink crack) cold or stress crack, blow holes or in homogeneity. All these defects can be tested ultrasonically by proper selection of probes (normal or angle) frequency and attenuation.

In recent years ultrasonic testing and evaluation techniques are widely used for obtaining information about micro structural and mechanical properties of metals [3-7] and wide applications have been found in medical and biological fields. The use of ultrasound for breaking kidney stones is well established in the medical field. The effect of sonic vibrations on the people suffering from other diseases of kidneys is not known.

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The ultrasonic technique provides a powerful effective and reliable tool to investigate properties of polymer solutions. Among the ultrasonic measurements, the ultrasonic velocity measurements are easy to carry out with less instrumentation and much reliability. Propagation of ultrasonic wave in polymer -polymer solution forms the basis for the qualitative characterization. The studies of ultrasonic wave propagation in solids provide valuable informations [8,9] on the structure of solids, the intra and intermolecular interactions and behavior of polymeric chain in an ultrasonic field [10].

A review of literature [11-14] on acoustical studies on polymer solutions reveals that ultrasonic velocity measurements are used to understand the nature of molecular interactions. In recent years, an extensive use of polymeric materials in technology has necessitated the study of molecular interactions of polymers with solvents. Knowledge of acoustical properties of any solutions gives information about interactions occurring in the solutions like excess volume; the isentropic compressibility also throws light on the nature and degree of molecular interactions in the binary mixtures.

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Recently sound velocity measurements on condensation polymers in protic or aprotic solvents are carried out by Parsania et.al. [15-32] and investigated the influence of solvent, concentration, temperature and the nature of the substituents on the structure of polymers and molecular interactions in the solutions under investigations.

With a view to understand the influence of solvents on the structure and molecular interactions occurring in the solutions, the present chapter reports the effects of temperature, concentration and solvent on sound velocity and acoustical parameters of SBDAC-1 to 16 solutions.

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EXPERIMENTAL

The solvents and SBDAC-1 to 16 used in the present study were purified by appropriate methods prior to their use. The densities (?), viscosities (?) and sound velocities(U) were measured by means of specific gravity bottle, Ubbelohde suspended level viscometer and multi frequency interferometer operating at 2 MHz (Mittal Enterprises, New Delhi),respectively. All the measurements were carried out at three different temperatures: 30^{o}, 35^{o}, $40^{o} \pm 0.1^{o}$ C

(1) Density measurements

The densities of pure solvents were measured by means of specific gravity bottle at three different temperatures: 30^{o}, 35^{o} and 40^{o}C by determining the weights of distilled water, solvents and solutions. The density (ρ) was calculated according to Eqn. 5.1 with an accuracy of ± 0.0001 g/cm^{3}:

$$r \ \mathbf{(g / cc)} = \frac{Wt.of solvent/solution}{Wt.of water} \qquad \mathbf{\ldots\ 5.1}$$

(2) Viscosity measurements

The method for determining the dynamic viscosity or coefficient of viscosity of liquids relies on Stoke's law.

In present investigation, suspended level viscometer developed by Ubbelohde was used. The viscometer was washed with chromic acid, distilled water, acetone and then dried at 50^{o}C in an oven. Viscometer was suspended in a thermostat at 30 ± 0.1^{o}C and measured quantity of the distilled water / solvent / solution was placed into the viscometer reservoir by means of a pipette and thermally equilibrated for about 10 min. The efflux time of liquid between two marks was measured by means of digital stopwatch with an accuracy of ± 0.01 sec. Three replicate measurements on each liquid were made and the arithmetic mean was considered for the purpose of calculations.

Using the flow times (t) and known viscosity of standard (water) sample, the viscosities of solvents and solutions were determined according to Eqn. 5.2.:

$$\frac{\eta_1}{\eta_2} = \frac{t_1 \rho_1}{t_2 \rho_2} \qquad \text{… 5.2}$$

Where η_1, ρ_1, t_1 and η_2, ρ_2, t_2 are the viscosities, densities and flow times of standard and unknown samples, respectively.

(3) Sound velocity measurements

Ultrasonic interferometer (F-81) (Mittal Enterprises, New Delhi) was used in the present investigation. The working of interferometer was tested by measuring the sound velocity of pure solvents: benzene, n-hexane, cyclohexane and carbon tetrachloride and comparing the results with literature data. The advantage of this instrument is that the quantity of sample needed for measurement is small (15-20 ml).

The measuring cell (2 MHz) with quartz crystal was filled with the solvent/ solution and then micrometer was fixed. The circulation of water from the thermostat (at 30^o, 35^o and 40^oC) was started and the experimental liquid in the cell is allowed to thermally equilibrate. The high frequency generator was switched on and the micrometer was rotated very slowly so as to obtain a maximum or minimum of the anode current. A number of maximum readings of anode current (n) were counted. The total distance (d) traveled by the micrometer for n=20 was read. The wave length (λ) was determined according to Eqn. 5. 3 :

$$\lambda = \frac{2d}{n} \qquad \text{…5.3}$$

The sound velocity (U) of solvents and solutions were calculated from the wave length (λ) and frequency (F) according to Eqn. 5.4:

$$U = \lambda \, . \, F \qquad \text{… 5.4}$$

RESULTS AND DISCUSSIONS

The density (?), viscosity(?) and sound velocity (U) for pure solvents and SABDAC –1 to 16 solutions at three different temperatures 30^0, 35^0 and 40^0C were determined according to Eqns. 5.1, 5.2 and 5.4, respectively and are reported in Tables 5.1to 5.45 along with pooled precision standard deviation (Sp) of wave length determination. It is observed that ? decreased linearly with C and decreased with T in CF. It is increased linearly with C and decreased with T in DMF, DO and THF. ? increased linearly with C and decreased with T in all solvent systems. U increased linearly with C and decreased with T except in DMF where it increased linearly with temperature.

?, ? and U are correlated with C and T. Least square Eqns. along with correlation coefficients (?) are reported in Tables 5.46 to 5.90, from which it is clear that good to excellent correlation observed for said parameters. Linear increase of ?, ? and U which indicated increase in cohesion forces due to strong molecular interactions (solute – solvents). Linear decrease ?, ? and U with C support decrease in cohesion forces.

Change in ? and U with C and T are not as appreciable as ? because molecular motion is affected by solvent–solute and solute – solute interactions [33 -36]. The increase in T results increase in kinetic energy and volume expansion and hence decrease of ? and ? and increase in intermolecular free path length [37].

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Table-5.1: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-1solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^{3}	Viscosity ?. 10^{3} Pa s.	Ave. Dist. d.10^{3}, m	Wave length ?.10^{3},m	U ms^{-1} (F=2MHz)	Sp.
SBDAC- 1+ CF at 30^{o} C						
0	1465.7	0.619	4.795	0.4795	959.0	0.002
0.01	1458.7	0.643	4.806	0.4806	961.2	
0.02	1455.1	0.679	4.818	0.4818	963.6	
0.04	1451.6	0.705	4.837	0.4837	967.4	
0.06	1448.1	0.728	4.844	0.4844	968.8	
0.08	1444.8	0.752	4.853	0.4853	970.6	
0.1	1442.5	0.776	4.866	0.4866	973.2	
SBDAC-1 + CF at 35^{o} C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1455.5	0.618	4.768	0.4768	953.6	
0.02	1451.9	0.628	4.786	0.4786	957.2	
0.04	1448	0.640	4.803	0.4803	960.6	
0.06	1444	0.676	4.818	0.4818	963.6	
0.08	1440.7	0.701	4.837	0.4837	967.4	
0.1	1437.8	0.724	4.848	0.4848	969.6	
SBDAC- 1 + CF at 40^{o} C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1452.9	0.589	4.717	0.4717	943.4	
0.02	1449.1	0.602	4.737	0.4737	947.4	
0.04	1445.4	0.625	4.765	0.4765	953.0	
0.06	1441.6	0652	4.787	0.4787	957.4	
0.08	1438.4	0.675	4.803	0.4803	960.6	
0.1	1435.7	0.697	4.818	0.4818	963.6	

Table-5.2: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-1 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp.**
SBDAC-1 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.001
0.01	946.3	0.984	7.268	0.7268	1453.6	
0.02	948.7	0.102	7.306	0.7306	1461.2	
0.04	951.2	0.108	7.347	0.7347	1469.4	
0.06	953.6	0.113	7.384	0.7384	1476.8	
0.08	954.2	0.118	7.414	0.7414	1482.8	
0.1	955.9	0.122	7.437	0.7437	1487.4	
SBDAC-1 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	944.5	0.934	7.322	0.7322	1464.4	
0.02	946.8	0.979	7.349	0.7349	1469.8	
0.04	948.9	1.037	7.386	0.7386	1477.2	
0.06	951.4	1.080	7.415	0.7415	1483.0	
0.08	952.9	1.118	7.444	0.7444	1488.8	
0.1	954.9	1.158	7.464	0.7464	1492.8	
SBDAC-1 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	943.7	0.878	7.333	0.7333	1466.6	
0.02	946.4	0.946	7.366	0.7366	1473.2	
0.04	948.3	1.014	7.399	0.7399	1479.8	
0.06	950.6	1.055	7.424	0.7424	1484.8	
0.08	951.5	1.080	7.459	0.7459	1491.8	
0.1	953.8	1.120	7.487	0.7487	1497.4	

Table-5.3: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-1 solutions in DO at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-1 + DO at 30^{o} C						
0	1043	0.110	6.637	0.6637	1327.4	0.002
0.01	1044	0.112	6.708	0.6708	1341.6	
0.02	1045	0.116	6.745	0.6745	1349.0	
0.04	1048	0.119	6.784	0.6784	1356.8	
0.06	1051	0.123	6.812	0.6812	1362.4	
0.08	1054	0.126	6.845	0.6845	1369.0	
0.1	1057	0.131	6.848	0.6848	1369.6	
SBDAC-1+ DO at 35^{o} C						
0	1039	1.042	6.598	0.6598	1319.6	0.001
0.01	1040	1.056	6.698	0.6698	1339.6	
0.02	1043	1.067	6.737	0.6737	1347.4	
0.04	1046	1.111	6.748	0.6748	1349.6	
0.06	1049	1.131	6.765	0.6765	1353.0	
0.08	1052	1.175	6.806	0.6806	1361.2	
0.1	1056	1.227	6.826	0.6826	1365.2	
SBDAC-1+ DO at 40^{o} C						
0	1035	1.015	6.459	0.6459	1291.8	0.001
0.01	1036	1.014	6.626	0.6626	1325.2	
0.02	1039	1.033	6.656	0.6656	1331.2	
0.04	1043	1.059	6.696	0.6696	1339.2	
0.06	1046	1.074	6.727	0.6727	1345.4	
0.08	1050	1.127	6.765	0.6765	1353.0	
0.1	1054	1.178	6.787	0.6787	1357.4	

Table-5.4: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-2 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-2 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.002
0.01	1460.0	0.643	4.808	0.4808	961.6	
0.02	1456.2	0.669	4.817	0.4817	963.4	
0.04	1452.6	0.720	4.837	0.4837	967.4	
0.06	1449.0	0.779	4.856	0.4856	971.2	
0.08	1443.6	0.817	4.884	0.4884	976.8	
0.1	1440.3	0.861	4.908	0.4908	981.6	
SBDAC-2 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1454.1	0.600	4.732	0.4732	946.4	
0.02	1450.6	0.624	4.748	0.4748	949.6	
0.04	1446.8	0.661	4.766	0.4766	953.2	
0.06	1443.1	0.726	4.792	0.4792	958.4	
0.08	1439.8	0.770	4.817	0.4817	963.4	
0.1	1438.0	0.814	4.838	0.4838	967.6	
SBDAC-2 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1451.7	0.577	4.638	0.4638	927.6	
0.02	1449.0	0.619	4.654	0.4654	930.8	
0.04	1446.2	0.668	4.682	0.4682	936.4	
0.06	1442.8	0734	4.707	0.4707	941.4	
0.08	1439.7	0.738	4.727	0.4727	945.4	
0.1	1436.9	0.782	4.747	0.4747	949.4	

Table-5.5: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-2 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-2 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	946.1	0.985	7.286	0.7286	1457.2	
0.02	948.8	1.032	7.316	0.7316	1463.2	
0.04	951.2	1.085	7.354	0.7354	1470.8	
0.06	953.6	1.145	7.398	0.7398	1479.6	
0.08	955.4	1.199	7.435	0.7435	1487.0	
0.1	957.2	1.239	7.464	0.7464	1492.8	
SBDAC-2 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.001
0.01	944.8	0.906	7.317	0.7317	1463.4	
0.02	947.2	0.953	7.356	0.7356	1471.2	
0.04	949.8	1.007	7.388	0.7388	1477.6	
0.06	952.8	1.068	7.422	0.7422	1484.4	
0.08	954.6	1.118	7.465	0.7465	1493.0	
0.1	956.5	1.171	7.497	0.7497	1499.4	
SBDAC- 2+ DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	943.3	0.883	7.346	0.7346	1469.2	
0.02	946.6	0.946	7.376	0.7376	1475.2	
0.04	948.9	0.994	7.407	0.7407	1481.4	
0.06	952.0	1.042	7.457	0.7457	1491.4	
0.08	954.3	1.107	7.486	0.7486	1497.2	
0.1	956.2	1.138	7.527	0.7527	1505.4	

Table-5.6: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-2 solutions in DO at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC- 2+ DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.001
0.01	1044	1.104	6.717	0.6717	1343.4	
0.02	1046	1.132	6.754	0.6754	1350.8	
0.04	1048	1.182	6.784	0.6784	1356.8	
0.06	1051	1.229	6.821	0.6821	1364.2	
0.08	1055	1.258	6.855	0.6855	1371.0	
0.1	1058	1.296	6.884	0.6884	1376.8	
SBDAC-2 + DO at 35^o C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1040	1.048	6.685	0.6685	1337.0	
0.02	1044	1.077	6.723	0.6723	1344.6	
0.04	1047	1.123	6.765	0.6765	1353.0	
0.06	1050	1.167	6.802	0.6802	1360.4	
0.08	1054	1.204	6.826	0.6826	1365.2	
0.1	1057	1.233	6.865	0.6865	1373.0	
SBDAC-2 + DO at 40^o C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1037	1.026	6.662	0.6662	1332.4	
0.02	1042	1.057	6.707	0.6707	1341.4	
0.04	1045	1.107	6.756	0.6756	1351.2	
0.06	1048	1.143	6.782	0.6782	1356.4	
0.08	1052	1.179	6.818	0.6818	1363.6	
0.1	1054	1.219	6.846	0.6846	1369.2	

Table-5.7: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-3 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-3 + CF at 30^o C						
0	1465.7	0.619	4.795	0.4795	959.0	0.002
0.01	1460.6	0.646	4.815	0.4815	963.0	
0.02	1456.4	0.671	4.837	0.4837	967.4	
0.04	1452.8	0.717	4.862	0.4862	972.4	
0.06	1447.3	0.739	4.893	0.4893	978.6	
0.08	1443.0	0.776	4.925	0.4925	985.0	
0.1	1440.6	0.814	4.957	0.4957	991.4	
SBDAC-3 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1455.0	0.584	4.746	0.4746	949.2	
0.02	1451.0	0.617	4.768	0.4768	953.6	
0.04	1447.7	0.655	4.795	0.4795	959.0	
0.06	1443.8	0.696	4.826	0.4826	965.2	
0.08	1440.2	0.738	4.846	0.4846	969.2	
0.1	1437.0	0.766	4.868	0.4868	973.6	
SBDAC-3 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1454.8	0.562	4.684	0.4684	936.8	
0.02	1446.3	0.597	4.717	0.4717	943.4	
0.04	1442.0	0.648	4.753	0.4753	950.6	
0.06	1438.2	0.671	4.784	0.4784	956.8	
0.08	1435.3	0.705	4.806	0.4806	961.2	
0.1	1432.7	0.736	4.826	0.4826	965.2	

Table-5.8 : The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-3 solutions in DMF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-3 + DMF at 30^{o} C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	944.8	0.926	7.296	0.7296	1459.2	
0.02	946.5	0.959	7.348	0.7348	1469.6	
0.04	948.9	0.982	7.386	0.7386	1477.2	
0.06	950.6	0.997	7.436	0.7436	1487.2	
0.08	953.6	1.029	7.475	0.7475	1495.0	
0.1	956.0	1.051	7.507	0.7507	1501.4	
SBDAC-3 + DMF at 35^{o} C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	944.3	0.892	7.319	0.7319	1463.8	
0.02	945.5	0.920	7.356	0.7356	1471.2	
0.04	947.7	0944	7.399	0.7399	1479.8	
0.06	949.4	0.959	7.456	0.7456	1491.2	
0.08	951.0	0.988	7.495	0.7495	1499.0	
0.1	953.1	1.013	7.538	0.7538	1507.6	
SBDAC-3+ DMF at 40^{o} C						
0	916.4	0.777	7.322	0.7322	1464.4	0.003
0.01	943.1	0.830	7.328	0.7328	1465.6	
0.02	945.1	0.893	7.376	0.7376	1475.2	
0.04	947.0	0.927	7.424	0.7424	1484.8	
0.06	947.7	0.950	7.498	0.7498	1499.6	
0.08	950.4	0.981	7.546	0.7546	1509.2	
0.1	952.5	0.996	7.565	0.7565	1513.0	

Table-5.9: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-4 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC- 4 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1458.4	0.636	4.801	0.4801	960.2	
0.02	1454.3	0.700	4.827	0.4827	965.4	
0.04	1449.8	0.721	4.866	0.4866	973.2	
0.06	1446.2	0.760	4.897	0.4897	979.4	
0.08	1442.9	0.773	4.925	0.4925	985.0	
0.1	1441.2	0.809	4.948	0.4948	989.6	
SBDAC-4 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1454.9	0.629	4.734	0.4734	946.8	
0.02	1452.4	0.655	4.745	0.4745	949.0	
0.04	1448.5	0.683	4.757	0.4757	951.4	
0.06	1445.1	0.717	4.778	0.4778	955.6	
0.08	1442.0	0.750	4.786	0.4786	957.2	
0.1	1439.6	0.774	4.796	0.4796	959.2	
SBDAC- 4 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1453.6	0.590	4.644	0.4644	928.8	
0.02	1450.9	0.625	4.668	0.4668	933.6	
0.04	1447.3	0.661	4.686	0.4686	937.2	
0.06	1443.9	0.694	4.705	0.4705	941.0	
0.08	1440.8	0.725	4.721	0.4721	944.2	
0.1	1438.4	0.750	4.738	0.4738	947.6	

Table-5.10: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-4 solutions in DMF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-4 + DMF at 30^{o} C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	945.8	0.896	7.276	0.7276	1455.2	
0.02	947.2	0.937	7.307	0.7307	1461.4	
0.04	949.4	0.962	7.335	0.7335	1467.0	
0.06	951.2	0.999	7.388	0.7388	1477.6	
0.08	954.4	1.038	7.426	0.7426	1485.2	
0.1	956.5	1.066	7.456	0.7456	1491.2	
SBDAC-4 + DMF at 35^{o} C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	944.5	0.855	7.318	0.7318	1463.6	
0.02	946.1	0.885	7.346	0.7346	1469.2	
0.04	948.5	0.925	7.382	0.7382	1476.4	
0.06	950.7	0.946	7.416	0.7416	1483.2	
0.08	953.5	1.005	7.457	0.7457	1491.4	
0.1	955.6	1.025	7.486	0.7486	1497.2	
SBDAC-4 + DMF at 40^{o} C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	943.9	0.828	7.343	0.7343	1468.6	
0.02	946.0	0.852	7.377	0.7377	1475.4	
0.04	947.6	0.899	7.416	0.7416	1483.2	
0.06	950.4	0.931	7.447	0.7447	1489.4	
0.08	953.1	0967	7.476	0.7476	1495.2	
0.1	955.4	0.999	7.506	0.7506	1501.2	

Table-5.11: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-5 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-5 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.002
0.01	1458.1	0.674	4.817	0.4817	963.4	
0.02	1454.6	0.734	4.826	0.4826	965.2	
0.04	1450.4	0.787	4.856	0.4856	971.2	
0.06	1446.7	0.830	4.886	0.4886	977.2	
0.08	1443.9	0.866	4.908	0.4908	981.6	
0.1	1441.2	0.893	4.926	0.4926	985.2	
SBDAC-5 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1454.6	0.619	4.736	0.4736	947.2	
0.02	1451.2	0.666	4.746	0.4746	949.2	
0.04	1447.9	0.717	4.764	0.4764	952.8	
0.06	1445.0	0.753	4.795	0.4795	959.0	
0.08	1441.8	0.784	4.816	0.4816	963.2	
0.1	1439.6	0.849	4.836	0.4836	967.2	
SBDAC-5 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1453.5	0.614	4.637	0.4637	927.4	
0.02	1450.6	0.638	4.642	0.4642	928.4	
0.04	1446.8	0.660	4.658	0.4658	931.6	
0.06	1443.4	0.747	4.696	0.4696	939.2	
0.08	1440.5	0.748	4.727	0.4727	945.4	
0.1	1438.2	0.767	4.744	0.4744	948.8	

Table-5.12: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-5 solutions in DMF at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-5 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	945.1	0.901	7.395	0.7395	1479.0	
0.02	947.5	0.934	7.429	0.7429	1485.8	
0.04	949.5	0.967	7.471	0.7471	1494.2	
0.06	955.0	1.010	7.512	0.7512	1502.4	
0.08	960.2	1.050	7.533	0.7533	1506.6	
0.1	963.7	1.079	7.546	0.7546	1509.2	
SBDAC-5 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	944.0	0.861	7.426	0.7426	1485.2	
0.02	946.9	0.892	7.458	0.7458	1491.6	
0.04	948.7	0.928	7.498	0.7498	1499.6	
0.06	954.5	0.962	7.532	0.7532	1506.4	
0.08	959.1	1.010	7.540	0.754	1508.0	
0.1	963.3	1.038	7.556	0.7556	1511.2	
SBDAC-5+ DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.003
0.01	942.3	0.842	7.446	0.7446	1489.2	
0.02	945.7	0.878	7.480	0.748	1496.0	
0.04	948.0	0.904	7.524	0.7524	1504.8	
0.06	953.9	0.942	7.547	0.7547	1509.4	
0.08	958.5	0.984	7.558	0.7558	1511.6	
0.1	963.1	1.018	7.572	0.7572	1514.4	

Table-5.13: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-5 solutions in DO at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-5 + DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.002
0.01	1054	1.229	6.648	0.6648	1329.6	
0.02	1057	1.267	6.684	0.6684	1336.8	
0.04	1061	1.311	6.722	0.6722	1344.4	
0.06	1064	1.355	6.768	0.6768	1353.6	
0.08	1066	1.399	6.798	0.6798	1359.6	
0.1	1069	1.450	6.843	0.6843	1368.6	
SBDAC-5 + DO at 35^o C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1047	1.129	6.615	0.6615	1323.0	
0.02	1051	1.187	6.656	0.6656	1331.2	
0.04	1054	1.230	6.686	0.6686	1337.2	
0.06	1059	1.277	6.718	0.6718	1343.6	
0.08	1064	1.318	6.756	0.6756	1351.2	
0.1	1067	1.361	6.797	0.6797	1359.4	
SBDAC-5 + DO at 40^o C						
0	1035	1.014	6.459	0.6459	1291.8	0.002
0.01	1036	1.112	6.596	0.6596	1319.2	
0.02	1041	1.160	6.623	0.6623	1324.6	
0.04	1050	1.195	6.656	0.6656	1331.2	
0.06	1057	1.241	6.691	0.6691	1338.2	
0.08	1062	1.280	6.725	0.6725	1345.0	
0.1	1065	1.300	6.744	0.6744	1348.8	

Table-5.14: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-5 solutions in THF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^{3}**	**Viscosity ?. 10^{3} Pa s.**	**Ave. Dist. d.10^{3}, m**	**Wave length ?.10^{3},m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-5 + THF at 30^{o} C						
0	882.3	0.470	6.319	0.6319	1263.8	0.001
0.01	888.9	0.543	6.386	0.6386	1277.2	
0.02	892.1	0.566	6.416	0.6416	1283.2	
0.04	895.4	0.604	6.447	0.6447	1289.4	
0.06	898.6	0.631	6.483	0.6483	1296.6	
0.08	900.7	0.670	6.517	0.6517	1303.4	
0.1	902.7	0.694	6.548	0.6548	1309.6	
SBDAC-5 + THF at 35^{o} C						
0	881.8	0.446	6.168	0.6168	1233.6	0.002
0.01	887.9	0.478	6.247	0.6247	1249.4	
0.02	891.2	0.492	6.278	0.6278	1255.6	
0.04	894.4	0.541	6.317	0.6317	1263.4	
0.06	897.5	0.579	6.344	0.6344	1268.8	
0.08	899.5	0.625	6.377	0.6377	1275.4	
0.1	902.1	0.657	6.404	0.6404	1280.8	
SBDAC- 5 + THF at 40^{o} C						
0	881.2	0.429	6.084	0.6084	1216.8	0.002
0.01	882.9	0.431	6.177	0.6177	1235.4	
0.02	886.3	0.460	6.209	0.6209	1241.8	
0.04	889.9	0.503	6.235	0.6235	1247.0	
0.06	892.3	0.541	6.280	0.6280	1256.0	
0.08	895.0	0.580	6.306	0.6306	1261.2	
0.1	897.3	0.615	6.325	0.6325	1265.0	

Table-5.15: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-6 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC- 6+ CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1460.5	0.701	4.817	0.4817	963.4	
0.02	1455.1	0.732	4.826	0.4826	965.2	
0.04	1451.4	0.779	4.846	0.4846	969.2	
0.06	1448.1	0.807	4.874	0.4874	974.8	
0.08	1444.3	0.845	4.891	0.4891	978.2	
0.1	1441.4	0.883	4.907	0.4907	981.4	
SBDAC-6 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1453.5	0.651	4.738	0.4738	947.6	
0.02	1450.3	0.674	4.757	0.4757	951.4	
0.04	1446.8	0.698	4.776	0.4776	955.2	
0.06	1443.0	0.748	4.796	0.4796	959.2	
0.08	1439.7	0.791	4.816	0.4816	963.2	
0.1	1437.5	0.824	4.838	0.4838	967.6	
SBDAC-6 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1451.5	0.596	4.636	0.4636	927.2	
0.02	1448.6	0.633	4.647	0.4647	929.4	
0.04	1445.3	0.674	4.675	0.4675	935.0	
0.06	1442.2	0.722	4.708	0.4708	941.6	
0.08	1439.4	0.763	4.727	0.4727	945.4	
0.1	1436.4	0.798	4.747	0.4747	949.4	

Table-5.16: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-6 solutions in DMF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC- 6+ DMF at 30^{o} C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	949.6	0.869	7.426	0.7426	1485.2	
0.02	953.2	0.925	7.462	0.7462	1492.4	
0.04	956.6	0.977	7.497	0.7497	1499.4	
0.06	960.1	1.010	7.526	0.7526	1505.2	
0.08	962.4	1.060	7.545	0.7545	1509.0	
0.1	965.0	1.090	7.567	0.7567	1513.4	
SBDAC-6 + DMF at 35^{o} C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	948.7	0.833	7.455	0.7455	1491	
0.02	952.8	0.855	7.493	0.7493	1498.6	
0.04	956.0	0.909	7.528	0.7528	1505.6	
0.06	959.2	0.951	7.545	0.7545	1509.0	
0.08	962.0	0.996	7.577	0.7577	1515.4	
0.1	964.3	1.040	7.606	0.7606	1521.2	
SBDAC- 6 + DMF at 40^{o} C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	948.1	0.818	7.464	0.7464	1492.8	
0.02	952.0	0.834	7.497	0.7497	1499.4	
0.04	955.3	0.871	7.542	0.7542	1508.4	
0.06	958.6	0.919	7.566	0.7566	1513.2	
0.08	961.8	0.961	7.604	0.7604	1520.8	
0.1	963.8	1.018	7.637	0.7637	1527.4	

Table-5.17: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-6 solutions in DO at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC- 6+ DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.002
0.01	1048	1.161	6.708	0.6708	1341.6	
0.02	1052	1.249	6.747	0.6747	1349.4	
0.04	1056	1.261	6.776	0.6776	1355.2	
0.06	1059	1.314	6.806	0.6806	1361.2	
0.08	1064	1.377	6.837	0.6837	1367.4	
0.1	1068	1.409	6.868	0.6868	1373.6	
SBDAC-6 + DO at 35^o C						
0	1039	1.044	6.598	0.6598	1319.6	0.002
0.01	1042	1.109	6.664	0.6664	1332.8	
0.02	1045	1.154	6.705	0.6705	1341.0	
0.04	1054	1.210	6.738	0.6738	1347.6	
0.06	1056	1.259	6.767	0.6767	1353.4	
0.08	1062	1.316	6.796	0.6796	1359.2	
0.1	1066	1.350	6.828	0.6828	1365.6	
SBDAC-6 + DO at 40^o C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1040	1.085	6.626	0.6626	1325.2	
0.02	1046	1.139	6.657	0.6657	1331.4	
0.04	1051	1.023	6.697	0.6697	1339.4	
0.06	1055	1.250	6.726	0.6726	1345.2	
0.08	1062	1.303	6.759	0.6759	1351.8	
0.1	1065	1.341	6.786	0.6786	1357.2	

Table-5.18: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-7 solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-7+ CF at 30^{o} C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1458.2	0.638	4.807	0.4807	961.4	
0.02	1453.6	0.684	4.826	0.4826	965.2	
0.04	1449.7	0.763	4.846	0.4846	969.2	
0.06	1446.5	0.821	4.861	0.4861	972.2	
0.08	1443.3	0.847	4.881	0.4881	976.2	
0.1	1441.1	0.872	4.896	0.4896	979.2	
SBDAC-7 + CF at 35^{o} C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1448.7	0.590	4.746	0.4746	949.2	
0.02	1444.7	0.634	4.756	0.4756	951.2	
0.04	1440.8	0.725	4.774	0.4774	954.8	
0.06	1436.9	0.756	4.786	0.4786	957.2	
0.08	1433.8	0.778	4.808	0.4808	961.6	
0.1	1431.4	0.796	4.828	0.4828	965.6	
SBDAC-7 + CF at 40^{o} C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1445.0	0.572	4.656	0.4656	931.2	
0.02	1441.0	0.623	4.665	0.4665	933.0	
0.04	1437.2	0.709	4.686	0.4686	937.2	
0.06	1433.6	0.726	4.718	0.4718	943.6	
0.08	1430.5	0.738	4.730	0.473	946.0	
0.1	1428.1	0.757	4.746	0.4746	949.2	

Table-5.19: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-7 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-7 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	955.4	0.999	7.605	0.7605	1521.0	
0.02	958.6	1.060	7.635	0.7635	1527.0	
0.04	961.2	1.100	7.668	0.7668	1533.6	
0.06	963.5	1.115	7.687	0.7687	1537.4	
0.08	967.2	1.148	7.716	0.7716	1543.2	
0.1	969.6	1.178	7.758	0.7758	1551.6	
SBDAC-7 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	951.0	0.920	7.626	0.7626	1525.2	
0.02	954.7	0.962	7.653	0.7653	1530.6	
0.04	959.3	1.003	7.685	0.7685	1537.0	
0.06	962.1	1.055	7.716	0.7716	1543.2	
0.08	964.9	1.084	7.748	0.7748	1549.6	
0.1	967.5	1.122	7.784	0.7784	1556.8	
SBDAC-7 + DMF at 40^o C						
0	916.4	0.774	7.322	0.7322	1464.4	0.002
0.01	950.2	0.866	7.654	0.7654	1530.8	
0.02	954.2	0.932	7.686	0.7686	1537.2	
0.04	958.9	0.988	7.716	0.7716	1543.2	
0.06	961.4	1.013	7.748	0.7748	1549.6	
0.08	964.8	1.069	7.777	0.7777	1555.4	
0.1	966.7	1.090	7.806	0.7806	1561.2	

Table-5.20: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-8 solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^{3}**	**Viscosity ?. 10^{3} Pa s.**	**Ave. Dist. d.10^{3}, m**	**Wave length ?.10^{3},m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-8 + CF at 30^{o} C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1458.7	0.715	4.836	0.4836	967.2	
0.02	1454.8	0.774	4.874	0.4874	974.8	
0.04	1451.9	0.821	4.899	0.4899	979.8	
0.06	1448.1	0.887	4.937	0.4937	987.4	
0.08	1445.5	0.913	4.957	0.4957	991.4	
0.1	1442.9	0.947	4.975	0.4975	995.0	
SBDAC-8 + CF at 35^{o} C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1457.1	0.627	4.787	0.4787	957.4	
0.02	1453.8	0.670	4.818	0.4818	963.6	
0.04	1451.5	0.739	4.847	0.4847	969.4	
0.06	1447.9	0.775	4.877	0.4877	975.4	
0.08	1444.0	0.839	4.897	0.4897	979.4	
0.1	1440.3	0.874	4.916	0.4916	983.2	
SBDAC-8 + CF at 40^{o} C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1453.8	0.616	4.683	0.4683	936.6	
0.02	1450.6	0.645	4.718	0.4718	943.6	
0.04	1448.1	0.714	4.755	0.4755	951.0	
0.06	1445.0	0.761	4.787	0.4787	957.4	
0.08	1441.5	0.813	4.807	0.4807	961.4	
0.1	1438.1	0.877	4.826	0.4826	965.2	

Table-5.21: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-8 solutions in DMF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-8 + DMF at 30^{o} C						
0	932.8	0.848	7.257	0.7257	1451.4	0.003
0.01	951.9	0.907	7.416	0.7416	1483.2	
0.02	956.4	0.952	7.447	0.7447	1489.4	
0.04	958.7	0.993	7.482	0.7482	1496.4	
0.06	961.5	1.040	7.515	0.7515	1503.0	
0.08	963.4	1.090	7.546	0.7546	1509.2	
0.1	965.1	1.130	7.578	0.7578	1515.6	
SBDAC -8+ DMF at 35^{o} C						
0	927.5	0.814	7.293	0.7293	1458.6	0.002
0.01	950.5	0.866	7.425	0.7425	1485.0	
0.02	954.0	0.916	7.462	0.7462	1492.4	
0.04	957.1	0.952	7.527	0.7527	1505.4	
0.06	959.6	1.010	7.546	0.7546	1509.2	
0.08	962.3	1.040	7.565	0.7565	1513.0	
0.1	964.5	1.070	7.596	0.7596	1519.2	
SBDAC- 8+ DMF at 40^{o} C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	950.2	0.847	7.446	0.7446	1489.2	
0.02	953.2	0.898	7.476	0.7476	1495.2	
0.04	956.4	0.937	7.538	0.7538	1507.6	
0.06	959.1	0.999	7.556	0.7556	1511.2	
0.08	961.5	1.030	7.586	0.7586	1517.2	
0.1	964.3	1.060	7.617	0.7617	1523.4	

Table-5.22: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-8 solutions in DO at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-8 + DO at 30^o C						
0	1043	1.101	6.637	0.6637	1327.4	0.002
0.01	1051	1.190	6.716	0.6716	1343.2	
0.02	1055	1.240	6.743	0.6743	1348.6	
0.04	1059	1.273	6.775	0.6775	1355.0	
0.06	1063	1.332	6.803	0.6803	1360.6	
0.08	1068	1.384	6.827	0.6827	1365.4	
0.1	1070	1.421	6.854	0.6854	1370.8	
SBDAC-8 + DO at 35^o C						
0	1039	1.041	6.598	0.6598	1319.6	0.001
0.01	1050	1.111	6.647	0.6647	1329.4	
0.02	1055	1.175	6.696	0.6696	1339.2	
0.04	1059	1.214	6.728	0.6728	1345.6	
0.06	1062	1.26	6.755	0.6755	1351.0	
0.08	1065	1.303	6.787	0.6787	1357.4	
0.1	1068	1.350	6.826	0.6826	1365.2	
SBDAC-8 + DO at 40^o C						
0	1035	1.023	6.459	0.6459	1291.8	0.002
0.01	1045	1.096	6.628	0.6628	1325.6	
0.02	1050	1.152	6.676	0.6676	1335.2	
0.04	1054	1.200	6.708	0.6708	1341.6	
0.06	1057	1.240	6.743	0.6743	1348.6	
0.08	1061	1.280	6.774	0.6774	1354.8	
0.1	1064	1.320	6.798	0.6798	1359.6	

Table-5.23: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-9 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-9 + CF at 30^o C						
0	1465.7	0.619	4.795	0.4795	959.0	0.001
0.01	1460.3	0.645	4.807	0.4807	961.4	
0.02	1456.7	0.664	4.835	0.4835	967.0	
0.04	1452.7	0.735	4.866	0.4866	973.2	
0.06	1449.5	0.803	4.892	0.4892	978.4	
0.08	1446.3	0.846	4.916	0.4916	983.2	
0.1	1444.0	0.885	4.935	0.4935	987.0	
SBDAC-9 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1457.7	0.623	4.755	0.4755	951.0	
0.02	1455.7	0.694	4.775	0.4775	955.0	
0.04	1450.9	0.735	4.806	0.4806	961.2	
0.06	1447.3	0.766	4.836	0.4836	967.2	
0.08	1444.9	0.804	4.868	0.4868	973.6	
0.1	1442.3	0.831	4.888	0.4888	977.6	
SBDAC-9 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1458.4	0.602	4.674	0.4674	934.8	
0.02	1455.1	0.630	4.698	0.4698	939.6	
0.04	1450.0	0.693	4.737	0.4737	947.4	
0.06	1447.0	0.736	4.796	0.4796	959.2	
0.08	1443.9	0.763	4.827	0.4827	965.4	
0.1	1440.6	0.792	4.846	0.4846	969.2	

Table-5.24: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-9 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-9 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.003
0.01	949.5	0.933	7.419	0.7419	1483.8	
0.02	954.2	0.984	7.453	0.7453	1490.6	
0.04	956.7	1.040	7.486	0.7486	1497.2	
0.06	960.6	1.088	7.496	0.7496	1499.2	
0.08	963.8	1.103	7.518	0.7518	1503.6	
0.1	966.2	1.144	7.548	0.7548	1509.6	
SBDAC-9 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	948.5	0.880	7.438	0.7438	1487.6	
0.02	952.1	0.927	7.466	0.7466	1493.2	
0.04	956.3	0.991	7.507	0.7507	1501.4	
0.06	960.3	1.032	7.528	0.7528	1505.6	
0.08	963.1	1.055	7.545	0.7545	1509.0	
0.1	965.6	1.088	7.566	0.7566	1513.2	
SBDAC-9 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	948.0	0.848	7.466	0.7466	1493.2	
0.02	951.9	0.907	7.497	0.7497	1499.4	
0.04	955.7	0.972	7.529	0.7529	1505.8	
0.06	960.0	0.998	7.536	0.7536	1507.2	
0.08	963.3	1.034	7.566	0.7566	1513.2	
0.1	965.4	1.065	7.586	0.7586	1517.2	

Table-5.25: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-9 solutions in DO at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-9 + DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.001
0.01	1052	1.119	6.717	0.6717	1343.4	
0.02	1056	1.243	6.753	0.6753	1350.6	
0.04	1061	1.285	6.786	0.6786	1357.2	
0.06	1064	1.356	6.817	0.6817	1363.4	
0.08	1068	1.405	6.857	0.6857	1371.4	
0.1	1071	1.446	6.889	0.6889	1377.8	
SBDAC-9 + DO at 35^o C						
0	1039	1.042	6.598	0.6598	1319.6	0.001
0.01	1050	1.110	6.686	0.6686	1337.2	
0.02	1055	1.179	6.718	0.6718	1343.6	
0.04	1058	1.211	6.747	0.6747	1349.4	
0.06	1062	1.280	6.783	0.6783	1356.6	
0.08	1065	1.308	6.819	0.6819	1363.8	
0.1	1068	1.364	6.846	0.6846	1369.2	
SBDAC-9 + DO at 40^o C						
0	1035	1.015	6.459	0.6459	1291.8	0.001
0.01	1048	1.057	6.624	0.6624	1324.8	
0.02	1054	1.118	6.668	0.6668	1333.6	
0.04	1057	1.162	6.707	0.6707	1341.4	
0.06	1061	1.229	6.746	0.6746	1349.2	
0.08	1064	1.267	6.771	0.6771	1354.2	
0.1	1066	1.308	6.801	0.6801	1360.2	

Table-5.26: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-10 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-10 + CF at 30^o C						
0	1465.7	0.612	4.795	0.4795	959.0	0.002
0.01	1459.7	0.720	4.822	0.4822	964.4	
0.02	1455.1	0.777	4.846	0.4846	969.2	
0.04	1451.5	0.836	4.875	0.4875	975.0	
0.06	1448.1	0.872	4.906	0.4906	981.2	
0.08	1445.3	0.911	4.936	0.4936	987.2	
0.1	1442.5	0.940	4.957	0.4957	991.4	
SBDAC-10 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1457.0	0.653	4.784	0.4784	956.8	
0.02	1452.9	0.697	4.807	0.4807	961.4	
0.04	1449.2	0.754	4.837	0.4837	967.4	
0.06	1445.8	0.792	4.864	0.4864	972.8	
0.08	1443.1	0.850	4.896	0.4896	979.2	
0.1	1440.5	0.879	4.917	0.4917	983.4	
SBDAC-10 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1455.6	0.611	4.688	0.4688	937.6	
0.02	1451.8	0.655	4.727	0.4727	945.4	
0.04	1448.3	0.711	4.754	0.4754	950.8	
0.06	1444.7	0.762	4.784	0.4784	956.8	
0.08	1441.5	0.815	4.812	0.4812	962.4	
0.1	1439.4	0.851	4.837	0.4837	967.4	

Table-5.27: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-10 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-10 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	953.2	0.915	7.407	0.7407	1481.4	
0.02	957.5	0.959	7.456	0.7456	1491.2	
0.04	959.9	0.996	7.484	0.7484	1496.8	
0.06	962.1	1.030	7.506	0.7506	1501.2	
0.08	963.6	1.081	7.533	0.7533	1506.6	
0.1	964.7	1.115	7.564	0.7564	1512.8	
SBDAC-10+ DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	952.6	0.892	7.426	0.7426	1485.2	
0.02	956.8	0.934	7.475	0.7475	1495.0	
0.04	959.2	0.961	7.515	0.7515	1503.0	
0.06	961.9	0.995	7.527	0.7527	1505.4	
0.08	963.3	1.031	7.546	0.7546	1509.2	
0.1	964.4	1.081	7.576	0.7576	1515.2	
SBDAC-10 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	952.4	0.874	7.456	0.7456	1491.2	
0.02	956.1	0.919	7.495	0.7495	1499.0	
0.04	958.9	0.952	7.523	0.7523	1504.6	
0.06	961.4	0.970	7.547	0.7547	1509.4	
0.08	963.0	1.015	7.568	0.7568	1513.6	
0.1	964.1	1.060	7.593	0.7593	1518.6	

Table-5.28: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-10 solutions in DO at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-10 + DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.002
0.01	1051	1.187	6.654	0.6654	1330.8	
0.02	1056	1.238	6.702	0.6702	1340.4	
0.04	1059	1.298	6.736	0.6736	1347.2	
0.06	1062	1.352	6.776	0.6776	1355.2	
0.08	1067	1.397	6.821	0.6821	1364.2	
0.1	1077	1.435	6.865	0.6865	1373.0	
SBDAC-10 + DO at 35^o C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1047	1.129	6.635	0.6635	1327.0	
0.02	1049	1.160	6.668	0.6668	1333.6	
0.04	1057	1.250	6.703	0.6703	1340.6	
0.06	1060	1.297	6.744	0.6744	1348.8	
0.08	1065	1.339	6.806	0.6806	1361.2	
0.1	1068	1.370	6.822	0.6822	1364.4	
SBDAC-10 + DO at 40^o C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1044	1.065	6.597	0.6597	1319.4	
0.02	1046	1.116	6.638	0.6638	1327.6	
0.04	1056	1.177	6.679	0.6679	1335.8	
0.06	1060	1.244	6.727	0.6727	1345.4	
0.08	1064	1.298	6.765	0.6765	1353.0	
0.1	1068	1.336	6.784	0.6784	1356.8	

Table-5.29: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-11 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC- 11+ CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1456.3	0.729	4.791	0.4791	958.2	
0.02	1452.8	0.765	4.806	0.4806	961.2	
0.04	1449.2	0.820	4.823	0.4823	964.6	
0.06	1445.4	0.875	4.856	0.4856	971.2	
0.08	1442.0	0.911	4.884	0.4884	976.8	
0.1	1439.1	0.959	4.906	0.4906	981.2	
SBDAC-11 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1454.4	0.681	4.737	0.4737	947.4	
0.02	1451.1	0.718	4.748	0.4748	949.6	
0.04	1447.1	0.774	4.756	0.4756	951.2	
0.06	1443.1	0.819	4.788	0.4788	957.6	
0.08	1439.6	0.860	4.818	0.4818	963.6	
0.1	1436.2	0.901	4.837	0.4837	967.4	
SBDAC-11 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1449.0	0.621	4.638	0.4638	927.6	
0.02	1445.1	0.656	4.646	0.4646	929.2	
0.04	1441.5	0.708	4.668	0.4668	933.6	
0.06	1438.2	0.745	4.696	0.4696	939.2	
0.08	1435.6	0.810	4.718	0.4718	943.6	
0.1	1432.7	0.851	4.748	0.4748	949.6	

Table-5.30: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-12 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-11 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	953.6	0.953	7.405	0.7405	1481.0	
0.02	957.7	1.016	7.452	0.7452	1490.4	
0.04	961.2	1.122	7.496	0.7496	1499.2	
0.06	964.7	1.186	7.522	0.7522	1504.4	
0.08	967.3	1.248	7.56	0.756	1512.0	
0.1	969.6	1.300	7.597	0.7597	1519.4	
SBDAC-11 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	953.3	0.899	7.416	0.7416	1483.2	
0.02	956.9	0.968	7.446	0.7446	1489.2	
0.04	960.3	1.052	7.497	0.7497	1499.4	
0.06	964.1	1.127	7.555	0.7555	1511.0	
0.08	967.0	1.186	7.596	0.7596	1519.2	
0.1	969.3	1.238	7.627	0.7627	1525.4	
SBDAC-11 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	952.6	0.874	7.464	0.7464	1492.8	
0.02	956.2	0.929	7.514	0.7514	1502.8	
0.04	959.0	0.988	7.546	0.7546	1509.2	
0.06	962.1	1.061	7.575	0.7575	1515.0	
0.08	964.7	1.109	7.624	0.7624	1524.8	
0.1	967.9	1.161	7.644	0.7644	1528.8	

Table-5.31: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-12 solutions in DO at three different temperatures: 30°, 35° and 40°C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-11 + DO at 30° C						
0	1043	1.103	6.637	0.6637	1327.4	0.002
0.01	1054	1.132	6.719	0.6719	1343.8	
0.02	1056	1.200	6.757	0.6757	1351.4	
0.04	1061	1.285	6.785	0.6785	1357.0	
0.06	1066	1.366	6.826	0.6826	1365.2	
0.08	1070	1.409	6.868	0.6868	1373.6	
0.1	1074	1.449	6.896	0.6896	1379.2	
SBDAC-11 + DO at 35° C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1049	1.086	6.706	0.6706	1341.2	
0.02	1053	1.147	6.742	0.6742	1348.4	
0.04	1058	1.216	6.780	0.678	1356.0	
0.06	1062	1.276	6.817	0.6817	1363.4	
0.08	1066	1.345	6.845	0.6845	1369.0	
0.1	1070	1.376	6.866	0.6866	1373.2	
SBDAC-11 + DO at 40° C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1048	1.046	6.676	0.6676	1335.2	
0.02	1052	1.113	6.719	0.6719	1343.8	
0.04	1057	1.198	6.755	0.6755	1351.0	
0.06	1061	1.268	6.786	0.6786	1357.2	
0.08	1064	1.314	6.817	0.6817	1363.4	
0.1	1068	1.347	6.840	0.684	1368.0	

Table-5.32: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-12 solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-12 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1458.4	0.679	4.798	0.4798	959.6	
0.02	1455.3	0.753	4.815	0.4815	963.0	
0.04	1451.8	0.765	4.838	0.4838	967.6	
0.06	1448.4	0.822	4.866	0.4866	973.2	
0.08	1444.8	0.860	4.897	0.4897	979.4	
0.1	1442.4	0.905	4.917	0.4917	983.4	
SBDAC-12 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1457.5	0.639	4.758	0.4758	951.6	
0.02	1453.8	0.706	4.775	0.4775	955.0	
0.04	1449.9	0.740	4.797	0.4797	959.4	
0.06	1446.7	0.786	4.827	0.4827	965.4	
0.08	1443.5	0828	4.856	0.4856	971.2	
0.1	1440.7	0.853	4.877	0.4877	975.4	
SBDAC-12 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1456.0	0.603	4.692	0.4692	938.4	
0.02	1453.3	0.654	4.718	0.4718	943.6	
0.04	1449.1	0.706	4.747	0.4747	949.4	
0.06	1446.0	0.757	4.773	0.4773	954.6	
0.08	1443.2	0.793	4.797	0.4797	959.4	
0.1	1440.3	0.819	4.816	0.4816	963.2	

Table-5.33: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-12 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-12 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	950.2	0.969	7.526	0.7526	1505.2	
0.02	953.8	1.005	7.577	0.7577	1515.4	
0.04	956.2	1.046	7.604	0.7604	1520.8	
0.06	959.8	1.085	7.628	0.7628	1525.6	
0.08	963.5	1.129	7.653	0.7653	1530.6	
0.1	965.0	1.160	7.677	0.7677	1535.4	
SBDAC-12 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	950.0	0.882	7.558	0.7558	1511.6	
0.02	953.5	0.937	7.594	0.7594	1518.8	
0.04	956.3	0.984	7.624	0.7624	1524.8	
0.06	959.1	1.035	7.647	0.7647	1529.4	
0.08	962.5	1.072	7.676	0.7676	1535.2	
0.1	964.6	1.103	7.695	0.7695	1539.0	
SBDAC-12 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	949.6	0.866	7.577	0.7577	1515.4	
0.02	953.1	0.920	7.618	0.7618	1523.6	
0.04	955.7	0.968	7.637	0.7637	1527.4	
0.06	958.7	1.005	7.653	0.7653	1530.6	
0.08	961.6	1.046	7.683	0.7683	1536.6	
0.1	963.7	1.073	7.707	0.7707	1541.4	

Table-5.34: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-12 solutions in DO at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-12 + DO at 30^{o} C						
0	1043	1.103	6.637	0.6637	1327.4	0.003
0.01	1046	1.112	6.664	0.6664	1332.8	
0.02	1048	1.178	6.698	0.6698	1339.6	
0.04	1051	1.236	6.724	0.6724	1344.8	
0.06	1055	1.293	6.766	0.6766	1353.2	
0.08	1059	1.340	6.798	0.6798	1359.6	
0.1	1060	1.374	6.828	0.6828	1365.6	
SBDAC-12 + DO at 35^{o} C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1043	1.048	6.616	0.6616	1323.2	
0.02	1045	1.137	6.659	0.6659	1331.8	
0.04	1048	1.168	6.692	0.6692	1338.4	
0.06	1052	1.201	6.727	0.6727	1345.4	
0.08	1055	1.243	6.754	0.6754	1350.8	
0.1	1058	1.290	6.786	0.6786	1357.2	
SBDAC-12 + DO at 40^{o} C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1037	1.028	6.577	0.6577	1315.4	
0.02	1042	1.066	6.628	0.6628	1325.6	
0.04	1045	1.117	6.665	0.6665	1333.0	
0.06	1047	1.168	6.697	0.6697	1339.4	
0.08	1052	1.210	6.718	0.6718	1343.6	
0.1	1055	1.253	6.736	0.6736	1347.2	

Table-5.35: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-13 solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-13 + CF at 30^{o} C						
0	1465.7	0.620	4.795	0.4795	959.0	0.002
0.01	1457.3	0.697	4.816	0.4816	963.2	
0.02	1453.0	0.750	4.820	0.4820	964.0	
0.04	1448.6	0.763	4.862	0.4862	972.4	
0.06	1444.3	0.820	4.898	0.4898	979.6	
0.08	1440.9	0.845	4.927	0.4927	985.4	
0.1	1437.8	0.923	4.957	0.4957	991.4	
SBDAC-13 + CF at 35^{o} C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1453.7	0.639	4.753	0.4753	950.6	
0.02	1448.6	0.671	4.774	0.4774	954.8	
0.04	1445.8	0.720	4.804	0.4874	964.8	
0.06	1442.3	0.763	4.839	0.4839	967.8	
0.08	1439.1	0.811	4.865	0.4865	973.0	
0.1	1436.2	0.866	4.882	0.4882	976.4	
SBDAC-13 + CF at 40^{o} C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1450.5	0.622	4.684	0.4684	936.8	
0.02	1447.2	0.655	4.704	0.4704	940.8	
0.04	1443.5	0.712	4.728	0.4728	945.6	
0.06	1440.8	0.743	4.764	0.4764	952.8	
0.08	1437.8	0.791	4.792	0.4792	958.4	
0.1	1435.7	0.837	4.814	0.4814	962.8	

Table-5.36: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-13 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-13 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	955.5	0.982	7.387	0.7387	1477.4	
0.02	958.2	1.045	7.423	0.7423	1484.6	
0.04	961.9	1.113	7.453	0.7453	1490.6	
0.06	964.0	1.162	7.496	0.7496	1499.2	
0.08	967.3	1.217	7.546	0.7546	1509.2	
0.1	978.7	1.278	7.575	0.7575	1515.0	
SBDAC-13 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	954.1	0.945	7.426	0.7426	1485.2	
0.02	957.7	1.005	7.462	0.7462	1492.4	
0.04	960.5	1.076	7.496	0.7496	1499.2	
0.06	963.5	1.127	7.536	0.7536	1507.2	
0.08	965.9	1.175	7.577	0.7577	1515.4	
0.1	967.8	1.206	7.605	0.7605	1521.0	
SBDAC-13 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	953.8	0.919	7.447	0.7447	1489.4	
0.02	957.5	0.988	7.476	0.7476	1495.2	
0.04	960.2	1.024	7.518	0.7518	1503.6	
0.06	963.1	1.083	7.556	0.7556	1511.2	
0.08	965.5	1.124	7.595	0.7595	1519.0	
0.1	967.6	1.163	7.627	0.7627	1525.4	

Table-5.37: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-13 solutions in THF at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-13 + THF at 30^o C						
0	882.3	0.467	6.319	0.6319	1263.8	0.002
0.01	886.3	0.504	6.325	0.6325	1265.0	
0.02	888.9	0.534	6.376	0.6376	1275.2	
0.04	892.7	0.562	6.401	0.6401	1280.2	
0.06	895.9	0.579	6.435	0.6435	1287.0	
0.08	898.0	0.604	6.465	0.6465	1293.0	
0.1	900.7	0.631	6.495	0.6495	1299.0	
SBDAC-13 + THF at 35^o C						
0	881.8	0.446	6.168	0.6168	1233.6	0.002
0.01	885.4	0.464	6.217	0.6217	1243.4	
0.02	888.0	0.487	6.246	0.6246	1249.2	
0.04	891.5	0.506	6.285	0.6285	1257.0	
0.06	893.9	0.524	6.314	0.6314	1262.8	
0.08	896.1	0.559	6.346	0.6346	1269.2	
0.1	897.9	0.595	6.376	0.6376	1275.2	
SBDAC-13 + THF at 40^o C						
0	881.2	0.429	6.084	0.6084	1216.8	0.002
0.01	884.6	0.453	6.102	0.6102	1220.4	
0.02	887.2	0.467	6.146	0.6146	1229.2	
0.04	890.1	0.487	6.176	0.6176	1235.2	
0.06	892.7	0.507	6.203	0.6203	1240.6	
0.08	895.1	0.531	6.236	0.6236	1247.2	
0.1	896.5	0.562	6.265	0.6265	1253.0	

Table-5.38: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-14 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-14 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.002
0.01	1457.1	0.687	4.806	0.4806	961.2	
0.02	1452.9	0.713	4.812	0.4812	962.4	
0.04	1448.9	0.781	4.846	0.4846	969.2	
0.06	1445.7	0.834	4.877	0.4877	975.4	
0.08	1442.0	0.883	4.906	0.4906	981.2	
0.1	1439.4	0.921	4.925	0.4925	985.0	
SBDAC-14 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1452.9	0.649	4.728	0.4728	945.6	
0.02	1450.0	0.679	4.737	0.4737	947.4	
0.04	1446.1	0.732	4.768	0.4768	953.6	
0.06	1442.7	0.801	4.797	0.4797	959.4	
0.08	1439.5	0.845	4.828	0.4828	965.6	
0.1	1436.6	0.871	4.848	0.4848	969.6	
SBDAC-14 + CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1451.2	0.628	4.648	0.4648	929.6	
0.02	1449.3	0.658	4.656	0.4656	931.2	
0.04	1444.4	0.698	4.684	0.4684	936.8	
0.06	1442.0	0.769	4.711	0.4711	942.2	
0.08	1438.6	0.799	4.738	0.4738	947.6	
0.1	1436.0	0.833	4.757	0.4757	951.4	

Table-5.39: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-14 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-14 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.001
0.01	956.9	0.996	7.397	0.7397	1479.4	
0.02	958.5	1.073	7.437	0.7437	1487.4	
0.04	961.8	1.135	7.479	0.7479	1495.8	
0.06	964.5	1.189	7.512	0.7512	1502.4	
0.08	966.8	1.239	7.545	0.7545	1509.0	
0.1	968.1	1.272	7.573	0.7573	1514.6	
SBDAC-14 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	955.9	0.947	7.426	0.7426	1485.2	
0.02	957.7	1.004	7.462	0.7462	1492.4	
0.04	961.0	1.077	7.496	0.7496	1499.2	
0.06	963.6	1.127	7.536	0.7536	1507.2	
0.08	966.1	1.175	7.577	0.7577	1515.4	
0.1	968.6	1.206	7.605	0.7605	1521.0	
SBDAC-14 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	954.6	0.920	7.447	0.7447	1489.4	
0.02	957.2	0.988	7.466	0.7466	1493.2	
0.04	960.1	1.024	7.518	0.7518	1503.6	
0.06	962.7	1.082	7.556	0.7556	1511.2	
0.08	965.9	1.125	7.595	0.7595	1519.0	
0.1	967.8	1.164	7.627	0.7627	1525.4	

Table-5.40: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-14 solutions in THF at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-14 + THF at 30^o C						
0	882.3	0.470	6.319	0.6319	1263.8	0.001
0.01	886.5	0.476	6.329	0.6329	1265.8	
0.02	889.5	0.482	6.345	0.6345	1269.0	
0.04	893.1	0.517	6.361	0.6361	1272.2	
0.06	896.0	0.549	6.383	0.6383	1276.6	
0.08	898.3	0.589	6.407	0.6407	1281.4	
0.1	900.5	0.626	6.427	0.6427	1285.4	
SBDAC-14 + THF at 35^o C						
0	881.8	0.446	6.168	0.6168	1233.6	0.002
0.01	884.8	0.451	6.277	0.6277	1255.4	
0.02	887.7	0.464	6.295	0.6295	1259.0	
0.04	891.6	0.487	6.318	0.6318	1263.6	
0.06	893.7	0.533	6.336	0.6336	1267.2	
0.08	896.9	0.572	6.362	0.6362	1272.4	
0.1	898.1	0.593	6.396	0.6396	1279.2	
SBDAC-14 + THF at 40^o C						
0	881.2	0.429	6.084	0.6084	1216.8	0.002
0.01	883.9	0.437	6.167	0.6167	1233.4	
0.02	886.0	0.456	6.175	0.6175	1235.0	
0.04	888.3	0.475	6.198	0.6198	1239.6	
0.06	891.5	0.498	6.226	0.6226	1245.2	
0.08	893.8	0.557	6.257	0.6257	1251.4	
0.1	896.6	0.574	6.284	0.6284	1256.8	

Table-5.41: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-15 solutions in chloroform (CF) at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-15 + CF at 30^o C						
0	1465.7	0.620	4.795	0.4795	959.0	0.001
0.01	1455.2	0.763	4.802	0.4802	960.4	
0.02	1451.4	0.786	4.818	0.4818	963.6	
0.04	1447.9	0.834	4.848	0.4848	969.6	
0.06	1443.4	0.884	4.874	0.4874	974.8	
0.08	1440.2	0.922	4.899	0.4899	979.8	
0.1	1437.4	0.958	4.916	0.4916	983.2	
SBDAC-15 + CF at 35^o C						
0	1460.9	0.574	4.727	0.4727	945.4	0.001
0.01	1454.2	0.623	4.728	0.4728	945.6	
0.02	1449.7	0.652	4.746	0.4746	949.2	
0.04	1445.4	0.695	4.763	0.4763	952.6	
0.06	1441.6	0.738	4.797	0.4797	959.4	
0.08	1438.5	0.782	4.822	0.4822	964.4	
0.1	1436.2	0.832	4.847	0.4847	969.4	
SBDAC-15+ CF at 40^o C						
0	1457.3	0.554	4.623	0.4623	924.6	0.001
0.01	1449.2	0.612	4.65	0.465	930.0	
0.02	1445.7	0.652	4.663	0.4663	932.6	
0.04	1442.8	0.663	4.695	0.4695	939.0	
0.06	1439.3	0.719	4.728	0.4728	945.6	
0.08	1435.9	0.765	4.753	0.4753	950.6	
0.1	1433.1	0.810	4.778	0.4778	955.6	

Table-5.42: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-15 solutions in DMF at three different temperatures: 30^o, 35^o and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-15 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	950.9	0.976	7.397	0.7397	1479.4	
0.02	953.7	1.028	7.435	0.7435	1487.0	
0.04	957.1	1.085	7.462	0.7462	1492.4	
0.06	960.9	1.122	7.496	0.7496	1499.2	
0.08	963.4	1.160	7.527	0.7527	1505.4	
0.1	965.5	1.189	7.557	0.7557	1511.4	
SBDAC-15 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.002
0.01	950.4	0.916	7.417	0.7417	1483.4	
0.02	953.0	0.970	7.446	0.7446	1489.2	
0.04	956.7	1.027	7.484	0.7484	1496.8	
0.06	960.1	1.070	7.524	0.7524	1504.8	
0.08	962.7	1.097	7.547	0.7547	1509.4	
0.1	965.1	1.135	7.576	0.7576	1515.2	
SBDAC-15 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.004
0.01	949.6	0.893	7.486	0.7486	1497.2	
0.02	951.4	0.906	7.518	0.7518	1503.6	
0.04	955.9	0.956	7.542	0.7542	1508.4	
0.06	959.7	0.995	7.554	0.7554	1510.8	
0.08	962.1	1.041	7.575	0.7575	1515.0	
0.1	964.7	1.074	7.608	0.7608	1521.6	

Table-5.43: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-16 solutions in chloroform (CF) at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	Density ?, kg / m^3	Viscosity ?. 10^3 Pa s.	Ave. Dist. d.10^3, m	Wave length ?.10^3,m	U ms^{-1} (F=2MHz)	Sp,
SBDAC-16 + CF at 30^{o} C						
0	1465.7	0.620	4.795	0.4795	959.0	0.002
0.01	1460.4	0.682	4.801	0.4801	960.0	
0.02	1456.2	0.703	4.816	0.4816	961.2	
0.04	1452.5	0.727	4.822	0.4822	962.4	
0.06	1449.3	0.777	4.834	0.4834	964.8	
0.08	1446.3	0.821	4.842	0.4842	968.4	
0.1	1444.0	0.862	4.867	0.4867	973.4	
SBDAC-16 + CF at 35^{o} C						
0	1460.9	0.574	4.727	0.4727	945.4	0.002
0.01	1457.3	0.658	4.728	0.4728	945.6	
0.02	1453.1	0.674	4.737	0.4737	947.4	
0.04	1449.6	0.702	4.759	0.4759	951.8	
0.06	1446.4	0.738	4.777	0.4777	955.4	
0.08	1443.8	0.770	4.801	0.4801	960.2	
0.1	1441.6	0.807	4.826	0.4826	965.2	
SBDAC-16 + CF at 40^{o} C						
0	1457.3	0.554	4.623	0.4623	924.6	0.002
0.01	1455.4	0.670	4.631	0.4631	926.2	
0.02	1451.9	0.636	4.646	0.4646	929.2	
0.04	1448.7	0.660	4.666	0.4666	933.2	
0.06	1445.9	0.705	4.686	0.4686	937.2	
0.08	1442.6	0.752	4.720	0.4720	944.0	
0.1	1440.3	0.780	4.748	0.4748	949.6	

Table-5.44: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-16 solutions in DMF at three different temperatures: 30^{o}, 35^{o} and 40^{o}C.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC-16 + DMF at 30^o C						
0	932.8	0.848	7.257	0.7257	1451.4	0.002
0.01	954.5	0.910	7.415	0.7415	1483.0	
0.02	956.0	0.952	7.446	0.7446	1489.2	
0.04	958.6	1.007	7.473	0.7473	1494.6	
0.06	960.4	1.057	7.505	0.7505	1501.0	
0.08	961.8	1.102	7.526	0.7526	1505.2	
0.1	964.0	1.143	7.558	0.7558	1511.6	
SBDAC-16 + DMF at 35^o C						
0	927.5	0.815	7.293	0.7293	1458.6	0.001
0.01	952.9	0.871	7.429	0.7429	1485.8	
0.02	955.3	0.918	7.46	0.746	1492.0	
0.04	957.1	0.965	7.494	0.7494	1498.8	
0.06	959.8	0.998	7.527	0.7527	1505.4	
0.08	962.0	1.044	7.565	0.7565	1513.0	
0.1	963.3	1.082	7.594	0.7594	1518.8	
SBDAC-16 + DMF at 40^o C						
0	916.4	0.777	7.322	0.7322	1464.4	0.002
0.01	951.9	0.834	7.457	0.7457	1491.4	
0.02	955.0	0.890	7.486	0.7486	1497.2	
0.04	956.7	0.940	7.528	0.7528	1505.6	
0.06	959.3	0.981	7.562	0.7562	1512.4	
0.08	961.0	1.033	7.595	0.7595	1519.0	
0.1	962.6	1.065	7.617	0.7617	1523.4	

Table-5.45: The density (?), viscosity (?), sound velocity (U) and pooled precision standard deviation (Sp) data of SBDAC-16 solutions in DO at three different temperatures: 30^o, 35^o and 40^oC.

Conc., mol/ lit	**Density ?, kg / m^3**	**Viscosity ?. 10^3 Pa s.**	**Ave. Dist. d.10^3, m**	**Wave length ?.10^3,m**	**U ms^{-1} (F=2MHz)**	**Sp,**
SBDAC- 16+ DO at 30^o C						
0	1043	1.103	6.637	0.6637	1327.4	0.001
0.01	1047	1.112	6.728	0.6728	1345.6	
0.02	1050	1.132	6.757	0.6757	1351.4	
0.04	1053	1.168	6.796	0.6796	1359.2	
0.06	1057	1.207	6.828	0.6828	1365.6	
0.08	1060	1.245	6.866	0.6866	1373.2	
0.1	1063	1.287	6.898	0.6898	1379.6	
SBDAC-16 + DO at 35^o C						
0	1039	1.042	6.598	0.6598	1319.6	0.002
0.01	1044	1.054	6.696	0.6696	1339.2	
0.02	1046	1.074	6.728	0.6728	1345.6	
0.04	1049	1.113	6.767	0.6767	1353.4	
0.06	1053	1.147	6.807	0.6807	1361.4	
0.08	1057	1.187	6.836	0.6836	1367.2	
0.1	1060	1.232	6.866	0.6866	1373.2	
SBDAC-16 + DO at 40^o C						
0	1035	1.015	6.459	0.6459	1291.8	0.002
0.01	1042	1.034	6.606	0.6606	1321.2	
0.02	1045	1.050	6.665	0.6665	1333.0	
0.04	1048	1.069	6.704	0.6704	1340.8	
0.06	1053	1.128	6.758	0.6758	1351.6	
0.08	1056	1.179	6.798	0.6798	1359.6	
0.1	1059	1.210	6.826	0.6826	1365.2	

1. Isentropic compressibility

Isentropic compressibility (κ_S) can be evaluated according to Newton and Laplace:

$$\kappa_S = \frac{1}{U^2 r} \qquad \textbf{… 5.5}$$

2. Specific acoustical impedance

$$Z = Ur \qquad \textbf{… 5.6}$$

3. Rao's molar sound function

Rao's molar sound function (R) can be evaluated by employing a method suggested by Bagchi et. al [38]

$$R = \frac{M}{r} U^{1/3} \qquad \textbf{… 5.7}$$

The apparent molecular weight (M) of the solution can be calculated according to Eqn. 5.8**:**

$$M = M_1W_1 + M_2W_2 \qquad \textbf{... 5.8}$$

Where W_1 and W_2 are weight fractions of solvent and schiff bases, respectively. M_1 and M_2 are the molecular weights of the solvent and schiff bases, respectively.

4. Van der Waal s constant

Van der waals constant (b) [39] can be calculated according to Eqn.5.9

$$b = \frac{M}{r}\left[1 - \left[\frac{RT}{MU^2}\right]\left[\sqrt{1 + \frac{MU^2}{3RT}} - 1\right]\right] \qquad \textbf{... 5.9}$$

Where R (8.314 JK^{-1} mol^{-1}) is the gas constant and T (^{0}K) is the absolute temperature.

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38. S. Bagchi, S. K. Nema and R. P. Singh, Eur. Polym. J., **22**(10) 851, 1989

39. P. Vigoureux, 'Ultrasonic', Chapman and Hall, Landon, 1952.

5. Internal pressure

Internal pressure (p) can be evaluated according to Suryanarayana and Kuppuswamy [40]:

$$p = b'RT\left(\frac{Kh}{U}\right)^{1/2}\frac{r^{2/3}}{M^{7/6}} \qquad \textbf{... 5.10}$$

Where R=8.3143 JK^{-1} mol^{-1} is the gas constant and b'=2, is the packing factor and K=4.28 X 10^{9} is a constant. The internal pressure (p) depends on temperature, density, ultrasonic velocity and specific heat at a constant pressure.

6. Classical absorption coefficient

The classical absorption coefficient $(a/f^2)_{cl}$ has its origin in the viscosity of the medium and it is proposed by Subrahmanyam et. al [41]:

$$\left({}^{a}\!\diagup_{f^2}\right)_{cl} = \frac{8p^2h}{3U^3r} \qquad \textbf{... 5.11}$$

7. Viscous relaxation time

The resistance offered by viscous force in the flow of sound wave appears as a classical absorption associated with it is the viscous relaxation time (τ):

$$t = \frac{4h}{3rU^2} \qquad \textbf{... 5.12}$$

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40. C.V.Suryanarayana and J.Kuppuswamy, J. Acoust Soc. (India), **9(1)**, 4, 1981

41. T. V. S. Subrahmanyam, A. Viswanadhasharma and K. Subbarao, J. Acoust. Soc. 7(1), 1, 1979

8. Solvation number

The solvation number (S_n) can be evaluated according to Passynsky [42] method. The number of grams of solvent connected in the apparent solvation of 1 g of solute assuming that the solvent molecules participating in the solvation are effectively incompressible due to strong localized electronic fields, is expressed as:

$$n = \left[1 - \frac{k_s(100 - x)}{k_{s1}x}\right] \qquad \textbf{... 5.13}$$

Where x is the number of grams of solute in 100 g of the solution. The Solvation number (Sn) can be expressed as:

$$Sn = \frac{M_2}{M_1\left(1 - \frac{k_s}{k_{s1}}\right)\left(\frac{100 - x}{x}\right)} \qquad \textbf{... 5.14}$$

Where M_1 and M_2 are the molecular weights of solvent and schiff bases , respectively.

9. Apparent molar volume

Apparent molar volume [43] can be calculated according to Eqn.5.15:

$$f_{\mathbf{V2}} = \frac{M}{r_1}\left[1 - \frac{(100)}{C}(r - r_1)\right] \qquad \textbf{... 5.15}$$

Where, M is the molecular weight of schiff bases and ρ_1 and ρ are the densities of solvent and schiff bases , respectively.

10. Apparent molar compressibility

Apparent molar compressibility [51] can be calculated according to Eqn. 5.16:

$$fk_s = M_2 k_{s1}\left[\frac{100}{C}\left(\frac{k_s}{k_{s1}} - \frac{r}{r_1}\right) + \frac{1}{r_1}\right] \qquad \textbf{... 5.16}$$

Where C is the concentration in dl/g and κ_{S1} and κ_S are the isentropic compressibility of solvent and schiff base solutions, respectively

11. Free volume

Free volume [44] can be calculated according to Eqn. 5.17:

$$V_f = \left[\frac{MU}{Kh}\right]^{3/2} \qquad \textbf{... 5.17}$$

12. Inter molecular free path length

Intermolecular free path length (L_f) can be evaluated according to Eqn. 5.18, as proposed by Jacobson [45]:

$$L_f = K_J (k_s)^{1/2} \qquad \textbf{... 5.18}$$

where K_J= (93.875 + 0.375T) x 10^{-8} is a constant and temperature dependent.

In order to understand the effect of concentration, temperature, nature of solvents and nature of substituents of solute, various acoustical parameters were determined by using the experimental data on ?, ? and U of schiff base solutions at three temperatures according to above mentioned standard relations. The concentration and temperature dependence of acoustical parameters provide valuable information about strength of molecular interactions occurring in the solutions. Various acoustical parameters were fitted with concentration according to least square method to ascertain with concentration and temperature dependence of molecular interactions occurring in solutions and hence solvophilic or solvophobic nature of the schiff bases under investigation. From which it is clear that good to excellent correlation are observed for said parameters. Correlation equations and correlation coefficients are reported in Tables 5.46 to 5.90 from which it is observed that good to excellent correlation is observed between said parameter with C and T. In case of nonlinear relations, polynomial type correlation equations are reported in respective tables.

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42. A. Passynsky, Acta Phys. Chem. USSR, 22, 317, 1943
43. P. R. Chowdhury, Indian J. Chem., **7**, 692, 1969
44. C. V. Surayanarayana and J. Kuppusami, J. Acoust. Soc. India, 4, 75, 1976
45. B. Jacobson, Nature, 173, 772, 1954

Table-5.46 :The correlation equations and correlation coefficients for SBDAC-1+CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^{o}	**35^{o}**	**40^{o}**
ρ , kg.m^{-3}	-175.62C+1459.2 (-0.991)	-192.19C+1456.2 (-0.993)	-185.51C+1453.4 (-0.991)
η, mPa s	1.3745C+0.6428 (0.986)	1.2277C+0.6027 (0.987)	1.2121C+0.577 (0.999)
U, ms^{-1}	125.15C+961 (0.983)	172.93C+953.07 (0.992)	220.55C+942.84 (0.987)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.01C +1.4024 (0.917)	0.2C + 1.3982 (0.985)	0.125C +1.3715 (0.973)
κ_s x 10^{+10}, Pa $^{-1}$	-2.5414C+7.7383 (-0.983)	-1.689C+7.5588 (-0.989)	-1.0153C+7.4201 (-0.962)
R x10^{4} , m$^{10/3}$s$^{1/3}$mol^{-1}	8.1408C+ 8.0681 (0.999)	8.3378C +8.064 (0.999)	8.5222C+8.0484 (0.999)
b x10^{5}, m^{3}	7.7852C+8.0438 (0.999)	7.9282C+8.0584 (0.999)	7.9085C+8.0374 (0.999)
L$_f$ x10^{11}, m	-0.4192C+5.7067 (-0.964)	-0.7288C+5.761 (-0.985)	- 0.9945C+5.8264 (-0.989)
π x10^{-8}, Pa	-0.95 C + 4.1816 (-0.998)	-0.7971C+4.0903 (-0.998)	-0.75C+4.0832 (-0.985)
V$_f$ x 10^{7}, m^{3}	-2.735C+2.5889 (-0.997)	- 3.4433C+2.9196 (-0.964)	-3.6395C+3.053 (-0.996)
τ x10 ^{13} , s	12.556C+6.3623 (0.984)	11.756C+ 6.1263 (0.998)	10.056C+5.9669 (0.999)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	2.3778C+1.3056 (0.983)	1.9268C+1.2563 (0.985)	1.7636 +1.249 (0.998)

Table-5.47: The correlation equations and correlation coefficients for SBDAC-1+ DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	101.18C+946.2 (0.972)	110.79C+944.18 (0.991)	103.15C+943.72 (0.982)
η, mPa s	2.6532C+0.9669 (0..997)	2.4049C+0.9267 (0.991)	2.4814C+0.8873 (0.966)
U, ms^{-1}	366.47C+1452.9 (0.987)	312.11C+1463.2 (0.991)	327.34C+1465.4 (0.994)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.4967C+ 1.3752 (0.986)	0.4564C+1.3818 (0.990)	0.2493C+1.3945 (0.959)
κ_S x10^{+10}, Pa $^{-1}$	-2.931C+5.0034 (-0.983)	-2.5912C+4.9452 (-0.991)	-2.6466C+4.9337 (-0.992)
R x10^{4} , m$^{10/3}$ s$^{1/3}$ mol^{-1}	20.148C+8.7485 (1)	19.965C +8.7933 (1)	20.175C+8.7996 (1)
b x10^{5}, m^{3}	16.869C+7.6134 (0.999)	16.832C+7.6342 (1)	16.94 C+ 7.6366 (0.999)
L$_f$ x10^{11}, m	-1.3973C+4.6822 (-0.987)	-1.189C+4.6548 (-0.992)	-1.2575 C+ 4.65 (-0.983)
π x10^{-8}, Pa	-6.700C +5.6382 (-0.999)	-5.3815 C+5.2658 (-0.971)	-6.0104C+5.2758 (-0.983)
V$_f$ x 10^{7} , m^{3}	6.7857C^{2} -0.7843C +1.3036 (0.992)	12.679C^{2}-1.1164C +1.4046 (0.947)	27.143C^{2}-2.6871C +1.5034 (0.876)
τ x10 ^{13} , s	12.41C +6.4996 (0.998)	10.585C+6.2155 (0.994)	9.78 C+ 6.0414 (0.970)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	1.44C+0.8814 (0.999)	1.235C+0.8367 (0986)	1.115C +0.8129 (0.955)

Table-5.48 : The correlation equations and correlation coefficients for SBDAC- 1 + DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	146.58C+1042.3 (0.999)	175.07C+1038.5 (0.991)	199.73 C+ 1034.2 (0.994)
η, mPa s	2.0468C+ 1.1061 (0.996)	1.854C+ 1.0314 (0.989)	1.7562C+ 0.9909 (0.980)
U, ms^{-1}	267C +1345.3 (0.973)	236C+1341.1 (0.978)	331C+ 1325.4 (0.996)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.5244C+ 1.3989 (0.990)	0.5145C+ 1.3904 (0.989)	0.6397C+ 1.3688 (0.995)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-3.0885 C+5.3234 (-0.981)	-2.8926C+5.3681 (-0.984)	-3.8312C+5.5166 (-0.993)
$R\ x10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	14.93C+ 9.3291 (0.999)	14.58C + 9.357 (0.999)	14.593C+ 9.3605 (0.999)
$b\ x10^{5}$, m^{3}	12.719C+ 8.337 (0.999)	12.501C+ 8.36 (0.999)	12.351C+ 8.403 (0.999)
$L_f\ x10^{11}$, m	-1.4438C+4.8 (-0.985)	1.337C+ 4.85 (-0.980)	-1.7233C+ 4.9174 (-0.994)
$\pi\ x10^{-8}$, Pa	-4.8767C + 5.2246 (-0.996)	-4.6353C+ 5.0333 (-0.992)	-4.7825C+ 4.949 (-0.982)
$V_f\ x\ 10^{7}$, m^{3}	$-10.536C^2$+ 1.5293C +1.2 (0.940)	$-15.714C^2$+ 1.7957C +1.3626 (0.992)	$-16.439C^2$ +2.225C + 1.4056 (0.963)
$\tau\ x10^{13}$, s	9.1159C+ 7.8695 (0.990)	8.4888C+ 7.4014 (0.981)	6.8917C+ 7.3304 (0.978)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	1.049C+1.1157 (0.969)	1.15C+1.0802 (0.979)	0.795C +1.0845 (0.949)

Table-5.49 : The correlation equations and correlation coefficients for SBDAC – 2 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-214C+1461.3 (-0.996)	-177.37C+1454.6 (-0.988)	-161.07 C+1452.7 (-0.998)
η, mPa s	2.4458C+0.6218 (0.998)	2.409C+0.575 (0.998)	2.201 C+0.573 (0.976)
U, ms^{-1}	222.36C+958.84 (0.997)	234.36 C+944.32 (0.999)	241.48C+ 926.02 (0.996)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.135C +1.3997 (0.987)	0.2C +1.3982 (0.985)	0.185C + 1.3461 (0.993)
κ_S x10^{+10}, Pa^{-1}	-2.2655C+7.4412 (-0.994)	-2.7701C+7.7073 (- 0.998)	-3.174 C+8.0258 (-0.994)
R x10^{4} , $m^{10/3}\ s^{1/3} mol^{-1}$	9.9915 C+8.044 (0.999)	9.5674C + 8.046 (0.999)	9.46C+ 8.003 (0.999)
b x10^{5}, m^{3}	9.0953C+8.0301 (0.999)	8.9099C+8.0675 (0.999)	8.8126 C+8.0767 (1)
L_f x10^{11}, m	-0.9315 C+5.715 (-0.995)	-1 C+ 5.81 (-1)	-1.1205 C+5.930 (-0.997)
π x10^{-8} , Pa	-23.892C^2 +4.0937C +4.051 (0.983)	-6.7854C^2 +2.6282C + 4.0098 (0.972)	-54.633C^2 + 7.3905C + 4.0067 (0.915)
V_f x 10^{7}, m^3	-7.5871C +2.7605 (-0.983)	-8.8153C +3.0261 (-0.992)	-8.1016C +2.9851 (-0.923)
τ x10^{13} , s	21.598 C + 6.1843 (0.996)	21.975C +5.9041 (0.996)	17.855C + 6.3349 (0.949)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	-15.543C^2 +5.7412C +1.2436 (0.999)	4.2282C+ 1.2344 (0.998)	-38.027C^2+ 8.0207C + 1.238 (0.983)

Table-5.50 : The correlation equations and correlation coefficients for SBDAC -2 + DMF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30^o	35^o	40^o
ρ , kg.m^{-3}	105C+ 946.94 (0.997)	117C + 945.16 (0.994)	123C + 944.22 (0.997)
η, mPa s	2.7975C+ 0.9696 (0.996)	2.8764C+0.8886 (0.997)	2.7463 C+0.8764 (0.989)
U, ms^{-1}	395.01C+1454.0 (0.99)	384.82C+ 1461.6 (0.99)	393.81C+1466.3 (0.997)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.52C+1.3784 (0.997)	0.2C +1.3982 (0.985)	0.545 C+1.3853 (0.998)
κ_S x10^{+10}, Pa $^{-1}$	-3.3225C+5.004 (-0.989)	-3.129 C+4.945 (- 0.985)	-3.2027C+4.9288 (-0.998)
R x10^{4} , $m^{10/3}$ $s^{1/3}$ mol^{-1}	22.919 C+8.7593 (1)	22.868C +8.7888 (1)	22.827C+8.8105 (1)
b x10^{5}, m^{3}	19.228C+7.621 (1)	19.168 C+7.6343 (1)	19.102C+7.6446 (1)
L_f x10^{11}, m	-1.5479C+4.682 (-0.996)	-1.4027C+4.6558 (-0.993)	-1.4959 C+4.6473 (-0.993)
π x10^{-8} , Pa	-7.6249C +5.4495 (-0.999)	-6.7649 C+5.2899 (-0.999)	-6.9512C+5.3228 (-0.991)
V_f x 10^{7} , m^3	14.357C^2 -1.3861C +1.3256 (0.876)	14.359C^2 -1.9762C +1.5229 (0.892)	28.729C^2-3.685C + 1.609 (0.930)
τ x10^{13} , s	13.263 C +6.47 (0.989)	14.003 C+5.89 (0.993)	13.061C+ 5.718 (0..991)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	14.09C +8.8656 (0.997)	15.49C + 8.0214 (0.998)	12.895C + 7.9451 (0.987)

Table-5.51 : The correlation equations and correlation coefficients for SBDAC – 2 + DO

Parameter, **Y**	**Correlation equations (Correlation coefficients, ?),** **mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	153.97C+1042.4 (0.996)	179.73C+1039.4 (0.993)	178.63C+1037.1 (0.982)
η, mPa s	2.1205C+1.090 (0995)	2.0647C+ 1.03 (0.995)	2.0844 C+1.010 (0.996)
U, ms^{-1}	358.19C+1342 (0.994)	379.18C+1335.9 (0.990)	387.67 C+1332.3 (0.983)
Z x 10^{-6} , $kg.m^{-2}\ s^{-1}$	0.5833 C+1.399 (0.996)	0.6403C+1.3884 (0.983)	0.6455 C+1.382 (0.962)
κ_S x10^{+10}, Pa $^{-1}$	-3.466C+5.3246 (-0.995)	-3.7885 C+5.3874 (-0.990)	-3.8986 C+5.3874 (-0.981)
R x10^{4} , $m^{10/3}\ s^{1/3} mol^{-1}$	17.261 C+9.329 (0.999)	17.086C +9.3424 (0.999)	17.188C+ 9.3541 (0.999)
b x10^{5}, m^{3}	14.679 C+8.3379 (0.999)	14.492C+ 8.3621 (0.999)	14.571C+8.3802 (0.999)
L_f x10^{11}, m	-1.5425 C+4.828 (-0.993)	-1.792C+ 4.8626 (-0.988)	-1.8192C+ 4.881 (-0.981)
π x10^{-8} , Pa	-5.7523 C +5.174 (-0.999)	-5.4734 C+5.043 (-0.999)	-5.3403C+4.991 (-0.998)
V_f x 10^{7} , m^3	0.585C +1.2677 (0.892)	0.59C +1.360 (0.898)	0.51C+ 1.397 (0.956)
τ x10^{13} , s	8.9781C +7.7595 (0.988)	8.520C+ 7.4548 (0.992)	8.7655 C+ 7.3568 (0.998)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	0.982C+1.141 (0.979)	0.9164C+1.1012 (0.986)	0.949 + 1.0896 (0.998)

Table-5.52 : The correlation equations and correlation coefficients for SBDAC - 3 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX + b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	-222.27C+1461.6 (-0.990)	-192.47C+1455.7 (-0.994)	-165.56C+1455.7 (0.995)
η, mPa s	1.7981C+0.634 (0.996)	2.0061C+0.5742 (0.996)	1.8413C+0.5579 (0.987)
U, ms^{-1}	308.55C+960.36 (0.999)	267.23C+947.83 (0.995)	305.86C+936.53 (0.984)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.2225C+1.4042 (0.990)	0.2493C+1.3945 (0.956)	0.2901C+1.3565 (0.962)
κ_S x10^{+10}, Pa $^{-1}$	-3.4529C+7.4149 (-0.999)	-3.1611C+7.6443 (- 0.993)	-4.0518C+7.8672 (- 0.991)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	10.222 C+8.0522 (0.999)	9.9378C +8.048 (0.999)	9.9353C+8.0547 (0.999)
b x10^5, m ^{3}	9.297C+8.029 (0.999)	9.1677C+8.0603 ((0.999)	9.1499C+8.0911 (0.999)
L$_f$ x10^{11}, m	-1.3671C+5.7023 (- 0.995)	-1.2082C+5.7874 (- 0.996)	-1.5863C+5.877 (- 0.974)
π x10^{-8} , Pa	$650.99C^3 – 119.64C^2$ +5.7145C+4.0516 (0.931)	$93.394C^3$ $-35.978C^2$ + 3.6176C+ 3.9574 (0.954)	$962.95C^3$ $-191.02C^2$ +10.995C+ 3.8906 (0.966)
V$_f$ x 10^7 , m^3	-4.5874C+2.7197 (- 0.973)	-7.2068C+3.0895 (-0.978)	-6.7663C+3.1678 (- 0.945)
τ x10 ^{13} , s	13.963C +6.2834 (0.993)	17.162 C+ 5.8478 (0.996)	15.313C+5.8667 (0.986)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	2.3704C+1.2915 (0.989)	2.370C+1.2182 (0.995)	2.7277C+1.2367 (0.985)

Table-5.53 : The correlation equations and correlation coefficients for SBDAC-3 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	121.21C+ 943.8 (0.998)	95.342C+943.57 (0.998)	97.096C+942.62 (0.988)
η, mPa s	1.2931C+0.9239 (0.986)	1.2551C+0.8879 (0.991)	1.631C+0.84 (0.942)
U, ms^{-1}	451.73C+1458.3 (0.989)	480.27C+1460.6 (0.997)	539.45C+1463.4 (0.986)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.6052C+1.3766 (0.994)	0.2493C+1.3945 (0.959)	0.6367 C+1.3818 (0.986)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.5403C+4.9796 (-0.991)	-3.5671C+4.9643 (-0.997)	-3.9216C+4.9503 (-0.988)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	23.551C+8.7874 (1)	24.032C +8.791 (1)	24.197C+8.8062 (1)
$b \times 10^{5}$, m^{3}	19.636C+7.64 (1)	19.984C+7.6387 (1)	19.993C+7.6465 (1)
$L_f \times 10^{11}$, m	-1.2603C+4.6418 (-0.967)	-1.6219C+4.6605 (-0.996)	-1.9096C+4.6603 (-0.993)
$\pi \times 10^{-8}$, Pa	-10.318C +5.2816 (-0.998)	-10.397C+5.2582 (-0.998)	-9.2795C+5.2004 (-0.993)
$V_f \times 10^{7}$, m^3	3.2551 C+1.4037 (0.992)	3.4937C+1.4932 (0.993)	3.43C+ 1.5478 (0.996)
$\tau \times 10^{13}$, s	3.5918C +6.1444 (0.963)	3.4805C+5.8868 (0.960)	5.7704C+5.5755 (0.886)
$(\alpha/f^2)_{cl.} 10^{14}$, $s^2 m^{-1}$	2.315C +8.3157 (0.936)	2.1433C +7.9468 (0.921)	2.155C +7.7265 (0.920)

Table-5.54 : The correlation equations and correlation coefficients for SBDAC- 4 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-187.73C+1458.5 (-0.981)	-169.78 C+1455.9 (-0.995)	-167.53 C+1454.5 (-0.995)
η, mPa s	1.6849C+0.6459 (0.961)	1.5973C+0.6148 (0.997)	1.7241C+0.5851 (0.991)
U, ms^{-1}	323.4C+958.76 (0.993)	138.74C+946.03 (0.989)	196.71 C+928.57 (0.988)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.2844C+1.3983 (0.996)	0.2493C+1.3945 (0.959)	0.1247C+1.3507 (0.959)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.8679 C+7.4558 (- 0.993)	-1.3167C+7.674 (- 0.981)	-2.3841C+7.9725 (-0.982)
$R \times 10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	10.058 C+8.064 (0.999)	9.3674C +8.0435 (1)	9.5011C+8.001 (1)
$b \times 10^{5}$, m^3	9.0934C+8.0473 (1)	8.9868C+8.061 (1)	8.9929C+8.0667 (1)
$L_f \times 10^{11}$, m	-1.5976 C+5.721 (-0.991)	-0.5488C+5.803 (-0.994)	-0.9268 C+5.9129 (-0.982)
$\pi \times 10^{-8}$, Pa	$2287.9C^3 -382.55C^2$ 17.614C +3.9483 (0.836)	$733.61C^3 -108.59C^2$ 4.3904C+4.1075 (0.788)	$1152.7C^3 -192.41C^2$ 9.5806C+4.035 (0.971)
$V_f \times 10^{7}$, m^3	-2.255C+ 2.5059 (-0.965)	-3.99C+2.7252 (-0.988)	-4.505C+ 2.8279 (-0.985)
$\tau \times 10^{13}$, s	9.33C +6.6794 (0.984)	14.245C+ 6.3865 (0.998)	14.485C+ 6.3379 (0.997)
$(\alpha/f^2)_{cl.} 10^{14}$, $s^2 m^{-1}$	2.5833C+1.281 (0.959)	2.8789C+1.3209 (1)	3.0348C +1.324 (0.989)

Table-5.55 : The correlation equations and correlation coefficients for SBDAC-4 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^{o}	**35^{o}**	**40^{o}**
ρ , kg.m^{-3}	118.27C+944.64 (0.998)	122.6 C+943.48 (1)	125.1 C+942.94 (0.997)
η, mPa s	1.7759C+0.8919 (0.994)	1.8784C+0.8433 (0.991)	1.8841C+0.8433 (0.996)
U, ms^{-1}	401.53C+1452.2 (0.996)	369.59C+1461.1 (0.998)	348C+1467.5 (0.991)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.540C+ 1.3726 (0.998)	0.2C+1.3982 (0.985)	0.48 C+1.3864 (0.999)
κ_S x10^{+10}, Pa $^{-1}$	-3.2307C+5.0163 (-0.997)	-3.0192C+4.9627 (-0.998)	-2.8608C+4.9221 (-0.993)
R x10^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	23.398C+8.7674 (1)	23.361C +8.7965 (1)	23.324C+8.8151 (1)
b x10^{5}, m^{3}	19.64C+7.6324 (0.999)	19.636C+7.6415 (1)	19.618C+7.6464 (0.999)
L_f x10^{11}, m	-1.5945 C+4.962 (-0.996)	-1.3945 C+4.66 (-1)	-1.3562 C+ 4.645 (-0.993)
π x10^{-8} , Pa	-8.957C +5.2046 (-0.998)	-8.4951C+5.1347 (-0.997)	-8.2353 C+5.1173 (-1)
V_f x 10^{7} , m^{3}	2.21C+1.4542 (0.993)	1.835 C+1.6003 (0.954)	1.61C + 1.6984 (0.976)
τ x10^{13} , s	7.4575C +5.962 (0.984)	8.146C+5.592 (0.988)	8.523 C+5.361 (0.994)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	7.6699C+8.1 (0.975)	8.857C+7.552 (0.985)	9.5C+7.208 (0.994)

Table-5.56 : The correlation equations and correlation coefficients for SBDAC - 5 + CF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30^o	35^o	40^o
ρ , kg.m^{-3}	-183.04C+1458.6 (-0.990)	-161.4 C+1455 (-0.991)	-168 C+1454.2 (-0.992)
η, mPa s	2.3225C+0.6772 (0.977)	2.3422C+0.61 (0.990)	1.7487C+0.5979 (0.994)
U, ms^{-1}	252.55C+960.92 (0.996)	228.44C+944.63 (0.997)	256.77C+923.53 (0.989)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.1849C+ 1.4019 (0.987)	0.2545C+1.394 (0.963)	0.2164 C + 1.3432 (0.960)
κ_S x10^{+10}, Pa $^{-1}$	-2.8449 C+7.4227 (-0.995)	-2.7403C+1.394 (-0.995)	-3.725C+8.084 (-0.987)
R x10^{4} , $m^{10/3}$ $s^{1/3}$$mol^{-1}$	10.96 C+8.069 (0.999)	10.742C +8.0433 (0.999)	10.833C+7.9871 (0.999)
b x10^{5}, m^3	10.206C+ 8.0462 (0.999)	10.094 C+8.065 (0.999)	10.157C+8.067 (0.999)
L_f x10^{11}, m	-1.1123 C+5.704 (-0.987)	-1.0795 C+5.812 (-0.983)	-1.2164 C+ 5.942 (-0.979)
π x10^{-8} , Pa	-52.235C^2 +5.7876C +4.1334 (-0.873)	-20.936C^2 +3.0236C +4.1006 (-0.935)	-31.739C^2+3.4635C +4.1591 (-0.888)
V_f x 10^{7} , m^3	-3.64 C+ 2.3244 (-0.942)	-5.515C+2.6747 (-0.977)	-4.27C+2.773 (-0.969)
τ x10^{13} , s	19.503C +6.717 (0.968)	20.87C+6.2797 (0.985)	18.815C+6.3944 (0.945)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	3.5408C+1.3801 (0.960)	3.9405C+1.3122 (0.981)	2.78C+1.3764 (0.993)

Table-5.57 : The correlation equations and correlation coefficients for SBDAC- 5 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	210.74C+942.61 (0.993)	213.95 C+941.7 (0.994)	227.97C+940.14 (0.996)
η, mPa s	1.9551C+0.8887 (0.997)	1.9208 C+0.8483 (0.998)	1.8904 C+0.8303 (0.996)
U, ms^{-1}	296C+1481.9 (0.975)	238C+1489.1 (0.962)	218C+1494.2 (0.958)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.6315C+1.3942 (0.993)	0.2493C+1.3945 (0.959)	0.6014 C+1.4011 (0.992)
κ_S x10^{+10}, Pa $^{-1}$	-3.1419C+ 4.8487 (- 0.988)	-2.7912C+4.8082 (-0.985)	-2.766C+4.7866 (-0.982)
R x10^4 , $m^{10/3}$ $s^{1/3}$ mol^{-1}	25.214 C+8.8518 (0.999)	25.115C+8.8751 (1)	24.972C+8.9 (1)
b x10^5, m^3	21.248 C+7.6602 (0.999)	21.244 C+7.6677 (0.999)	21.128C+7.6812 (0.999)
L_f x10^{11}, m	-1.5151C+4.6099 (- 0.989)	-1.3973 C+ 4.592 (- 0.987)	-1.3178 C+4.5798 (- 0.976)
π x10^{-8} , Pa	-9.26C + 5.1226 (- 0.996)	-8.8866 C+5.024 (- 0.947)	-9.1241 C+ 5.102 (- 0.995)
V_f x 10^7 , m^3	2.1362C+1.5241 (0.992)	2.0819 C + 1.6449 (0.990)	2.0932C+1.7065 (0.971)
τ x10^{13} , s	8.0967C+5.7572 (0.997)	8.3836 C+5.4518 (0.997)	8.3137C+5.31 (0.993)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	8.8342C+7.6804 (0.997)	9.601C+7.2361 (0.995)	9.538+7.0302 (0.989)

Table-5.58 : The correlation equations and correlation coefficients for SBDAC- 5 +DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^{o}	**35^{o}**	**40^{o}**
ρ , kg.m^{-3}	159.73C+1053.6 (0.988)	220.27 C+1045.6 (0.995)	327.4C+1034.9 (0.983)
η, mPa s	2.3379C+1.214 (0.998)	2.4335C+1.125 (0.990)	2.1171C+1.107 (0.990)
U, ms^{-1}	416.6C+1327.2 (0.996)	378.85C+1321.4 (0.994)	330.25C+1317.4 (0.994)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.6592C+1.3979 (0.995)	0.6994C+1.3814 (0.995)	0.7748C+1.3636 (0.990)
κ_S x10^{+10}, Pa $^{-1}$	-3.9767C+5.3846 (-0.994)	-4.0652C+5.476 (-0.994)	-4.3148 C+5.5638 (-0.989)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$ mol^{-1}	19.71 C+9.1953 (1)	19.093C +9.1953 (0.999)	17.982C+9.3488 (0.999)
b x10^{5}, m ^{3}	16.784C+8.2485 (0.999)	16.586C+ 8.253 (0.999)	16.333C+8.3151 (0.999)
L_f x10^{11}, m	-1.8164C+4.8588 (-0.993)	-1.7973C+4.8962 (-0.993)	-1.9041C+4.937 (-0.986)
π x10^{-8} , Pa	-7.5559C +5.519 (-0.999)	-6.93C+5.3264 (-0.999)	-6.7499C+5.3959 (-0.997)
V_f x 10^{7} , m^{3}	0.99C+1.0624 (0.997)	0.9 C+1.1658 (0.997)	1.195C+ 1.1949 (0.992)
τ x10 ^{13} , s	9.0438 C +8.7371 (0.997)	10.293C+8.2325 (0.979)	8.1033C+8.2308 (0.981)
$(\alpha/f^{2})_{cl.}10^{14}$, s^{2}m^{-1}	0.909C+1.2984 (0.996)	1.147C+1.2293 (0.968)	0.8847C+1.2321 (0.971)

Table-5.59 : The correlation equations and correlation coefficients for SBDAC- 5 + THF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	148.77C+888.71 (0.985)	150.36C+887.66 (0.988)	152.52C+ 882.74 (0.987)
η, mPa s	1.6811C+ 0.531 (0.997)	2.0519 C+0.456 (0.998)	1.8807C+0.4194 (0.985)
U, ms^{-1}	351.4 C+1275.1 (0.997)	338.03C+1248.1 (0.993)	328C+1234.1 (0.989)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.5058C+1.1332 (0.993)	0.4912C+1.1078 (0.990)	0.4792C+1.0897 (0.989)
κ_S x10^{+10}, Pa $^{-1}$	-4.740 C+6.918 (- 0.995)	-4.891C+7.228 (- 0.991)	-5.006C+7.435 (- 0.988)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	27.006C+10.759 (1)	26.824C +10.696 (1)	26.945C+10.716 (1)
b x10^5, m ^{3}	23.606C+9.7778 (0.999)	23.721 C+9.802 (0.999)	23.845C+9.8413 (0.999)
L_f x10^{11}, m	-1.937C+5.5084 (- 0.994)	-1.9699 C +5.6301 (-0.994)	-1.8712C+5.705 (- 0.987)
π x10^{-8} , Pa	-4.2011C+3.3207 (- 0.984)	-2.5753 C +3.1247 (-0.993)	-2.18 C+2.9978 (- 0.983)
V_f x 10^7 , m^3	-2.4293C +3.5203 (- 0.907)	-6.3082C+4.1744 (- 0.974)	-8.4915C+4.6824 (-0.962)
τ x10 ^{13} , s	11.05C +4.9153 (0.997)	15.392 C+4.4181 (0.997)	15.855 C+ 4.158 (0.998)
$(\alpha/f^2)_{cl.}$10^{14}, s^{2}m^{-1}	14.564C+7.6085 (0.994)	21.801C+6.9906 (0.997)	22.936C+6.6533 (0.997)

Table-5.60 : The correlation equations and correlation coefficients for SBDAC - 6 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-198.63C+1460.4 (-0.983)	-176.27C+1454.2 (-0.993)	-162.08C+1452.3 (-0.996)
η, mPa s	1.951C+0.6904 (0.996)	1.9482C+0.6302 (0.997)	2.2132C+0.5833 (0.996)
U, ms^{-1}	207.07C+961.3 (0.996)	213.1 C+946.3 (0.997)	254.47C+924.8 (0.996)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.1414 C+1.4017 (0.982)	0.2197C+1.343 (0.959)	0.2493C+1.3945 (0.987)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-2.1093C+7.4081 (- 0.989)	-2.4405 C+7.6768 (- 0.997)	-3.3847 C+8.048 (- 0.993)
$R\ x10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	10.909 C+8.06 (0.999)	10.809C +8.053 (0.999)	10.806C+8.002 (1)
$b\ x10^{5}$, m^{3}	10.293 C+8.0355 (0.999)	10.254C+ 8.0451 (0.999)	10.14C+8.0784 (1)
$L_f\ x10^{11}$, m	-0.8658C+ 5.701 (- 0.981)	-0.9288 C+5.803 (-0.990)	-1.2603 C+5.942 (-0.996)
$\pi\ x10^{-8}$, Pa	$-14.228C^2$ +0.7214C + 4.2701 (-0.914)	$-4.6216C^2$+0.0009C +4.2007 (-0.956)	$-24.084C^2$+ 3.2211C +4.1063 (- 0.928)
$V_f\ x\ 10^{7}$, m^3	-3.9696 C+2.3989 (-0.967)	-4.9356 C+ 2.674 (-0.988)	-7.0512C+2.8908 (-0.974)
$\tau\ x10^{13}$, s	16.732 C +6.8297 (0.993)	16.787C+6.5173 (0.998)	20.059 C+6.2753 (0.995)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	3.104C+1.402 (0.990)	3.807C+1.339 (0.994)	3.981+1.3483 (0.994)

Table-5.61 : The correlation equations and correlation coefficients for SBDAC- 6 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	164.19C+949.3 (0.988)	164.93C+948.65 (0.985)	168.82C+947.88 (0.987)
η, mPa s	2.422C+0.8654 (0.988)	2.2893C+0.8121 (0.999)	2.0833 C+0.793 (0.999)
U, ms^{-1}	297.59C+1485.4 (0.980)	310.68C+1490.7 (0.986)	368.99C+1491.3 (0.993)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.46C+1.4152 (0.995)	0.20C +1.3982 (0.985)	0.56C +1.4172 (0.997)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-2.6405 C+4.7728 (-0.981)	-2.6901 C+4.7415 (-0.985)	-3.0526C+4.7417 (-0.991)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	25.617C+8.801 (0.999)	25.633C +8.812 (1)	25.77C+8.820 (1)
$b \times 10^{5}$, m^3	21.584C+7.601 (1)	21.612 C+7.6054 (1)	21.601C+7.611 (1)
$L_f \times 10^{11}$, m	-1.2575C+4.57 (- 0.983)	-1.3836C+4.5632 (- 0.990)	-1.5041 C+4.563 (- 0.986)
$\pi \times 10^{-8}$, Pa	-8.3888 C +5.0886 (-0.996)	-8.275C+5.002 (-0.999)	-8.7255C+5.019 (-0.996)
$V_f \times 10^{7}$, m^3	1.6433C+1.6144 (0.988)	1.0071C+1.7613 (0.981)	1.6129C+1.8265 (0.963)
$\tau \times 10^{13}$, s	11.533C +5.519 (0.985)	10.736 C+ 5.145 (0.999)	9.078C+ 5.027 (0.990)
$(\alpha/f^2)_{cl.} 10^{14}$, $s^2 m^{-1}$	12.025C+7.4475 (0.993)	12.85C+6.7848 (0.998)	12.85C +6.4328 (0.991)

Table-5.62 : The correlation equations and correlation coefficients for SBDAC - 6 + DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	212.33C+1046.9 (0.996)	253.97C+1041.4 (0.986)	269.32 C+1039.3 (0.989)
η, mPa s	2.7652C+1.0982 (0.995)	2.577C+ 1.0962 (0.991)	2.758 C+1.078 (0.991)
U, ms^{-1}	334.58 C+1340.8 (0.992)	340.71C+1332.3 (0.989)	346.03C+1323.8 (0.993)
Z x 10^{-6} , $kg.m^{-2}$ s^{-1}	0.6414C+1.4037 (0.994)	0.7167C+1.386 (0.992)	0.723C+1.3758 (0.991)
κ_S x10^{+10}, Pa $^{-1}$	-3.5647C+5.3127 (- 0.991)	-3.9378 C+5.411 (- 0.989)	-4.0649C+5.487 (- 0.991)
R x10 ^{4} , $m^{10/3}$ $s^{1/3}$ mol^{-1}	19.094C+ 9.291 (0.999)	18.657C +9.3304 (0.999)	18.62C+9.3218 (0.999)
b x10^{5}, m ^{3}	16.378C+8.3065 (0.999)	16.005 C+ 8.3586 (0.999)	15.97C+8.3689 (0.999)
L_f x10^{11}, m	-1.6575 C+4.824 (-0.989)	-1.7918C+4.8726 (-0.988)	-1.8384 C+4.903 (-0.987)
π x10^{-8} , Pa	– 6.54C+ 5.3534 (0.983)	-5.78C+5.1948 (0.998)	-5.4923C+5.1669 (0.991)
V_f x 10 ^{7} , m^3	$11.618C^2$ – 1.1879C +1.2117 (0.843)	$12.929C^2$ -1.2574C +1.278 (0.893)	$16.175C^2$ -1.868C +1.3101 (0.827)
τ x10 ^{13} , s	10.07C +8.343 (0.981)	11.185C +7.9867 (0.993)	12.79C +7.876 (0.971)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	1.255C+1.2185 ((0.982)	1.335C+1.1809 (0.988)	1.31C+1.1988 (0.974)

Table-5.63 : The correlation equations and correlation coefficients for SBDAC -7 +CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	-181.04C+1458.1 (- 0.981)	-187.04C+1449 (- 0.988)	-181.64C+1445.3 (- 0.987)
η, mPa s	2.6041C+0.6363 (0.971)	2.3419 C+0.5843 (0.973)	2.1074 C+0.5714 (0.972)
U, ms^{-1}	190.41C+960.73 (0.993)	177.86C+947.71 (0.997)	208.05C+929.28 (0.991)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.986C+1.401 (0.993)	0.2493C+1.3945 (0.959)	0.126C+1.3428 (0.967)
κ_S x10^{+10}, Pa $^{-1}$	-1.9633C+7.4298 (- 0.995)	-1.8255 C+7.6868 (- 0.988)	-2.4868C+8.01 (-0.985)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	16.76C+8.0686 (0.999)	16.908C+8.081 (1)	16.955C+8.05 (0.999)
b x10^5, m ^{3}	16.171C+8.0743 (1)	16.414C+8.0948 (1)	16.455 C+8.114 (1)
L_f x10^{11}, m	-07342 C+5.7046 (-0.992)	-0.7397 C+5.8082 (-0.989)	-0.9342 C+5.9266 (-0.984)
π x10^{-8} , Pa	-67.994C^2+ 5.6835C + 3.9878 (0.996)	-84.334C^2+ 7.0524C + 3.808 (0.991)	-79.127C^2+5.8991C+ 3.9698 (0.931)
V_f x 10 ^{7} , m^3	138.76C^2 – 20.84C + 2.9776 (-0.994)	186.24C^2 – 25.812C + 3.2986 (-0.977)	178.44C^2 -23.808C + 3.2944 (-0.967)
τ x10 ^{13} , s	23.949 C +6.2424 (0.973)	21.986C+ 6.003 (0.964)	19.914C+6.109 (0.967)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	4.46C + 1.2974 (0.960)	4.0671C+1.2767 (0.921)	3.6123C +1.3299 (0.897)

Table-5.64 : The correlation equations and correlation coefficients for SBDAC- 7 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	151.1C+954.78 (0.993)	175.86C+950.83 (0.984)	176.83C+950.23 (0.980)
η, mPa s	1.7923C+1.0061 (0.970)	2.1759C+0.9119 (0.990)	2.3542C+0.8712 (0.973)
U, ms^{-1}	313.59 C+1519.4 (0.992)	338.63C+1522.9 (0.998)	324.77C+1529.5 (0.995)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.5323C+1.4507 (0.993)	0.2493C+1.3945 (0.959)	0.5808C+1.4537 (0.990)
κ_S x10^{+10}, Pa $^{-1}$	-2.4857C+4.5369 (-0.993)	-2.7282C+4.5326 (-0.995)	-2.6381C+4.4971 (-0.990)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	41.804C+8.8813 (1)	41.786C +8.8652 (1)	41.726C+8.8176 (1)
b x10^{5}, m ^{3}	35.289C+7.5661 (0.999)	35.225C+7.5984 (1)	35.253C+7.6027 (1)
L$_f$ x10^{11}, m	-1.2548 C+4.458 (- 0.992)	-1.4082 C+4.4594 (- 0.997)	-1.463 C+4.4456 (- 0.993)
π x10^{-8} , Pa	-16.481 C +5.3363 (- 0.997)	-15.022C+5.1548 (- 0.998)	-14.358 C+5.108 (- 0.998)
V$_f$ x 10^{7} , m^{3}	6.63C+1.2762 (0.999)	5.79 C+1.5389 (0.998)	5.9C + 1.5934 (0.992)
τ x10 ^{13} , s	5.18C +6.2222 (0.990)	8.14C+ 5.59 (0.992)	8.29C+5.3818 (0.980)
$(\alpha/f^2)_{cl.}$10^{14}, s^{2}m^{-1}	5.03C+8.0706 (0.982)	8.77 C+7.2382 (0.988)	9.5971C +6.8857 (0.982)

Table-5.65 : The correlation equations and correlation coefficients for SBDAC- 8 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-168.19C+1459 (- 0.989)	-179.18C+1458.4 (- 0.996)	-166.49 C+1454.8 (- 0.996)
η, mPa s	2.4973C+0.7138 (0.980)	2.7266 C+0.6135 (0.993)	2.8537 C+0.5906 (0.998)
U, ms^{-1}	297.53C+967.23 (0.981)	276.82C+957.1 (0.985)	307.18C+936.66 (0.979)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.2677C+1.4113 (0.975)	0.2493C+1.3945 (0.959)	0.2819C+1.3629 (0.95 9)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.01C+7.287 (-0.987)	-2.815 C+7.4489 (-0.986)	-3.435C+7.7853 (-0.977)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	12.274C+8.011 (0.999)	11.403 C +8.059 (0.999)	11.395C+8.0211 (0.999)
$b \times 10^{5}$, m^3	11.35C+7.9723 (0.990)	10.576C+8.0457 (0.999)	10.531C+8.0644 (0.999)
$L_f \times 10^{11}$, m	-1.4C+5.668 (- 0.971)	-1.2712C+5.729 (- 0.984)	-1.5315C+5.8608 (- 0.971)
$\pi \times 10^{-8}$, Pa	$-47.835C^2+5.399C$ +4.2429 (0.967)	$-58.799C^2 +8.3191C$ + 3.9754 (0.912)	$- 13.667C^2 +3.2554C$ +4.1426 (0.972)
$V_f \times 10^{7}$, m^3	-2.955C+2.1441 (- 0.945)	-6.825C+ 2.7069 (- 0.971)	-8.205C+2.8081 (- 0.987)
$\tau \times 10^{13}$, s	17.365C +7.1773 (0.987)	21.88C+6.248 (0.992)	25.064 C+6.193 (0.997)
$(\alpha/f^2)_{cl.} 10^{14}$, s^2m^{-1}	3.5027C+1.4606 (0.985)	4.045C+1.2869 (0.990)	4.735C+1.3031 (0.997)

Table-5.66 : The correlation equations and correlation coefficients for SBDAC- 8 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	135.12C+952.2 (0.968)	147.78 C+950.36 (0.987)	149.34 C+949.73 (0.992)
η, mPa s	2.4047C+ 0.8949 (0.996)	2.2458C+0.8608 (0.988)	2.2945C+0.8406 (0.978)
U, ms^{-1}	326C+1483.2 (1)	306C+1489.5 (0.965)	330 C+ 1491.1 (0.980)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.485 C+ 1.4151 (0.999)	0.2 C+ 1.3982 (0.953)	0.525C+ 1.4173 (0.990)
κ_S x10^{+10}, Pa^{-1}	-2.8052 C+4.7814 (-0.998)	-2.9107 C+4.7661 (-0.996)	-2.9545C+4.751 (-0.999)
R x10^{4} , $m^{10/3}$ $s^{1/3}$$mol^{-1}$	12.563 C+7.9994 (0.986)	26.934C +8.7844 (1)	26.96C+8.7944 (0.999)
b x10^{5}, m^3	19.839 C+7.660 (0.988)	22.647 C+7.59 (1)	22.65 C+7.595 (1)
L_f x10^{11}, m	-1.3973C+4.5822 (-0.987)	-1.3781C+4.5695 (-0.978)	-1.4301C+4.5639 (-0.978)
π x10^{-8} , Pa	-9.2584 C + 5.188 (-0.998)	-9.2868C+5.1463 (-0.997)	-9.3559C+5.1809 (-0.997)
V_f x 10^{7} , m^3	1.695C+ 1.4857 (0.993)	2.115 C+ 1.5723 (0.968)	2.22C + 1.6128 (0.932)
τ x10^{13} , s	11.057C +5.7202 (0.995)	10.042C+5.4842 (0.985)	9.9929C+5.3637 (0.969)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	11.77C+7.6832 (0.998)	10.3C+7.3596 (0.978)	9.67 C + 7.2276 (0.955)

Table-5. 67: The correlation equations and correlation coefficients for SBDAC-8 +DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	210.41C+1050.1 (0.991)	186.03C+1050.2 (0.981)	198.63C+1044.9 (0.986)
η, mPa s	2.506C+1.177 (0.995)	2.426C+1.1088 (0.991)	2.3493C+ 1.0895 (0.984)
U, ms^{-1}	295.78 C+1342 (0.994)	362.36C+1329.2 (0.986)	356.99 C+1325.8 (0.983)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.5964C+1.4094 (0.995)	0.6348C+1.396 (0.985)	0.6455C+ 1.385 (0.985)
κ_S x10^{+10}, Pa $^{-1}$	-3.2446 C+5.2856 (-0.993)	-3.7047C+5.3861 (-0.983)	-3.7819C+5.4421 (-0.981)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	19.722C+9.2644 (0.999)	20.169C +9.2314 (1)	20.168C+ 9.272 (1)
b x10^5, m^3	17.03C+ 8.2803 (0.999)	17.302C+8.2776 (0.999)	17.34C+8.3204 (0.999)
L_f x10^{11}, m	-1.523C+4.8154 (-0.992)	-1.6795 C+4.8584 (-0.980)	-1.7863 C+4.889 (-0.982)
π x10^{-8} , Pa	-7.005C +5.3924 (0.997)	-6.8763C+ 5.2577 (0.998)	-6.6507C+5.1947 (0.992)
V_f x 10^7 , m^3	0.735C+1.1293 (0.911)	0.93 C+1.2062 (0.992)	1.1586C+1.2229 (0.989)
τ x10 ^{13} , s	12.184C +8.2493 (0.995)	10.837C+7.9796 (0.990)	10.491 C+7.9073 (0.997)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	1.3497C+1.2251 (0.991)	1.2632C+1.1824 (0.990)	1.2007 +1.1768 (0.977)

Table-5.68 : The correlation equations and correlation coefficients for SBDAC- 9 + CF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30°	35°	40°
ρ , kg.m^{-3}	-176.19C+1460.7 (-0.989)	-172.77C+1458.7 (-0.991)	-191.29 C+1459 (-0.990)
η, mPa s	2.7792C+0.6197 (0.994)	2.3414C+ 0.6137 (0.978)	2.1227C+0593 (0.985)
U, ms^{-1}	276.44C+960.75 (0.989)	298.41C+ 948.85 (0.997)	400.11C+931.93 (0.989)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.2247C+1.4037 (0.987)	0.2493C+1.3945 (0.959)	0.3989 C+1.3597 (0.979)
κ_S x10^{+10}, Pa $^{-1}$	-3.2282C+7.4146 (- 0.988)	-3.6997 C+7.6108 (-0.997)	-5.3962C+7.8865 (- 0.985)
R x10 ^{4} , $m^{10/3}$ $s^{1/3}$$mol^{-1}$	11.348 C+8.057 (0.999)	11.387C +8.0339 (0.999)	11.821C+7.9799 (0.999)
b x10^{5}, m ^{3}	10.521 C+8.0343 (0.999)	10.584C+8.0387 (0.999)	10.64C+8.041 (0.999)
L_f x10^{11}, m	-1.2575 C+5.7 (-0.983)	-1.4548 C+ 5.780 (-0.997)	-1.9945C+5.8764 (- 0.989)
π x10^{-8} , Pa	-636.57C^3 +73.163C^2 + 0.1101C+4.0737 (-0.965)	1047.8C^3 -210.95C^2 11.216C +4.0842 (-0.919)	429.46C^3 – 114.62C^2 +7.7224C +4.0633 (-0.977)
V_f x 10 ^{7} , m^3	71.013C^2 -15.822C + 2.9133 (-0.994)	108.55 C^2 -18.214C +2.9757 (-0.997)	92.072C^2 -15.972C +3.0464 (-0.977)
τ x10 ^{13} , s	23.611 C +6.1439 (0.992)	13.24C+6.7436 (0.997)	16.56C+ 6.2584 (0.977)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	4.3627C +1.2626 (0.990)	2.245C +1.4019 (0.996)	2.8121C + 1.326 (0.968)

Table-5.69 : The correlation equations and correlation coefficients for SBDAC- 9 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	176.22C+949.4 (0.985)	186.33C+948.02 (0.988)	190.88 C+947.52 (0.988)
η, mPa s	2.2167C+0.934 (0.975)	2.2184 C+0.8809 (0.975)	2.2647C+0.8533 (0.967)
U, ms^{-1}	257.21 C+1484 (0.977)	272.11 C+1487.6 (0.977)	246.58C+1493.3 (0.979)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.5142 C+1.4086 (0.987)	0.2447C+1.3945 (0.958)	0.526C+1.4148 (0.989)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-2.4271C+4.7789 (- 0.978)	-2.5868C+4.7653 (-0.980)	-2.4271C+4.7319 (- 0.984)
$R\ x10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	26.294 C+8.794 (0.999)	26.286C +8.814 (1)	26.205C+8.8309 (1)
$b\ x10^{5}$, m^3	22.324 C+7.6014 (0.999)	22.277 C+7.611 (1)	22.222 C+7.6167 (1)
$L_f\ x10^{11}$, m	-1.1973 C+4.5802 (-0.978)	-1.2575C+4.57 (-0.983)	-1.189 C+4.5548 (-0.992)
$\pi\ x10^{-8}$, Pa	-9.7353C +5.2763 (-0.997)	-9.3408C+ 5.1989 (-0.997)	-9.0819C+5.1941 (-0.993)
$V_f\ x\ 10^{7}$, m^3	$20.357C^2$-0.1429C +1.4358 (0.980)	$29.107C^2$ -1.2279C +1.5906 (0.988)	$22.5C^2$ - 0.41C +1.6352 (0.980)
$\tau\ x10^{13}$, s	8.825C +6.0795 (0.969)	8.775 C+5.7225 (0.975)	8.745C+5.5503 (0.979)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	10.32C+8.0674 (0.961)	10.24C+7.575 (0.973)	10.31C + 7.3216 (0.975)

Table-5.70 : The correlation equations and correlation coefficients for SBDAC-9 + DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	203.84C+1051.5 (0.990)	187.95 C+1050 (0.985)	186.85C+1048.7 (0.971)
η, mPa s	η=2.63C+1.1892 (0.996)	η=2.335 C+1.1283 (0.993)	η= 2.425C+1.0713 (0.997)
U, ms^{-1}	367.18C+1341.7 (0.995)	348 C+1335.3 (0.996)	373.97C+1324.6 (0.985)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.6753C+1.4103 (0.994)	0.6214C+1.4019 (0.993)	0.6485C+1.389 (0.979)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.7121C+5.28 (-0.993)	-3.5616C+5.3387 (-0.993)	-3.851C+5.4326 (- 0.980)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	19.956C+9.2508 (1)	20.13 C +9.2489 (0.999)	20.232C+ 9.2342 (0.999)
$b \times 10^{-5}$, m^3	17.069C+8.2674 (0.999)	17.291C+8.2781 (0.999)	17.356C+8.2871 (0.999)
$L_f \times 10^{11}$, m	-1.7973C+4.8162 (-0.993)	-1.6493C+4.8385 (-0.994)	-1.8055 C+4.882 (- 0.984)
$\pi \times 10^{-8}$, Pa	-7.105 C +5.5937 (- 0.998)	-7.25C+ 5.4544 (- 0.995)	-6.79C+5.3342 (- 0.998)
$V_f \times 10^{7}$, m^3	$500 C^3 -85.357C^2$ +4.6929C +1.0696 (0.959)	$114.58C^3 - 24.196C^2$ 2.7202C+1.1836 (0.872)	$385.42C^3 - 61.518C^2$ +3.2155C +1.262 (0.927)
$\tau \times 10^{13}$, s	11.56C +8.3706 (0.988)	10.45C+ 8.0288 (0.984)	11.45 C+7.7288 (0.993)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	1.335C+1.2301 (0.980)	1.250C+1.1847 (0.975)	1.38C+1.148 (0.993)

Table-5.71 : The correlation equations and correlation coefficients for SBDAC – 10 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-179.95C+1459.7 (-0.984)	-174.88C+1457.1 (-0.986)	-175.53 C+1456 (-0.988)
η, mPa s	2.3279C+0.7226 (0.978)	2.4762 C+0.6427 (0.992)	2.651C+0.5974 (0.995)
U, ms^{-1}	298.41C+962.65 (0.996)	293.32 C+955.01 (0.997)	312.66C+937.25 (0.997)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.2573 C+1.4052 (0.996)	0.2493C+1.3945 (0.959)	0.2756C+1.3651 (0.984)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-3.5063 C+7.3902 (-0.997)	-3.5515C+7.522 (-0.997)	-4.0666C+7.8159 (-0.986)
$R\ x10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	11.468 C+8.0673 (0.999)	11.423C +8.0606 (0.999)	11.454C+8.0166 (0.999)
$b\ x10^{5}$, m^{3}	10.565 C+8.0398 (0.999)	10.55C+8.0537 (0.999)	10.572C+8.0584 (0.999)
$L_f\ x10^{11}$, m	-1.3342C+5.6906 (-0.998)	-1.3342C+5.7406 (-0.998)	-1.5507C+5.8535 (-0.990)
$\pi\ x10^{-8}$, Pa	$985.7C^3$ -211.83C^2 12.139C +4.2227 (0.974)	267.53C^3-88.232C^2 +7.2755C +4.1285 (0.983)	214.08C^3-88.232C^2 7.2755C+4.1285 (0.983)
$V_f\ x\ 10^{7}$, m^3	78.061C^2-12.771C +2.398 (0.975)	68.385C^2 -13.803C +2.7581 (0.990)	77.339 C^2 -16.409C +2.9783 (0.997)
$\tau\ x10^{13}$, s $(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	18.438C +7.137 (0.936) 3.22C+1.4638 (0.956)	20.609 C+6.4629 (0.979) 3.7304C+1.3359 (0.987)	22.874C+6.248 (0.988) 4.226C+1.3168 (0.993)

Table-5.72 : The correlation equations and correlation coefficients for SBDAC- 10 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	90.5C+956.13 (0.988)	96.5C+955.33 (0.984)	100.5C+954.67 (0.984)
η, mPa s	2.1433C+0.9054 (0.994)	1.9392C+ 0.8821 (0.993)	1.8822C+0.8678 (0.987)
U, ms^{-1}	313.42C+1482.1 (0.977)	292.66C+1487 (0.956)	280.66 C+1491.6 (0.981)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.385 C+1.4209 (0.999)	0.2C+1.3982 (0.985)	0.385C+1.4265 (0.995)
κ_S x10^{+10}, Pa $^{-1}$	-2.5816C+4.7703 (- 0.997)	-2.3863C+4.742 (-0.955)	-2.3005 C+ 4.715 (-0.975)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	27.083 C+8.739 (0.999)	27.018C +8.7559 (0.999)	27.021C+8.7693 (1)
b x10^{5}, m ^{3}	22.88 C+ 7.5584 (0.999)	22.859C+ 7.5631 (0.999)	22.862C+7.5663 (0.999)
L_f x10^{11}, m	-0.95C+4.555 (-0.990)	-0.95C+4.543 (-0.985)	-0.95 C+4.533 (-0.985)
π x10^{-8} , Pa	-10.014C +5.2222 (-0.998)	-10.282C+5.2269 (-0.996)	-10.367C+5.2577 (-0.996)
V_f x 10^{7} , m^{3}	2.205C+1.4651 (0.990)	2.545C+1.5385 (0.971)	2.815C+1.5731 (0.963)
τ x10 ^{13} , s	9.8205 C +5.7724 (0.996)	8.7932C+5.5885 (0.991)	8.5632C+5.4681 (0.984)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	11.202C+7.684 (0.996)	9.977C+7.415 (0.988)	9.706C+7.232 (0.980)

Table-5.73 : The correlation equations and correlation coefficients for SBDAC- 10 +DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^{o}	**35^{o}**	**40^{o}**
ρ , kg.m^{-3}	254.79C+1048.8 (0.974)	238.9C+1045.3 (0.988)	272.33C+1042.3 (0.983)
η, mPa s	2.6962C+ 1.1785 (0.991)	2.7216C+1.1167 (0.982)	3.003C+1 .051 (0.993)
U, ms^{-1}	442.85C+1328.9 (0.994)	425.86C+ 1323.9 (0.992)	415.12 C+1318.2 (0.987)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.8189C+1.3935 (0.959)	0.2493C+1.3945 (0.959)	0.2493C+1.3943 (0.959)
κ_S x10^{+10}, Pa $^{-1}$	-4.6022C+5.3934 (-0.993)	-4.4745C+5.4532 (-0.993)	-4.6364C+5.517 (-0.987)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	19.51C+9.2501 (0.999)	19.828C+9.2656 (0.999)	19.936C+9.2671 (0.999)
b x10^{5}, m ^{3}	16.532 C+8.2948 (0.999)	16.883C+8.3174 (0.999)	16.652C+8.3416 (0.999)
L$_f$ x10^{11}, m	-2.0959C+4.863 (-0.996)	-2.063 C+4.8916 (-0.988)	-2.1507C+4.919 (-0.987)
π x10^{-8} , Pa	-6.7704C+ 5.416 (-0.998)	-6.4608C+5.3571 (-0.991)	-5.4449C+5.2047 (-0.996)
V$_f$ x 10 ^{7} , m^{3}	-193.88C^{3}+48.373C^{2} -2.693 + 1.1678 (-0.993)	144.99C^{3} -3.4508C^{2} -0.8705C +1.2446 (-0.959)	-53.933C^{3}+28.208C^{2} -2.7927C +1.3541 (-0.956)
τ x10 ^{13} , s $(\alpha/f^2)_{cl.}$10^{14}, s^{2}m^{-1}	10.448C +8.5025 (0.967) 1.6367C+1.1608 (0.992)	11.522 C + 8.1432 (0.957) 1.3077C+1.2129 (0.931)	13.738 C+7.7562 (0.992) 1.0951 C+1.2623 (0.939)

Table-5.74 : The correlation equations and correlation coefficients for SBDAC- 11 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-186.36C+1457.1 (-0.994)	-197.84C+1455.5 (-0.996)	-172.03C+1449.2 (-0.988)
η, mPa s	2.5132C+0.7133 (0.996)	2.3997 C+0.6682 (0.995)	2.5285C+0.6012 (0.997)
U, ms^{-1}	259.29 C+955.47 (0.997)	229.59C+ 944.27 (0.989)	245.37C+924.46 (0.998)
Z x 10^{-6} , $kg.m^{-2}\ s^{-1}$	0.2016 C+1.3919 (0.988)	0.2493C+1.3945 (0.959)	0.1855 C+1.3406 (0.987)
κ_S x10^{+10}, Pa^{-1}	-2.9871 C+7.5155 (-0.995)	-2.5868C+7.7033 (-0.974)	-3.1937C+ 8.0718 (-0.993)
R x10^4 , $m^{10/3}\ s^{1/3}mol^{-1}$	15.66C+8.0586 (1)	15.54C + 8.0326 (1)	15.519C+ 8.0145 (1)
b x10^5, m^3	14.866 C+8.0516 (1)	14.982C+ 8.0586 (1)	14.901 C+8.0926 (1)
L_f x10^{11}, m	-1.2137C+5.741 (-0.993)	-0.8658C+5.8014 (-0.981)	-1.0986 C+5.945 (-0.991)
π x10^{-8} , Pa	-22.342C^2 +0.1984C +4.331 (-0.991)	-27.719C^2+ 0.9215C +4.2736 (-0.989)	-19.289C^2 +0.9348C +4.1756 (-0.981)
V_f x 10^7 , m^3	42.754C^2 – 8.3253C +2.341 (0.993)	55.456C^2 – 10.245C +2.5531 (0.992)	36.793C^2 – 10.019C +2.8274 (0.988)
τ x10^{13} , s	19.895C +7.2721 (0.995)	19.685C+7.0139 (0.994)	22.415C+6.5695 (0.995)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	3.57C+1.5042 (0.992)	3.625C+1.4689 (0.989)	4.25C+ 1.4058 (0.994)

Table-5.75 : The correlation equations and correlation coefficients for SBDAC- 11 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	170.22C+953.56 (0.984)	173.56C+952.86 (0.990)	159.92C+952.15 (0.992)
η, mPa s	3.8173C+ 0.9366 (0.990)	3.6899C+0.8877 (0.990)	3.126C+0.8588 (0.995)
U, ms^{-1}	397.7 C+1480.5 (0.988)	478.74C+ 1479.8 (0.995)	381.97C+ 1492.5 (0.984)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.57C+1.4168 (0.998)	0.2C+1.3982 (0.985)	0.55C+1.4256 (0.999)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-3.2605C+4.782 (-0.985)	-3.7542C+4.7888 (-0.993)	-3.0603 C+4.7128 (-0.985)
$R\ x10^4$, $m^{10/3}\ s^{1/3} mol^{-1}$	37.763 C+8.7516 (1)	37.979C +8.756 (1)	38.077C+8.788 (1)
$b\ x10^5$, m^3	37.123C+7.1378 (0.962)	31.945C+7.5782 (1)	32.163C+7.5834 (1)
$L_f\ x10^{11}$, m	-1.5726 C+4.578 (-0.978)	-1.8548 C+4.584 (-0.991)	-1.5096C+4.5463 (-0.992)
$\pi\ x10^{-8}$, Pa	-11.744 C +5.284 (-0.999)	-11.519 C+5.217 (-0.999)	-12.166C+5.1838 (-0.999)
$V_f\ x\ 10^7$, m^3	$39.835C^2$ -3.2052C +1.4799 (0.974)	$36.032C^2$-2.6073C +1.596 (0.964)	$21.989C^2$ -0.295C +1.6722 (0.981)
$\tau\ x10^{13}$, s	$-140.93C^2$ + 33.765C +5.7595 (0.999)	$-112.86C^2$ + 29.397C +5.4838 (0.997)	$-63.223C^2$ +21.697C +5.2954 (0.998)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	$-171.53C^2$ +40.422C +7.7068 (0.999)	$-1444C^2$+35.454C +7.3278 (0.997)	$-78.562C^2$ +25.834C +7.0134 (0.997)

Table-5.76 : The correlation equations and correlation coefficients for SBDAC- 11 + DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	226.03C+1051.8 (0.998)	225.75 C+1048 (0.994)	213.15C+1047.3 (0.991)
η, mPa s	3.07C+1.156 (0.984)	2.935C+1.0959 (0.993)	2.92C+1.0728 (0.983)
U, ms^{-1}	384.49C+ 1341.8 (0.994)	348.27 C+1340.5 (0.986)	347.01C+1335.2 (0.990)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.7181C+1.4111 (0.997)	0.6696C+1.4051 (0.990)	0.6573 C+1.3982 (0.987)
κ_S x10^{+10}, Pa $^{-1}$	-3.7973C+5.2742 (-0.995)	-3.72 C+5.3072 (-0.987)	-3.6893C+5.3529 (-0.984)
R x10 ^{4} , $m^{10/3}$ $s^{1/3}$$mol^{-1}$	28.461C+9.2599 (0.999)	28.645 C + 9.2646 (0.999)	28.735C+9.2787 (1)
b x10^5, m ^{3}	24.608 C +8.2739 (0.999)	24.794C+8.3038 (1)	24.99 C+8.3075 (1)
L_f x10^{11}, m	-1.8685 C+4.814 (-0.997)	-1.7836 C+4.8272 (-0.989)	-1.6712C+4.843 (-0.990)
π x10^{-8} , Pa	-8.9362C +5.253 (-0.997)	-8.9066 C + 5.1223 (-0.998)	-8.4948C+5.0526 (-0.996)
V_f x 10^7 , m^3	35.925C^2 -3.1965C +1.2883 (0.979)	22.154C^2 – 1.5098C +1.3486 (0.952)	41.988C^2 -3.9554C +1.4402 (0.981)
τ x10 ^{13} , s	-180.56C^2 +36.227C +7.6136 (- 0.998)	-92.605C^2+25.766C +7.4577 (- 0.952)	-164.72C^2+34.687C +7.1552 (- 0.999)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	-28.062C^2 +5.2109C +1.115 (- 0.998)	-12.106C^2+3.283C +1.1008 (- 0.996)	-22.805C^2+4.6114C +1.0607 (-0.998)

Table-5.77 : The correlation equations and correlation coefficients for SBDAC- 12 +CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-175.37C+1459.2 (-0.995)	-179.64C+1458 (-0.990)	-170.77C+1456.8 (-0.994)
η, mPa s	2.2844C+0.6793 (0.979)	2.2375C+0.6432 (0.977)	2.349C+0.6006 (0.983)
U, ms^{-1}	268.88C + 937.54 (0.991)	266.63C+949.22 (0.999)	266.9C+ 957.4 (0.998)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.2293C+ 1.3657 (0.989)	0.2493C+1.3945 (0.959)	0.2186C+1.3947 (0.998)
$\kappa_s \times 10^{+10}$, Pa^{-1}	-3.4088C+7.807 (-0.989)	-3.189C+7.609 (-0.998)	-3.1277C+7.4763 (-0.998)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	9.9052C+8.014 (0.999)	9.9792 C + 8.04 (0.999)	10.203C+ 8.048 (0.999)
$b \times 10^{5}$, m^3	9.1652C+8.055 (0.999)	9.2052 C+8.0486 (0.999)	9.1625C +8.0418 (0.9859
$L_f \times 10^{11}$, m	-1.3041C+5.8507 (-0.982)	-1.1863C+5.773 (-0.993)	-1.1863 C+5.723 (-0.993)
$\pi \times 10^{-8}$, Pa	$-52.427C^2 +6.995C$ +3.9582 (-0.971)	$-50.13C^2 +6.6253C$ +4.1045 (-0.995)	$-26.873C^2+ 4.0961C$ +4.3079 (0.984)
$V_f \times 10^{7}$, m^3	$109.6C^2 -19.53 C$ +3.0413 (- 0.991)	$90.499C^2- 15.997C$ +2.7889 (- 0.961)	$48.227C^2 -11.146C$ +2.5698 (- 0.981)
$\tau \times 10^{13}$, s $(\alpha/f^2)_{cl.} 10^{14}$, $s^2 m^{-1}$	$-161.62C^2 +38.117 C$ +5.9579 (0.998) $-32.825C^2+7.4059C$ +1.2588 (0.987)	$-152.19C^2+35.501C$ +6.2473 (0.987) $-31.667C^2+6.9031C$ +1.299 (0.984)	$-60.853C^2+25.506C$ +6.6723 (0.973) $-12.86C^2 +4.7962C$ +1.3756 (0.966)

Table-5.78 : The correlation equations and correlation coefficients for SBDAC- 12 +DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	162.44C+949.69 (0.989)	156.38 C+949.59 (0.991)	150.47C+ 949.29 (0.990)
η, mPa s	2.0866C+0.9579 (0.996)	2.3732C+0.8797 (0.985)	2.1915C+ 0.8666 (0.982)
U, ms^{-1}	303.18C+ 1506.5 (0.971)	289.21C+1511.5 (0.985)	260.44C+1515.7 (0.979)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.5452C+1.4302 (0984)	0.2493C+1.3945 (0.959)	0.4775C+1.4388 (0.985)
$\kappa_S\ x10^{+10}$, Pa^{-1}	-2.5627C+4.6384 (-0.977)	-2.4384C+4.6083 (- 0.986)	-2.234C+4.5844 (- 0.982)
$R\ x10^4$, $m^{10/3}\ s^{1/3} mol^{-1}$	23.037 C+8.8356 (0.999)	23.251C +8.8225 (0.999)	23.081C+8.8498 (0.999)
$b\ x10^5$, m^3	19.416 C+ 7.5815 (0.999)	19.416 C+7.5815 (0.999)	19.438 C+7.6 (1)
$L_f\ x10^{11}$, m	-1.2055C+4.5056 (- 0.973)	-1.137 C+4.4904 (- 0.986)	-1.0438 C+ 4.479 (- 0.977)
$\pi\ x10^{-8}$, Pa	-8.9877C +5.4989 (-0.999)	-7.5512C+5.1748 (-0.996)	-7.6156 C+5.0483 (-0.996)
$V_f\ x\ 10^7$, m^3	1.54 C+1.3856 (0.994)	1.095C+1.5489 (0.932)	1.48C +1.5874 (0.965)
$\tau\ x10^{13}$, s	8.9332 C +5.9341 (0.998)	10.965C+5.4141 (0.982)	10.166C+5.3054 (0.978)
$(\alpha/f^2)_{cl}.10^{14}$, s^2m^{-1}	9.9232C+7.7708 (0.998)	12.704C+7.0671 (0.981)	11.839C+6.9051 (0.975)

Table-5.79 : The correlation equations and correlation coefficients for SBDAC-12 +DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	164.11C+1044.7 (0.990)	167.4 C+1041.5 (0.999)	185.21C+1036.8 (0.984)
η, mPa s	2.8055C+1.1104 (0.998)	2.3471C+1.0599 (0.966)	2.4586 C+1.033 (0.994)
U, ms^{-1}	354.96C+1330.9 (0.995)	355.18C+ 1322.8 (0.988)	330.03C+ 1317 (0.964)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.6014 C + 1.3901 (0.995)	0.5959C + 1.3777 (0.994)	0.589 C+1.3652 (0.978)
κ_S x10^{+10}, Pa $^{-1}$	-3.5474 C+5.400 (-0.995)	-3.6507C+5.4845 (-0.991)	-3.608 C+5.5584 (- 0.970)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	17.71 C+ 9.2823 (0.999)	17.728 C + 9.293 (0.999)	17.576C+9.3226 (0.999)
b x10^5, m ^{3}	15.115 C + 8.3174 (0.999)	15.163C+ 8.3424 (1)	15.097C+ 8.3818 (0.999)
L$_f$ x10^{11}, m	-1.663C+4.8676 (-0.992)	-1.6712C+4.903 (-0.990)	-1.6603C+4.9358 (-0.976)
π x10^{-8} , Pa	-5.1288C +5.425 (-0.985)	-6.49C+5.367 (-0.995)	-5.0784C+5.367 (-0.999)
V$_f$ x 10^7 , m^3	27.583C^2 -3.5029C +1.2931 (0.989)	21.464C^2 -2.6308 C +1.3826 (0.821)	8.5805C^2 -1.1489C +1.4001 (0.956)
τ x10 ^{13} , s	13.598C +8.0166 (0.972)	8.055 C+7.9783 (0.988)	12.144 C+ 7.5287 (0.999)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	1.656C+1.188 (0.962)	1.272C+1.158 (0.915)	1.494C+1.1282 (0.999)

Table-5.80 : The correlation equations and correlation coefficients for SBDAC- 13 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-210C+1457.8 (-0.995)	-180.96 C+1453.6 (-0.984)	-159.42 C+1450.8 (-0.988)
η, mPa s	2.251C+ 0.6834 (0.981)	2.4479 C+0.6184 (0.999)	2.3203 C+0.6066 (0.996)
U, ms^{-1}	328.11C+959.05 (0.997)	291.45C+948.84 (0.993)	291.4C+ 934.48 (0.997)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.2625C+1.3988 (0.981)	0.2493C+1.3945 (0.959)	0.2633 C+1.3562 (0.994)
$\kappa_s \times 10^{+10}$, Pa^{-1}	-3.8268 C+7.4547 (-0.993)	-3.301C+ 7.6344 (-0.983)	-3.8668 C+7.8901 (-0.997)
$R \times 10^4$, $m^{10/3} s^{1/3} mol^{-1}$	12.732 C+8.0657 (1)	12.354C +8.073 (0.999)	12.283C+8.036 (0.999)
$b \times 10^5$, m^3	11.848 C+8.1832 (0.999)	11.576C+8.072 (0.999)	11.464C+ 8.087 (0.999)
$L_f \times 10^{11}$, m	-1.463 C+5.7156 (- 0.986)	-1.3753C+5.7877 (- 0.990)	-1.474 C+5.8828 (-0.996)
$\pi \times 10^{-8}$, Pa	$-22.342C^2+0.1984C$ +4.331 (0.991)	$-27.719C^2+0.9251C$ +4.2736 (0.989)	$-24.394C^2+1.515C$ +4.1677 (0.992)
$V_f \times 10^7$, m^3	-4.9287C+2.4817 (- 0.978)	-6.4984C + 2.7559 (- 0.996)	-6.234C +2.7704 (- 0.972)
$\tau \times 10^{13}$, s	17.609C +6.817 (0.968)	21.157 C+6.2656 (0.995)	20.067C+ 6.3965 (0.993)
$(\alpha/f^2)_{cl.} 10^{14}$, s^2m^{-1}	3.4201C+1.3706 (0.987)	3.7852C+ 1.3158 (0.997)	3.6825C+1.3526 (0.991)

Table-5.81 : The correlation equations and correlation coefficients for SBDAC- 13 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , kg.m^{-3}	145.15C+955.1 (0.987)	145.67 C+954.06 (0.984)	145.34 C+953.77 (0.985)
η, mPa s	3.1137C+0.972 (0.993)	2.8359C+0.9423 (0.983)	2.5575 C+0.918 (0.985)
U, ms^{-1}	413.92C+1474.6 (0.996)	390.9C+1483.2 (0.995)	396.33 C+1486.8 (0.998)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.73C+1.4052 (0.986)	0.2C+ 1.3982 (0.985)	0.555C+1.4215 (0.999)
κ_s x10^{+10}, Pa $^{-1}$	-3.3989C+4.8163 (-0.997)	-3.0907C+4.7619 (-0.993)	-3.0942C+4.7402 (-0.995)
R x10 ^{4} , m$^{10/3}$ s$^{1/3}$mol^{-1}	28.106C+8.7552 (0.998)	29.285C +8.7499 (1)	29.388C+8.7556 (1)
b x10^5, m ^{3}	23.679 C+7.5826 (0.999)	24.669C+7.5613 (1)	24.686 C+ 7.5634 (1)
L_f x10^{11}, m	-1.7397C+4.5982 (-0.998)	-1.4822C+4.5682 (-0.996)	-1.5288 C+4.559 (-0.944)
π x10^{-8} , Pa	-9.6564C +5.4132 (-0.996)	-10.067 C+5.3993 (-0.998)	-10.643 C+5.4104 (-0.996)
V_f x 10^7 , m^3	1.31C+1.2902 (0.974)	1.855 C +1.3533 (0.946)	2.36C + 1.4138 (0.988)
τ x10 ^{13} , s	12.015C +6.4079 (0.994)	11.11C+6.141 (0.980)	9.545C+5.9625 (0.994)
$(\alpha/f^2)_{cl.}10^{14}$, s^{2}m^{-1}	13.32C+8.5714 (0.987)	12.385C+8.1615 (0.972)	10.31C+7.8956 (0.992)

Table-5.82 : The correlation equations and correlation coefficients for SBDAC- 13 + THF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	142.55C+886.72 (0.996)	135.56 C+885.13 (0.986)	130.47 C+884.29 (0.988)
η, mPa s	1.3101C+0.5013 (0.989)	1.3704C+ 0.4515 (0.992)	1.1403 C+0.4434 (0.997)
U, ms^{-1}	348.44C+1265.2 (0.983)	343.12C+1241.7 (0.995)	337.32 C+1220.2 (0.987)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.489C+ 1.1222 (0.994)	0.4756C+1.0991 (0.992)	0.4526 C+1.0793 (0.989)
$\kappa_s \times 10^{+10}$, Pa^{-1}	-4.7699C+7.0411 (-0.988)	-4.9178 C+7.3228 (-0.992)	-5.0792C+7.5913 (-0.986)
$R \times 10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	32.223 C+8.8078 (0.999)	32.292C +8.7662 (1)	32.255C+8.7225 (0.999)
$b \times 10^{5}$, m^{3}	28.527 C+ 8.0155 (1)	28.673C+ 8.0232 (1)	28.872C+8.0328 (1)
$L_f \times 10^{11}$, m	-1.9178 C+5.556 (-0.992)	-1.9178C+5.6658 (-0.992)	-1.9863 C+5.771 (-0.995)
$\pi \times 10^{-8}$, Pa	-9.331C + 4.1814 (- 0.998)	-8.5679C+4.0118 (- 0.992)	-9.000C+3.990 (- 0.995)
$V_f \times 10^{7}$, m^3	5.92C+2.7308 (0.993)	3.145C+3.2258 (0.972)	5.265C +3.2351 (0.957)
$\tau \times 10^{13}$, s	8.2156 C+4.721 (0.985)	9.4545 C+4.425 (0.985)	7.9701 C+ 4.4777 (0.994)
$(\alpha/f^2)_{cl.} 10^{14}$, $s^2 m^{-1}$	1.0499C+ 0.7361 (0.984)	1.2707C+6.7033 (0.979)	1.0575C+0.724 (0.990)

Table-5.83 : The correlation equations and correlation coefficients for SBDAC- 14 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-188.99C+1457.4 (- 0.989)	-177.75 C+1453.8 (- 0.996)	-169.12 C+1452.3 (- 0.994)
η, mPa s	2.6499C+0.6661 (0.996)	2.5715 C+0.6298 (0.992)	2.3279 C+0.6106 (0.992)
U, ms^{-1}	280.11C+957.93 (0.996	278.03C+942.5 (0.998)	252.16 C+926.77 (0.998)
$Z \times 10^{-6}$, $kg.m^{-2}\ s^{-1}$	0.255C + 1.3937 (0.993)	0.2C+ 1.3982 (0.985)	0.21C+1.3456 (0.993)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.246C+7.4744 (0.992)	-3.4499 C+7.7399 (0.997)	-3.2882C+8.0142 (0.997)
$R \times 10^{4}$, $m^{10/3}\ s^{1/3} mol^{-1}$	12.424 C+ 8.066 (0.999)	12.358C +8.0428 (1)	12.171C+ 8.006 (1)
$b \times 10^{5}$, m^{3}	11.60C+ 8.0535 (0.999)	11.508 C+8.0709 (0.999)	11.511 C+8.0768 (1)
$L_f \times 10^{11}$, m	-1.2658 C+5.725 (- 0.997)	-1.2466C+5.8227 (- 0.998)	-1.2603 C+5.932 (- 0.996)
$\pi \times 10^{-8}$, Pa	$-29.509C^2 + 3.3345C$ +4.1741 (- 0.974)	$-36.407C^2 + 4.2244C$ +4.1408 (- 0.969)	$-29.059C^2 + 3.0978C$ +4.187 (- 0.773)
$V_f \times 10^{7}$, m^3	$58.799C^2 - 12.429C$ +2.6098 (- 0.999)	$70.74C^2 - 14.257C$ +2.7822 (- 0.957)	$59.845C^2 - 12.723C$ +2.8257 (- 0.991)
$\tau \times 10^{13}$, s	22.375C +6.6565 (0.994)	22.339 C+6.5225 (0.989)	21.125C+6.5422 (0.989)
$(\alpha/f^2)_{cl}.10^{14}$, $s^2 m^{-1}$	4.08C+1.3722 (0.992)	4.1411C+1.3669 (0.986)	3.9986C+1.3939 (0.986)

Table-5.84 : The correlation equations and correlation coefficients for SBDAC- 14 + DMF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30^o	35^o	40^o
ρ , $kg.m^{-3}$	127.78C+956.1 (0.990)	139.81 C+954.9 (0.998)	144.52 C+953.9 (0.994)
η, mPa s	2.5C+1.0314 (0.994)	2.51C+0.9672 (0.989)	2.255C+0.9413 (0.997)
U, ms^{-1}	375.95 C+1478.7 (0.989)	390.9C+ 1483.2 (0.995)	406.74 C+1486 (0.997)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.5C+1.4178 (0.989)	0.2C+1.3982 (0.995)	0.585C+1.4191 (0.996)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-2.951 C+4.7816 (-0.988)	-3.0523 C+4.7575 (-0.996)	-3. 1562 C+4.745 (-0.996)
$R \times 10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	29.41C+8.7161 (1)	29.359C +8.7379 (1)	29.402C+ 8.7529 (1)
$b \times 10^{5}$, m^3	25.136C+7.4961 (0.997)	24.687C+7.5547 (1)	24.681C+7.5623 (1)
$L_f \times 10^{11}$, m	-1.5041C+4.5827 (- 0.986)	-1.4822C+4.5682 (-0.996)	-1.5151 C+4.560 (-0.996)
$\pi \times 10^{-8}$, Pa	-10.561C + 5.4903 (-0.997)	-10.243C+5.3726 (-0.957)	-10.666C+5.4126 (-0.996)
$V_f \times 10^{7}$, m^3	1.925C+1.2245 (0.982)	1.85C+ 1.3532 (0.946)	2.375C + 1.4125 (0.988)
$\tau \times 10^{13}$, s	11.36C +6.5524 (0.992)	11.07C+ 6.142 (0.979)	9.375C+5.9691 (0.993)
$(\alpha/f^2)_{cl}.10^{14}$, s^2m^{-1}	12.595C+8.7493 (0.989)	12.32C+8.1644 (0.971)	9.98C+ 7.9222 (0.989)

Table-5.85 : The correlation equations and correlation coefficients for SBDAC- 14 + THF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX + b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	150.93C+886.19 (0.988)	146.08 C+884.59 (0.982)	138.05 C+882.88 (0.999)
η, mPa s	1.7148C+ 0.4512 (0.997)	1.6751C+0.4295 (0.994)	1.5592C+ 0. 4189 (0.985)
U, ms^{-1}	214.25C+ 1264 (0.998)	249.97C+ 1253.2 (0.995)	265.7 C+1229.8 (0.997)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.3879C+1.12 (0.997)	0. 4033C+1.1088 (0.995)	0.4145 C+1.0854 (0.999)
κ_S $x10^{+10}$, Pa^{-1}	-3.4674C+7.0605 (-0.997)	-3.8934 C+7.1948 (- 0.997)	-4.2247C+7.4853 (- 0.999)
R $x10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	31.711 C+8.8118 (1)	31.947C + 8.801 (0.999)	32.039C+8.7633 (1)
b $x10^{5}$, m^{3}	28.434C+8.0206 (1)	28.612 C+8.034 (1)	28.803C+ 8.0488 (1)
L_f $x10^{11}$, m	-1.4027 C+5.566 (- 0.993)	-1.589C+5.619 (- 0.994)	-1.6849C+5.7321 (-0.998)
π $x10^{-8}$, Pa	-7.4233C + 3.9894 (- 0.992)	-7.2373 C+3.9066 (-0.993)	-7.4444 C+3.8843 (-0.986)
V_f x 10^{7} , m^3	$-45.485C^2+5.7171C$ + 3.1585 (-0.846)	$-52.841C^2+7.5415C$ +3.2313 (-0.958)	$-74.325C^2$ +10.492C +3.3268 (- 0.933)
τ $x10^{13}$, s	13.166 C +4.262 (0.995)	12.779 C+4.145 (0.989)	12.272C+4.195 (0.979)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	19.049C+6.6568 (0.994)	18.397C+6.53 (0.987)	18.05C+6.7133 (0.979)

Table-5.86 : The correlation equations and correlation coefficients for SBDAC-15 + CF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30^o	35^o	40^o
ρ , $kg.m^{-3}$	-193.67C+1455.9 (-0.992)	-193.1 C+1454.2 (- 0.983)	-172.93 C+1449.9 (- 0.995)
η, mPa s	2.2063C+0.7438 (0.998)	2.2696C+ 0.6031 (0.999)	2.1282C+ 0.5934 (0.990)
U, ms^{-1}	256.93 C+958.63 (0.996)	263.4 C+943.16 (0.998)	289.92 C+927.25 (0.998)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.1753 C+1.3963 (0.994)	0.2493C+1.3945 (0.959)	0.2504C+1.3447 (0.992)
$\kappa_S \; x10^{+10}$, Pa^{-1}	-2.8899C+7.4723 (- 0.995)	-3.1529 C+7.7279 (-0.995)	-3.8701 C+8.0183 (- 0.997)
$R \; x10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	12.229 C+8.0767 (0.999)	12.228C +8.0416 (0.999)	12.188C+8.0201 (1)
$b \; x10^{5}$, m^{3}	11.456 C+8.06 (0.999)	11.476C+ 8.0677 (0.999)	11.4C+ 8.09 (1)
$L_f \; x10^{11}$, m	-1.041C+ 5.7171 (-0.990)	-1.2137C+5.821 (-0.993)	-1.3863 C+5.925 (-0.998)
$\pi \; x10^{-8}$, Pa	-1.46C +4.465 (-0.961)	-0.28C+4.1306 (-0.896)	-1.004C+4.2283 (-0.917)
$V_f \; x \; 10^{7}$, m^3	-3.201C+2.1255 (-0.983)	-6.300 C+2.8272 (-0.993)	-6.2696C+2.8729 (-0.991)
$\tau \; x10^{13}$, s	18.281C +7.4237 (0.997)	19.802 C+6.2334 (0.999)	18.54C+ 6.3634 (0.985)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	3.2332C+1.5291 (0.994)	3.3663C+1.3052 (0.999)	3.409C+ 1.355 (0.981)

Table-5.87 : The correlation equations and correlation coefficients for SBDAC-15 +DMF

Parameter, Y	Correlation equations (Correlation coefficients, ?), mX +b		
	30^o	35^o	40^o
ρ , kg.m^{-3}	161.45C+950.24 (0.991)	161.75 C+949.64 (0.993)	170.58 C+948.42 (0.993)
η, mPa s	2.2696C+0.9761 (0.981)	2.2986C+0.9761 (0.961)	1.9529 C+0.8721 (0.9854)
U, ms^{-1}	337.97C+1478.3 (0.992)	347.18C+1481.9 (0.980)	240.6C+ 1497 (0.993)
Z x 10^{-6} , kg.m^{-2} s^{-1}	0.5625C+1.4048 (0.993)	0.2288C+1.396 (0.978)	0.4863C+1.42 (0.994)
κ_S x10^{+10}, Pa $^{-1}$	-2.8942 C+4.8132 (-0.992)	-2.903C+4.792 (-0.991)	-2.283 C+ 4.7038 (-0.990)
R x10 ^{4} , $m^{10/3}$ $s^{1/3}$$mol^{-1}$	28.663C+8.7734 (1)	28.483C +8.8294 (1)	28.483C+8.8294 (1)
b x10^5, m ^{3}	24.188C+7.6088 (1)	24.247 C+7.598 (1)	24.223 C+7.594 (1)
L_f x10^{11}, m	-1.3836 C+4.5932 (-0.990)	-1.3973 C+4.5822 (- 0.987)	-1.137C+4.5404 (-0.986)
π x10^{-8} , Pa	-11.064C +5.396 (- 0.999)	-10.557C+5.3041 (-0.998)	-10.546C+5.2292 (-0.998)
V_f x 10 ^{7} , m^3	2.705C+1.2869 (0.988)	2.715C+1.4131 (0.986)	2.215C + 1.6155 (0.990)
τ x10 ^{13} , s	8.395C +6.3935 (0.982)	8.495 C+6.0025 (0.987)	10.07C+5.4408 (0.995)
$(\alpha/f^2)_{cl}.10^{14}$, s^2m^{-1}	8.775C+8.5529 (0.980)	9.315C+7.9831 (0.983)	12.035C+7.1607 (0.992)

Table-5.88 : The correlation equations and correlation coefficients for SBDAC- 16 + CF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	-174.16C+1460.4 (-0.985)	-165.92 C+1457.2 (- 0.982)	-161.53 C+1455.8 (- 0.991)
η, mPa s	2.012C+ 0.658 (0.996)	1.5104 C+0.650 (0.989)	1.911 C + 0.5918 (0.996)
U, ms^{-1}	197.48 C+ 952.7 (0.991)	215.89 C+ 943.11 (0.999)	254.85 C+923.4 (0.996)
Z x 10^{-6} , $kg.m^{-2}\ s^{-1}$	0.15C +1.3892 (0.918)	0.2C+ 1.3982 (0.985)	0.24C+1.3428 (0.982)
κ_S x10^{+10}, Pa^{-1}	$-14.89C^2$ – 1.78C +8.0241 (- 0.998)	$-11.113C^2$- 1.3649C +7.6933 (- 0.998)	-2.1468C+7.5429 (- 0.990)
R x10^{4} , $m^{10/3}\ s^{1/3} mol^{-1}$	10.341C+8.037 (0.999)	10.4 C +8.026 (0.999)	9.22C+8.014 (0.990)
b x10^{5}, m^3	9.773 C+8.036 (0.999)	9.761 C+ 8.053 (0.999)	8.462C+8.098 (0.986)
L_f x10^{11}, m	-0.8192 C+5.7507 (- 0.976)	-1.011 C+5.8172 (-0.989)	-1.1918 C+5.937 (-.983)
π x10^{-8} , Pa	-2.2299C +4.3967 (-0.933)	-1.0132C+4.2377 (-0.984)	-2.0458C+ 4.3702 (-0.942)
V_f x 10^{7} , m^3	-4.7745C+2.5312 (-0.991)	-3.7244C +2.617 (-0.998)	-5.014C + 2.7922 (- 0.984)
τ x10^{13} , s	19.054C +6.5245 (0.995)	14.267 C+6.3881 (0.999)	16.355C+6.3957 (0.993)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	3.299C+1.374 (0.995)	2.5929C+1.377 (0.999)	2.875C+1.382 (0.990)

Table-5.89 : The correlation equations and correlation coefficients for SBDAC- 16 + DMF

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	101.89C+953.95 (0.994)	113.92 C+952.51 (0.990)	112.19 C+951.95 (0.982)
η, mPa s	2.5595C+0.8958 (0.995)	2.2312C+ 0.8644 (0.992)	2.4548 C+0.8298 (0.989)
U, ms^{-1}	300.77 C+1481.9 (0.993)	358.52C+1483.8 (0.997)	354.14C+1489.9 (0.992)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.4362 C+1.4141 (0.994)	0.2493C+1.3945 (0.959)	0.5038 C+1.4185 (0.990)
$\kappa_S \ x10^{+10}$, Pa^{-1}	-2.3723 C+4.7727 (-0.993)	-2.757C+4.7666 (- 0.995)	-2.7011C+4.7307 (- 0.989)
$R \ x10^{4}$, $m^{10/3} s^{1/3} mol^{-1}$	25.363C+8.7378 (1)	25.324C +8.7582 (1)	25.459C+8.7733 (1)
$b \ x10^{5}$, m^3	21.38C+7.5582 (1)	21.984 C+7.5178 (0.999)	21.349C+ 7.5735 (1)
$L_f \ x10^{11}$, m	-1.1425 C+4.574 (- 0.987)	-1.4027C+4.5758 (- 0.993)	-1.3288 C+4.557 (- 0.993)
$\pi \ x10^{-8}$, Pa	-8.3792C +5.2103 (-0.991)	-8.811 C+5.1862 (-0.996)	-8.1148 C+5.1862 (-0.995)
$V_f \ x \ 10^{7}$, m^3	0.96C+ 1.4778 (0.960)	1.72C+1.5586 (0.991)	1.215C+ 1.6497 (0.968)
$\tau \ x10^{13}$, s	11.53C +5.7876 (0.997)	9.08C+5.5876 (0.998)	10.255C+5.3537 (0.997)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	$-69.903C^2$ +22.387C +7.4822 (0.999)	$-55.341C^2$+ 17.437C +7.2156 (0.992)	$-73.324C^2$+21.369C +6.8187 (0.992)

Table-5.90 : The correlation equations and correlation coefficients for SBDAC - 16 + DO

Parameter, Y	**Correlation equations (Correlation coefficients, ?), mX +b**		
	30^o	**35^o**	**40^o**
ρ , $kg.m^{-3}$	174.25C+1046 (0.996)	180 C+1042.2 (0.999)	188.42 C+1040.8 (0.995)
η, mPa s	1.9285C+1.0922 (0.999)	1.9419 C+1.0343 (0.999)	2.051 C+1.006 (0.990)
U, ms^{-1}	369.81C+1343.3 (0.997)	370.41C+ 1337.5 (0.994)	471.0 C+1320.9 (0.985)
$Z \times 10^{-6}$, $kg.m^{-2} s^{-1}$	0.7841C+1.3899 (0.996)	0.6683C+1.3927 (0.996)	0.8232 C+1.3724 (0.993)
$\kappa_S \times 10^{+10}$, Pa^{-1}	-3.6121C+5.295 (-0.997)	-3.7153 C+5.3701 (- 0.974)	-4.6293 C+5.5023 (- 0.985)
$R \times 10^4$, $m^{10/3} s^{1/3} mol^{-1}$	19.014C+9.301 (1)	19.32C +9.2838 (0.9938)	19.208C+ 9.2956 (0.9999)
$b \times 10^5$, m^3	16.211 C+8.3088 (1)	16.154C+8.3256 (1)	16.093 C+8.3669 (0.999)
$L_f \times 10^{11}$, m	-1.7288C+4.821 (- 0.997)	-1.7425 C+4.85 (- 0.996)	-2.1397 C+4.912 (- 0.985)
$\pi \times 10^{-8}$, Pa	-7.2373 C +5.351 (-0.998)	-6.8321 C+5.205 (- 0.997)	-6.4315 C+5.1568 (-0.987)
$V_f \times 10^{7}$, m^3	1.1584C+1.2765 (0.992)	1.0411C+1.3769 (0.979)	1.0315C+1.3972 (0.956)
$\tau \times 10^{13}$, s	7.3521C +7.7286 (0.998)	7.6397 C+7.4188 (0.994)	7.4718 C+7.4026 (0.953)
$(\alpha/f^2)_{cl.}10^{14}$, s^2m^{-1}	0.8C+1.1308 (0.997)	0.865C+1.0889 (0.988)	0.925C+1.0881 (0.961)

It is observed that Z increased linearly with C and decreased with T in CF, DO, THF but in DMF it increased for SBDAC – 2, 4 and 9 and decreased for 5, 8, 11, 12 to 16. In some cases the effect of temperature is anomalous that is either Z is less than 30^0 and higher than 40^0C. k_s decreased linearly with C in all solvent systems and it increased linearly with T in CF, DO and THF system, while it decreased linearly in DMF system. In case of R and b both increased linearly with C but a little temperature effect is observed in all solvent systems. L_f decreased linearly with C in all systems and increased linearly with T except DMF in which it decreased linearly with T. p and V_f (Fig.5.1 to 5.90) either increased linearly or nonlinearly with C and T. t increased linearly with C and decreased linearly with T in all solvent systems except SBDAC-1 and 5 in CF in which t increased above 40 ^{0}C. $(a/f^2)_{cl}$ increased linearly with C and decreased with T in all systems except SBDAC-2,7,8,15 to 16 in CF in which it increased above 35^0C. Linear or non-linear increase or decrease of acoustical parameters with C and T support existence of strong molecular interactions. p, V_f and t are three basic thermodynamic parameters for liquid systems. p of a solution is a single factor to vary with intermolecular interaction namely solvation, solute-solvent interaction, quantum mechanical force of dispersion and dielectric forces. The internal pressure plays an important role in transport properties. Increase of p and decrease of Vf and vice-versa are measure of cohesion forces. The decrease in $?_s$ with C supports fully compressed solvated molecules by electrical force present in solute molecules. Thus, various acoustical parameters suggested the solvophilic nature of schiff bases in solvent systems investigated and it is further supported by positive values of S_n (Fig.5.91 to 5.135). The decrease of S_n with C supports the presence of solute-solvent interactions. Decrease of S_n with T attributed decrease of cohesive forces. When temperature increases the tendency of molecules to move away increases and the probability of molecular interaction decreases as a consequence cohesive force decreases and free path length increases.

$(a/f^2)_{cl}$ and t are dependent on ?, ? and U at constant temperature. Increase of $(a/f^2)_{cl}$ and t with C can be explained in terms of motion of intermolecular forces [26]. A contribution of acoustical relaxation is accounted due to entropy fluctuation associated in solution of dynamically formed physical entity. The presence of polar

groups in the solute molecule enhances molecular interactions. The solvation phenomena result in change in molar volume and molar compressibility. The dipole-dipole interaction of the opposite type favours solvation, while opposite type disrupts structure formed previously.

In conclusion strong molecular interactions exist in the schiff base solutions and it is further supported by positive values of S_n. Schiff bases have solvophilic nature and observed solvation order is CF THF DMF DO.

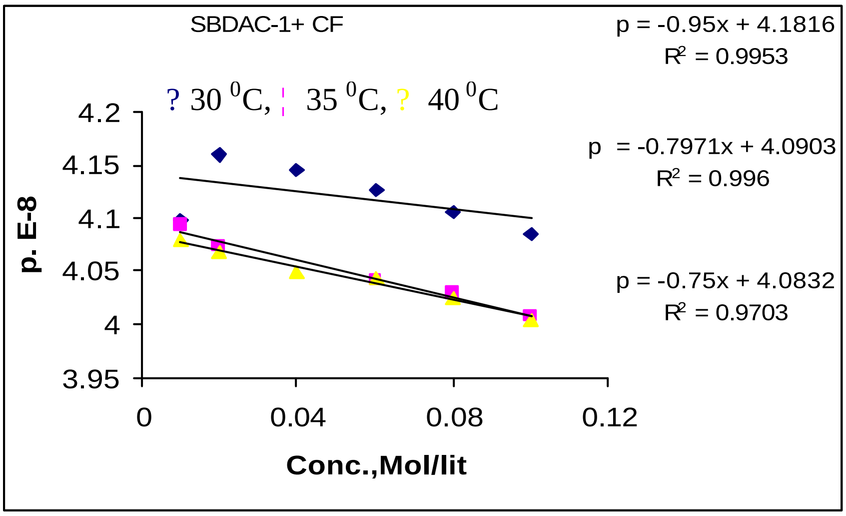

Fig 5.1:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-1 in , chloroform .

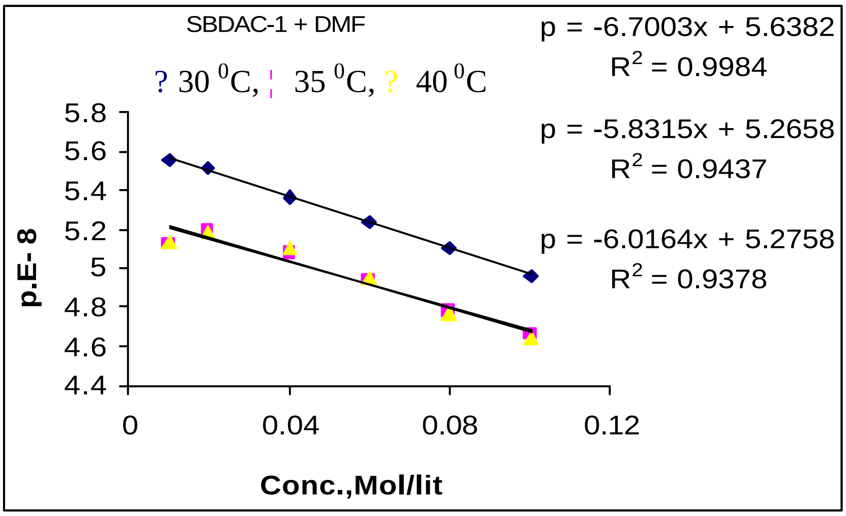

Fig 5.2:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-1 in dimethylformamide .

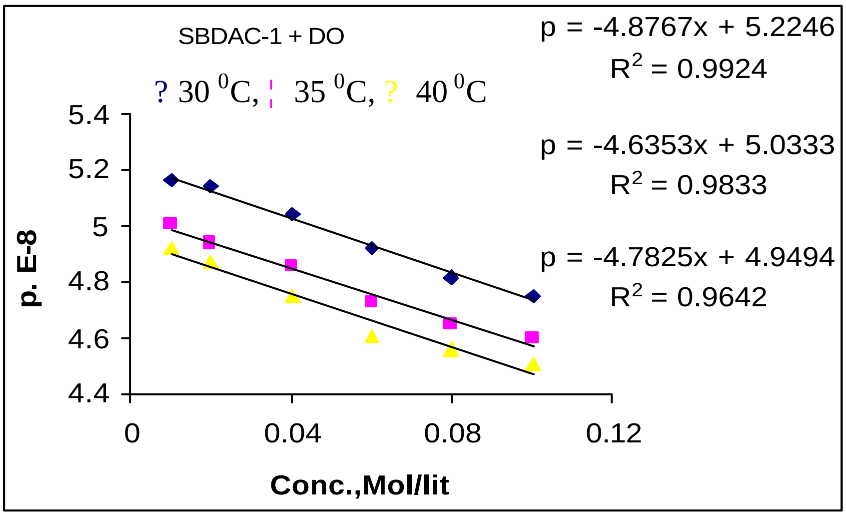

Fig 5.3:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-1 in 1,4 dioxane.

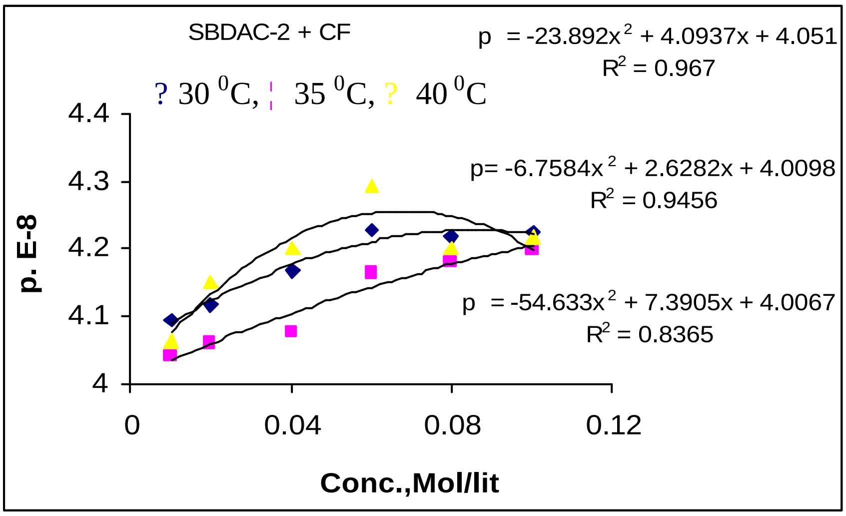

Fig 5.4 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-2 in , chloroform .

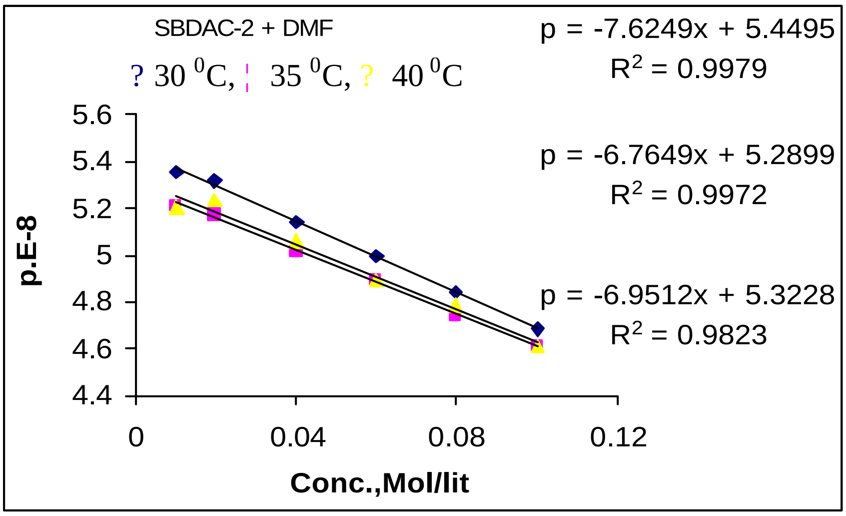

Fig 5.5 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-2 in dimethylformamide.

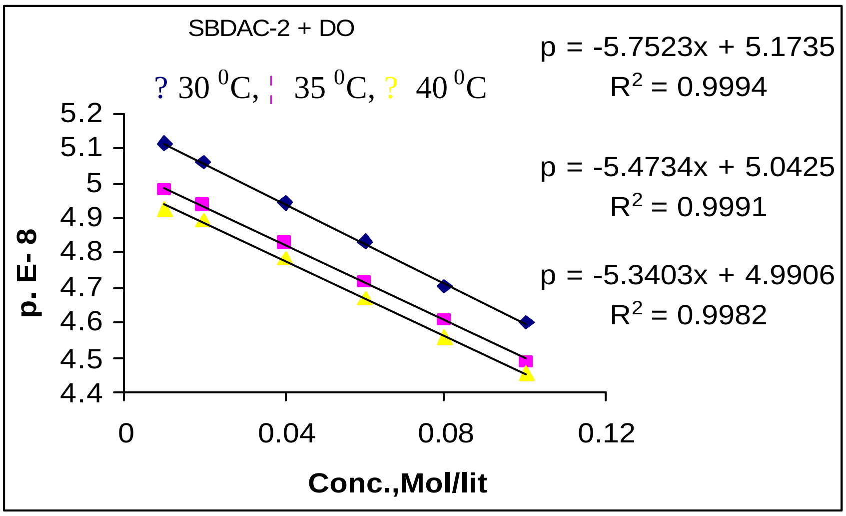

Fig 5.6:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-2 in 1,4 dioxane.

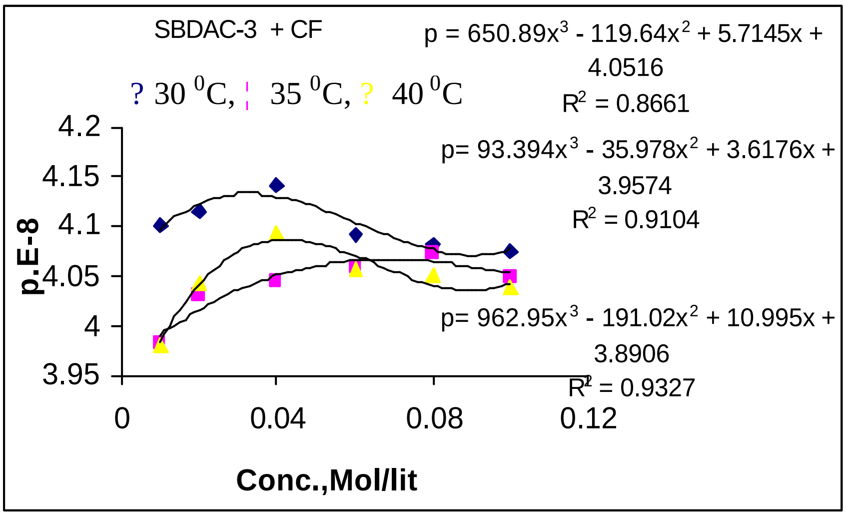

Fig 5.7 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-3 in , chloroform .

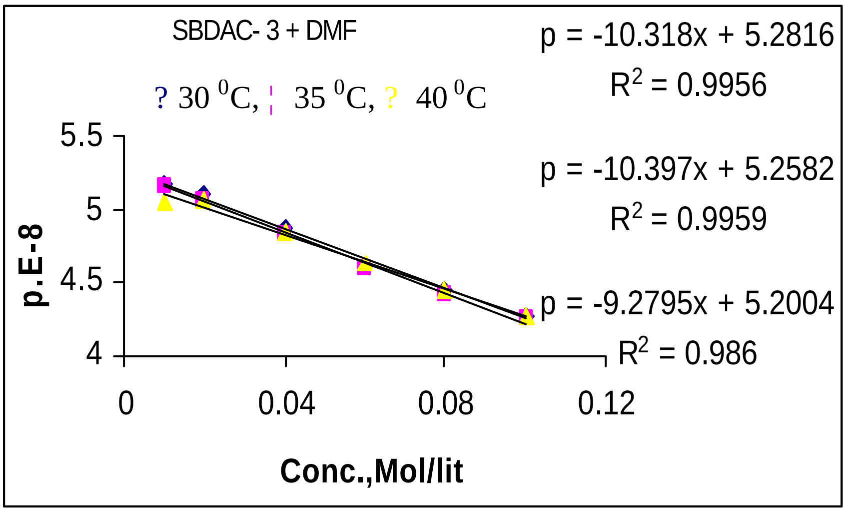

Fig 5.8 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-3 in dimethylformamide.

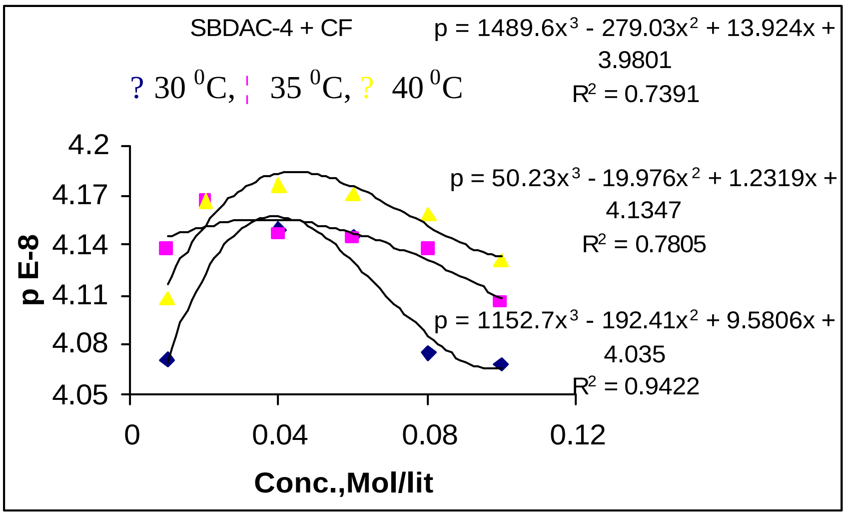

Fig 5.9 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-4 in , chloroform .

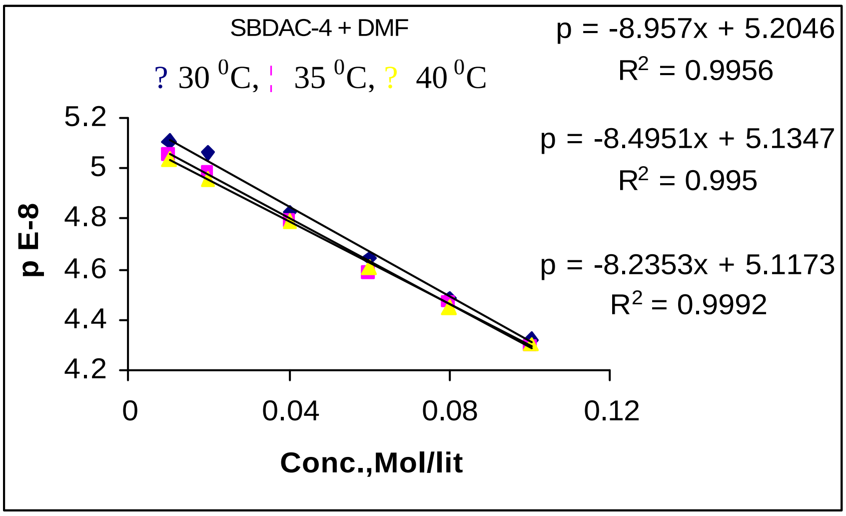

Fig 5.10:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-4 in dimethylformamide.

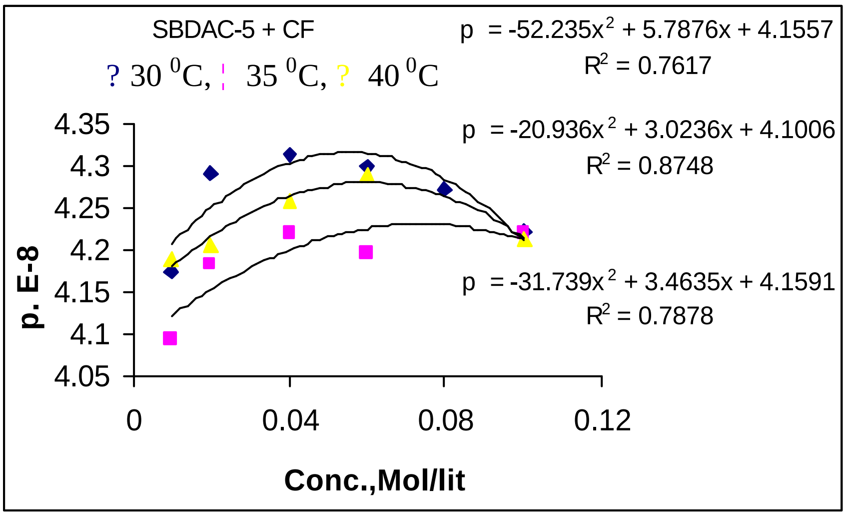

Fig 5.11 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in , chloroform .

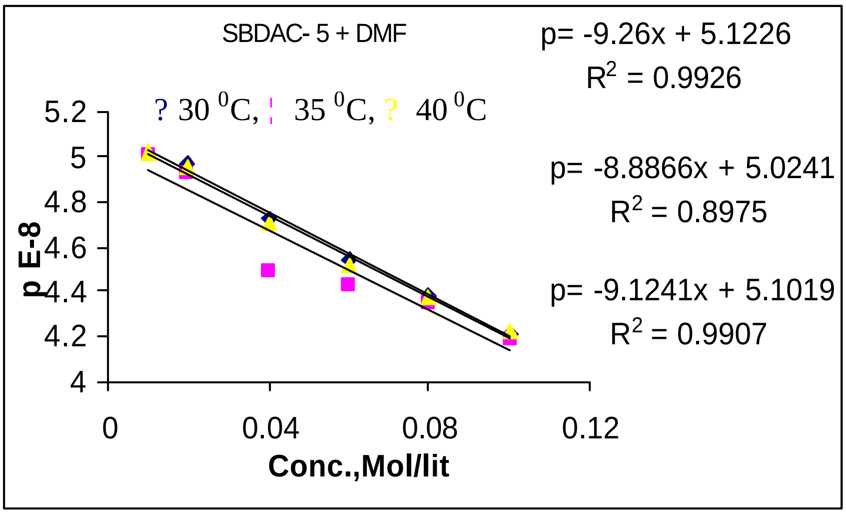

Fig 5.12 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 5 in , dimethylformamide .

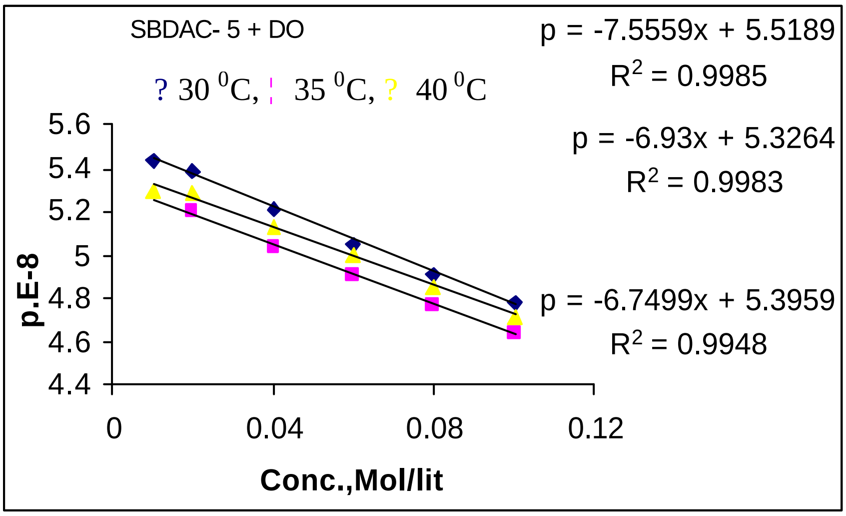

Fig 5.13 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in 1,4 dioxane.

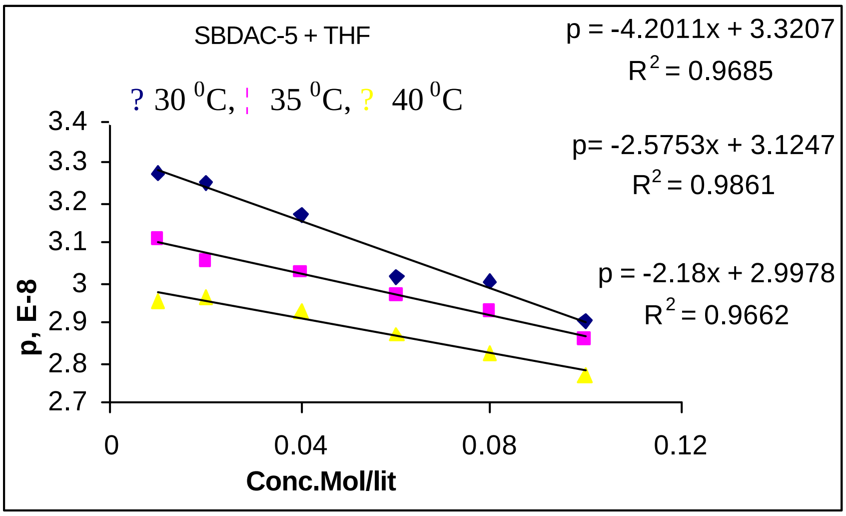

Fig 5.14 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in tetrahydrofuran.

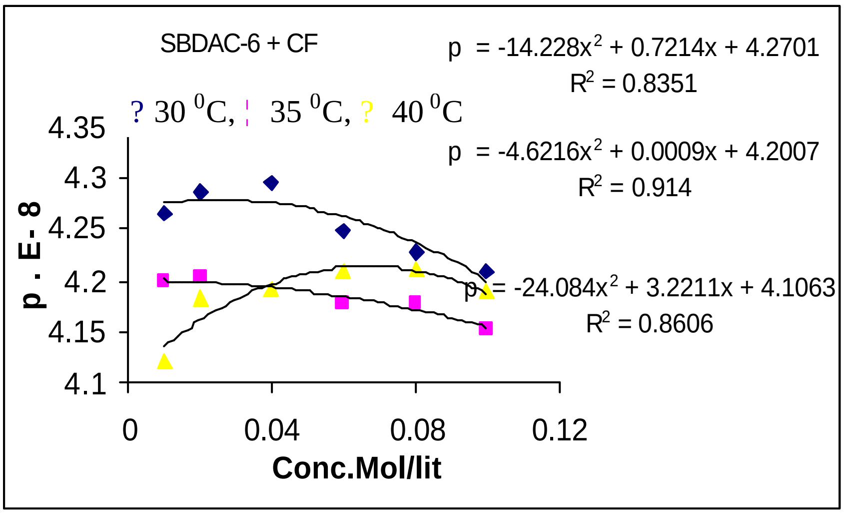

Fig 5.15 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in chloroform .

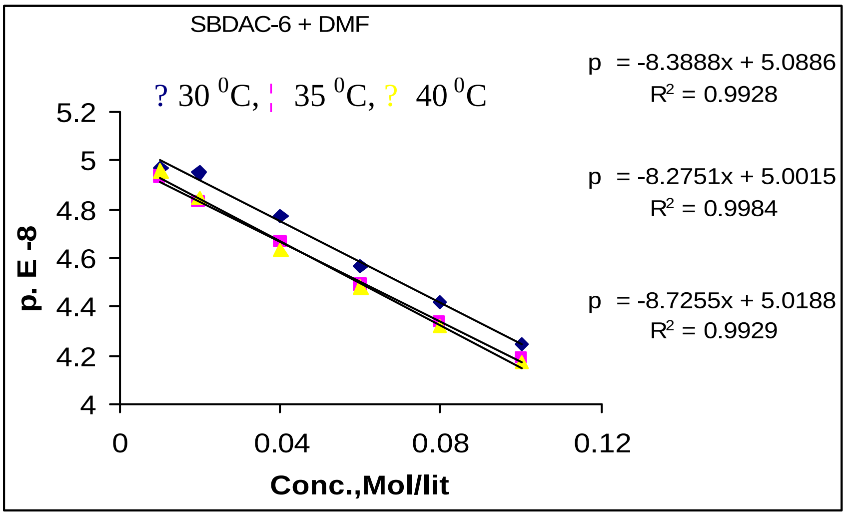

Fig 5.16 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in dimethylformamide .

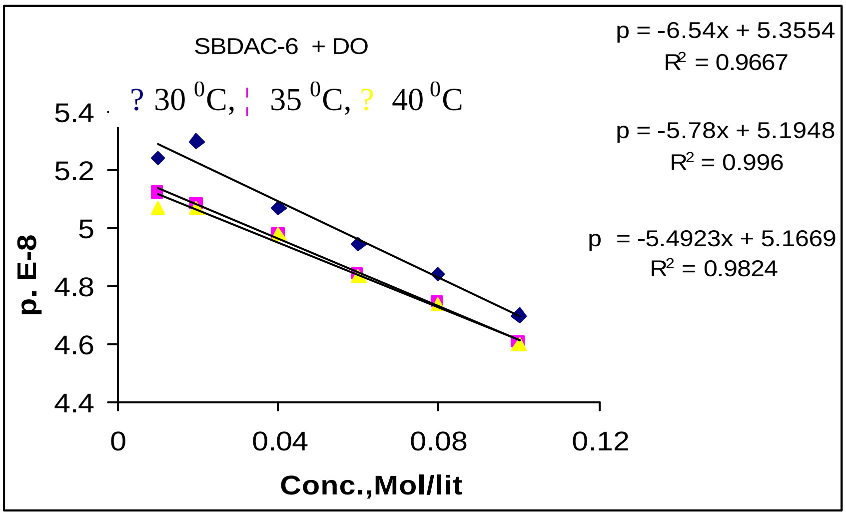

Fig 5.17 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in 1,4 dioxane.

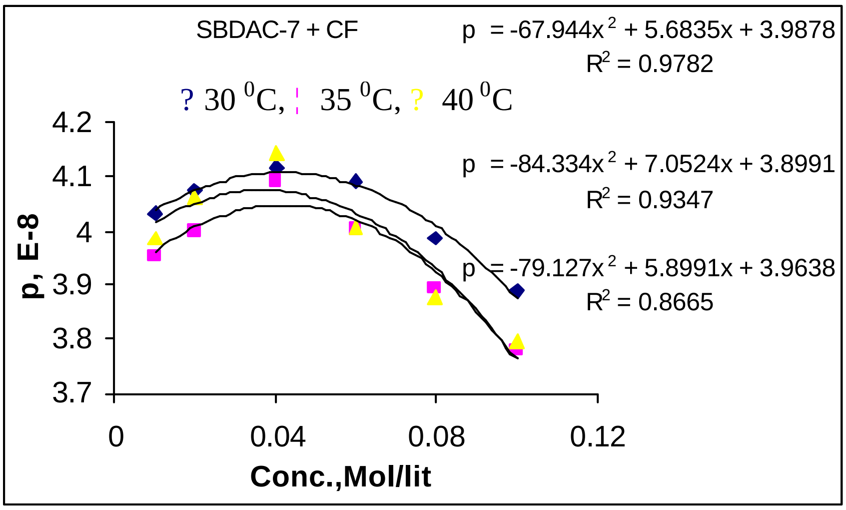

Fig 5.18 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-7 in chloroform .

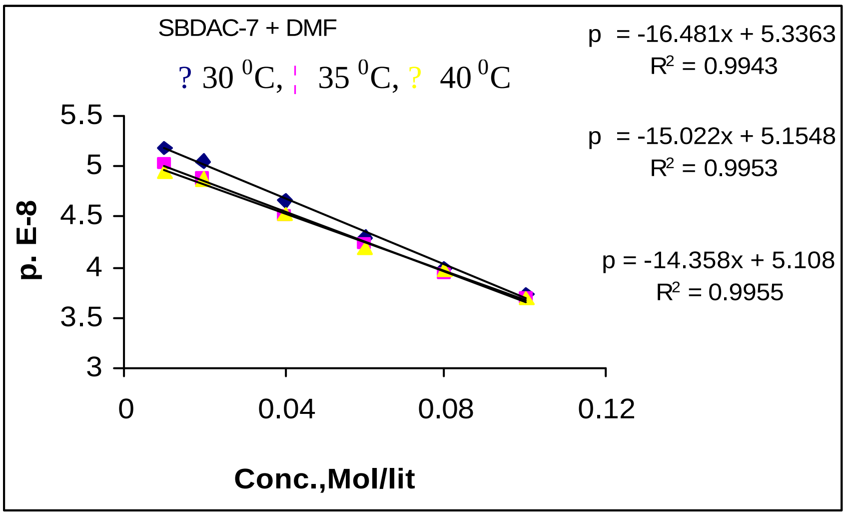

Fig 5.19 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-7 in dimethylformamide .

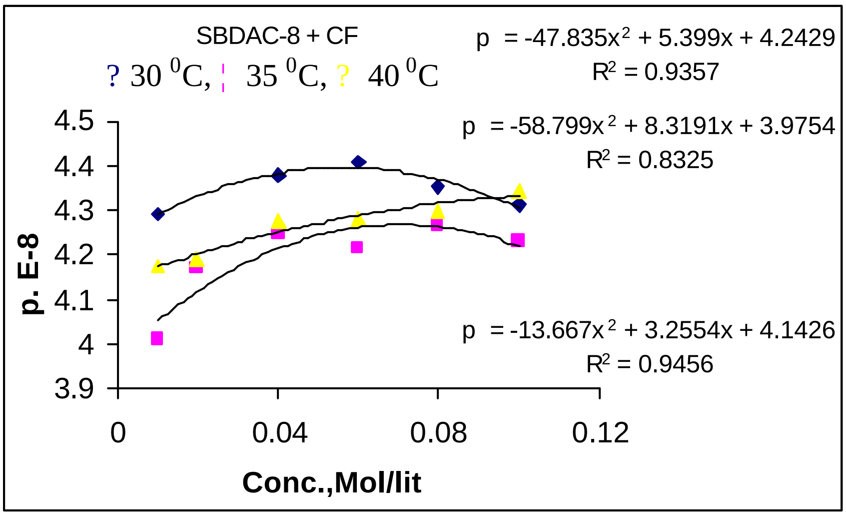

Fig 5.20 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in chloroform .

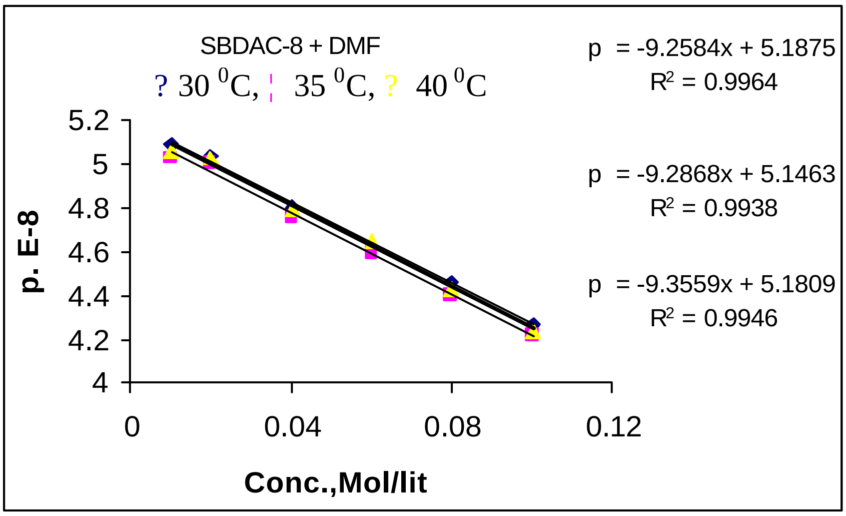

Fig 5.21:The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in dimethylformamide .

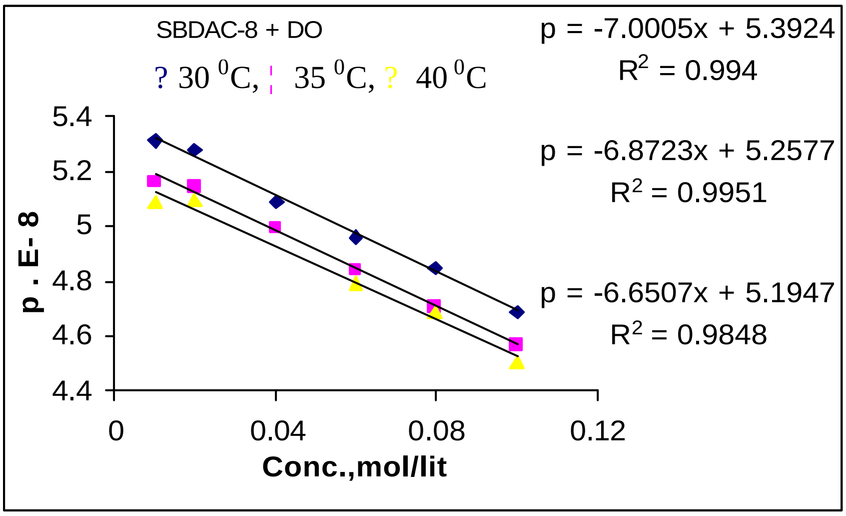

Fig 5.22 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in1,4 dioxane.

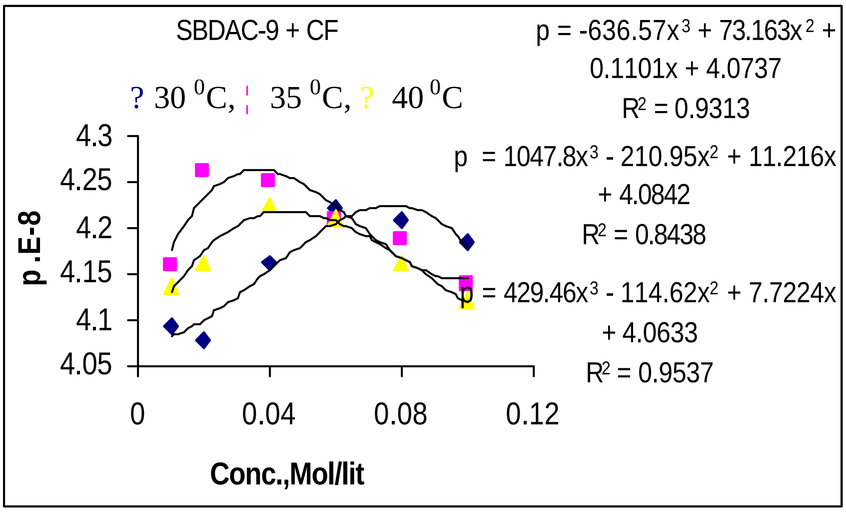

Fig 5.23 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 9 in chloroform .

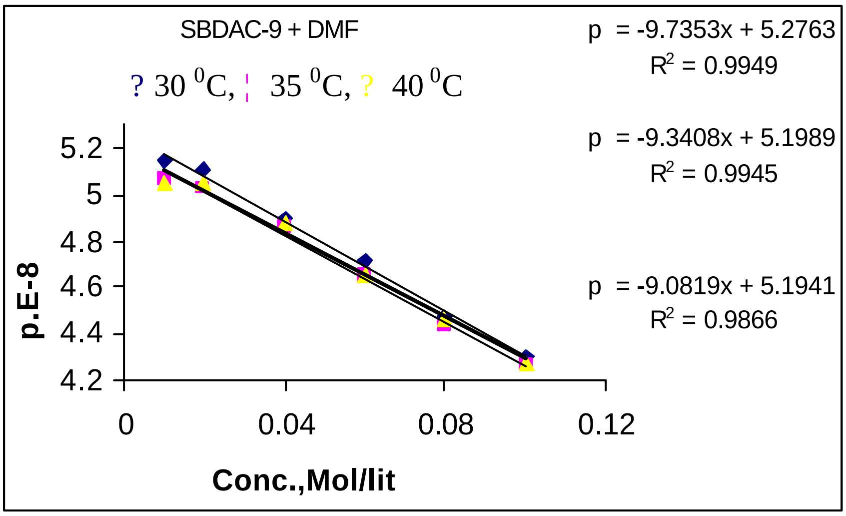

Fig 5.24 :The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-9 in dimethylformamide .

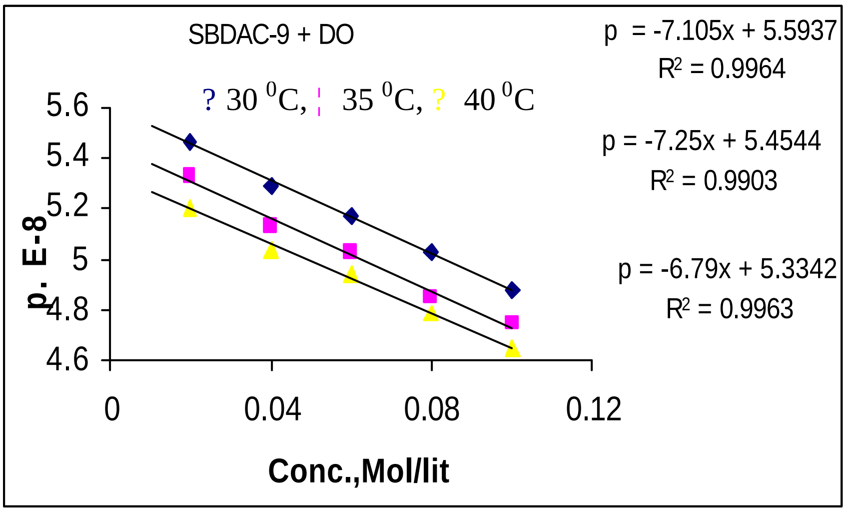

Fig 5.25: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-9 in 1,4 dioxane.

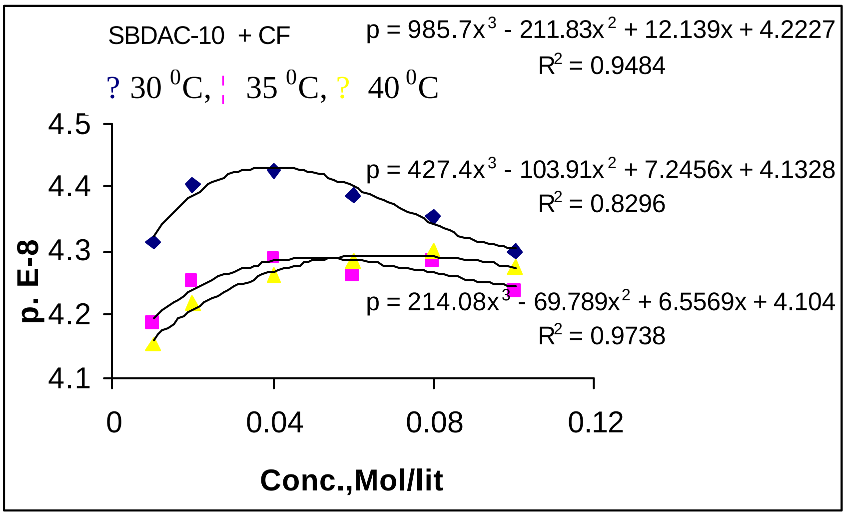

Fig 5.26: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in chloroform .

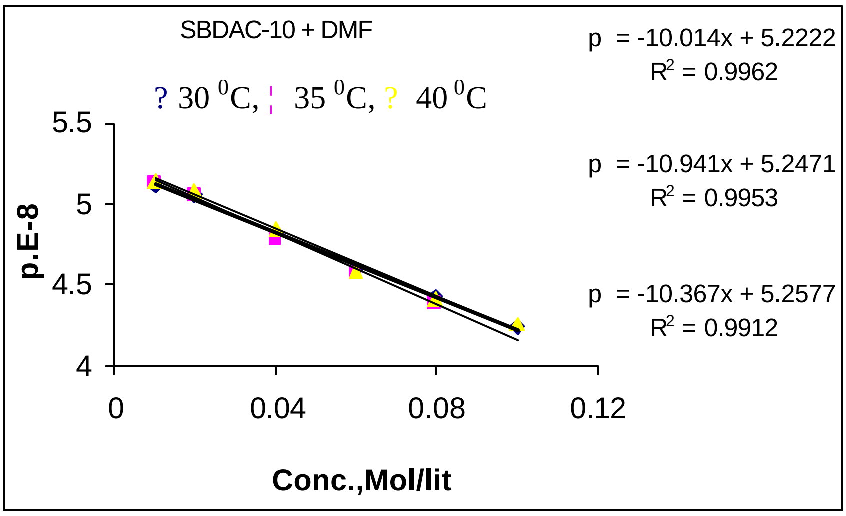

Fig 5.27: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in dimethylformamide .

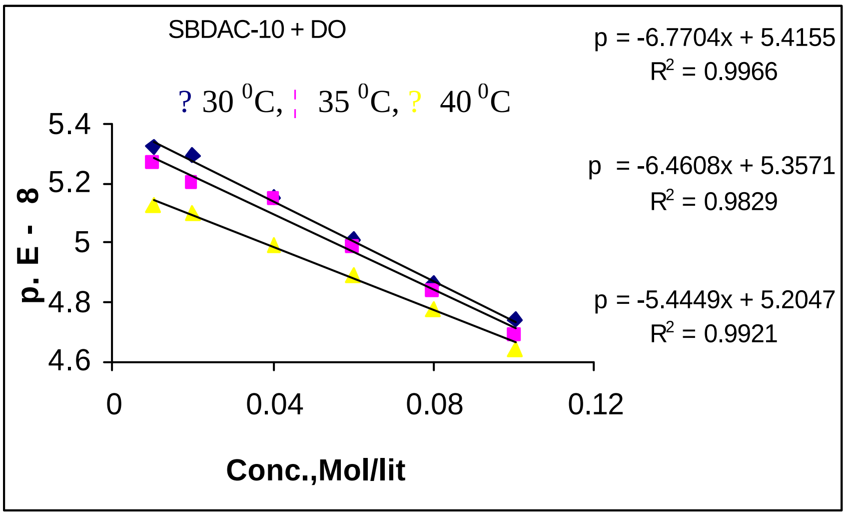

Fig 5.28: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in 1,4 dioxane.

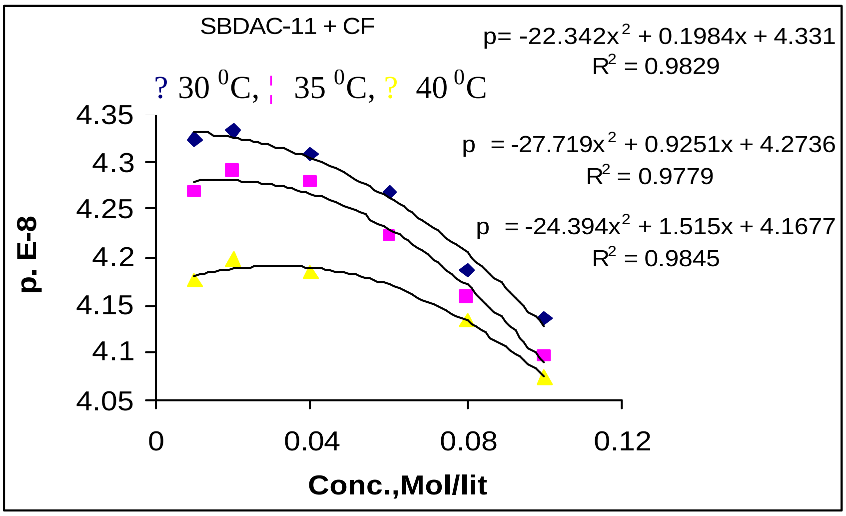

Fig 5.29: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in chloroform .

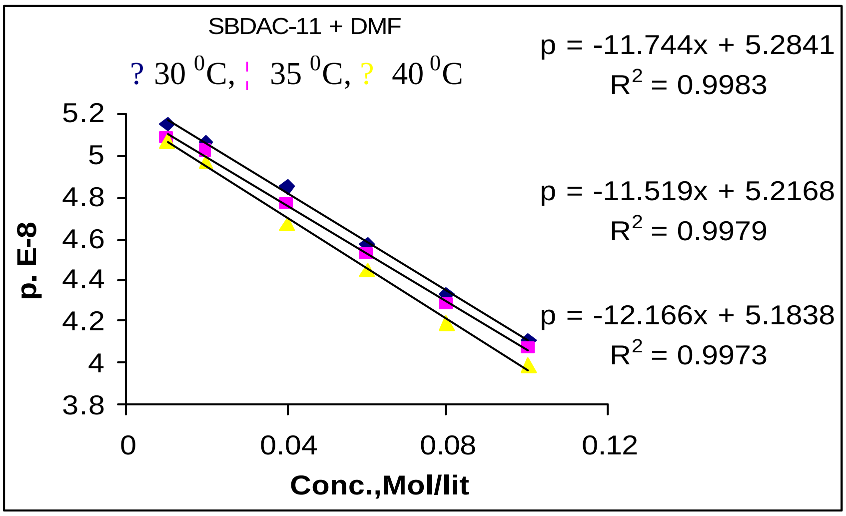

Fig 5.30: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in dimethylformamide .

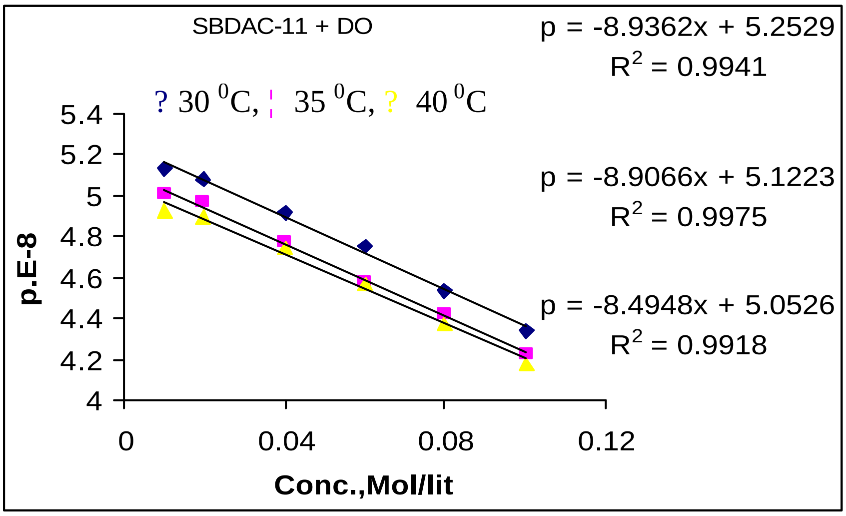

Fig 5.31: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-11 in 1,4 dioxane.

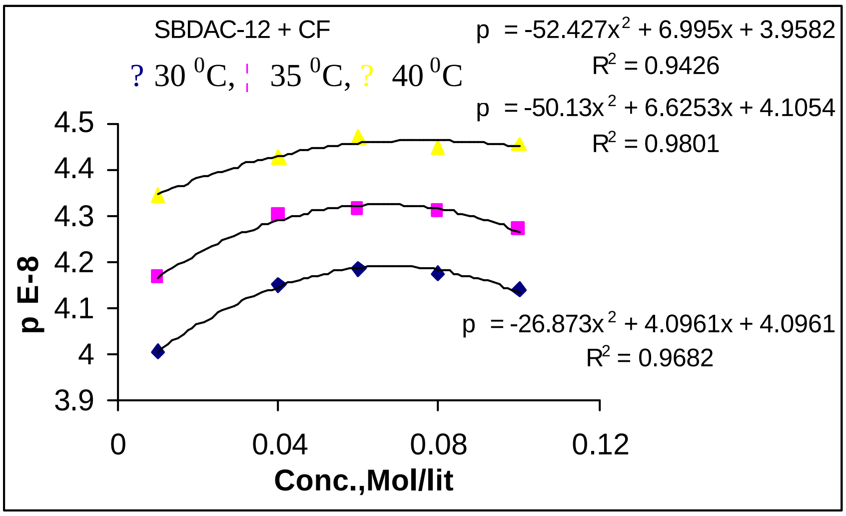

Fig 5.32: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-12 in chloroform .

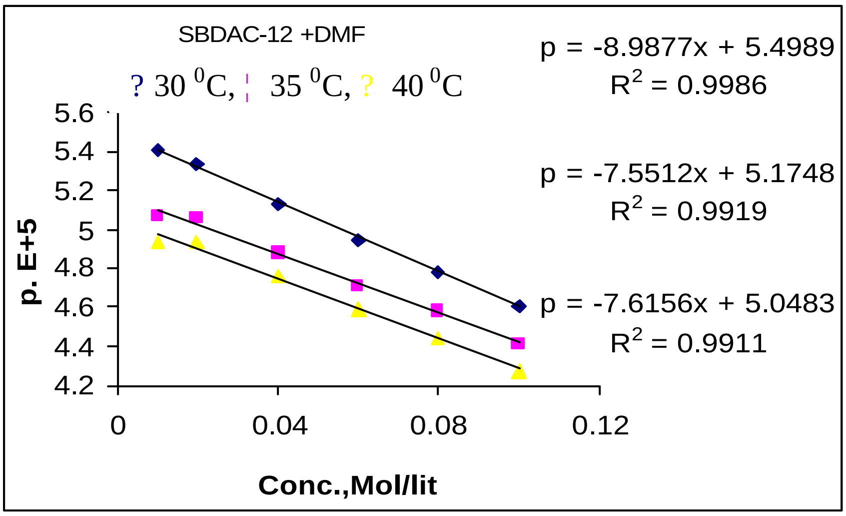

Fig 5.33: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-12 in dimethylformamide .

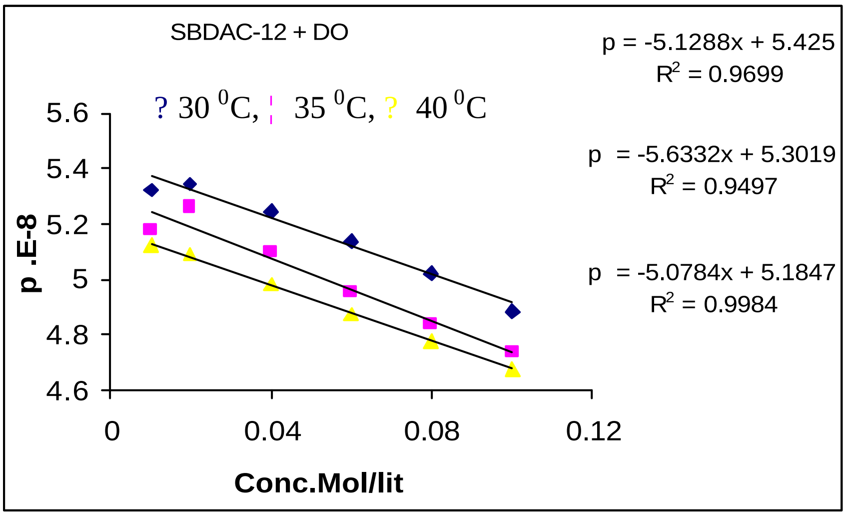

Fig 5.34: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-12 in 1,4 dioxane.

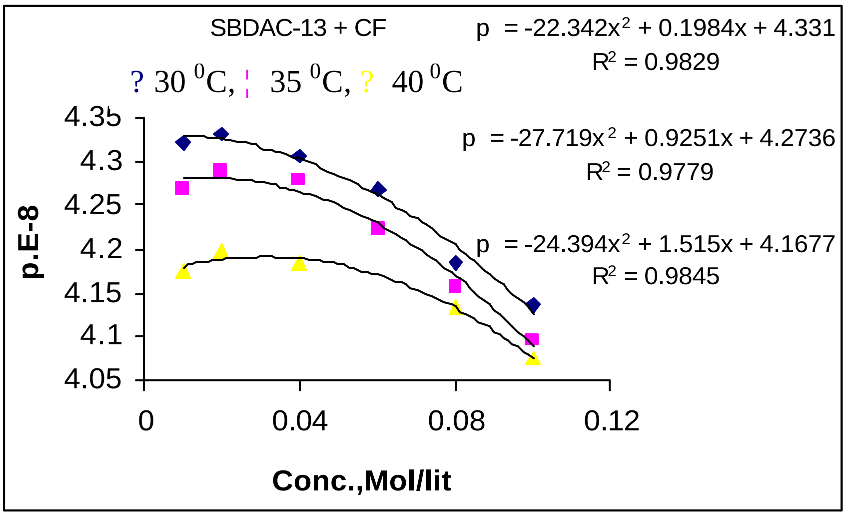

Fig 5.35: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in chloroform .

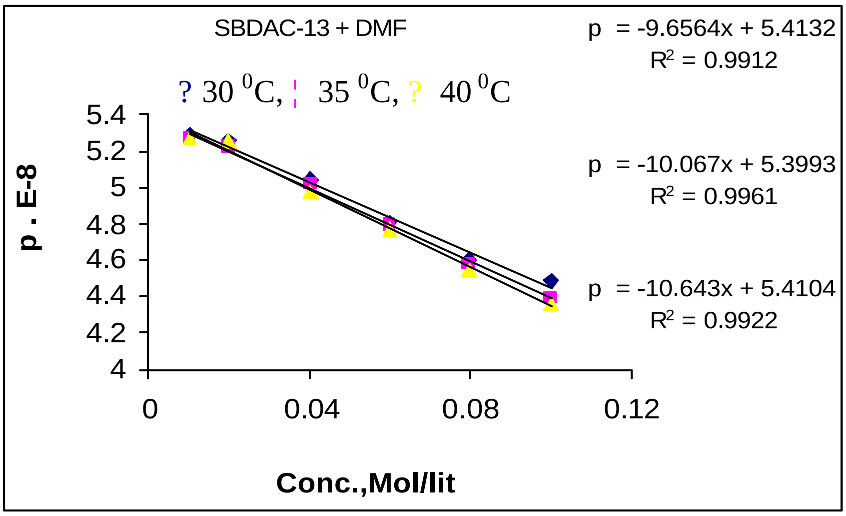

Fig 5.36: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in dimethylformamide .

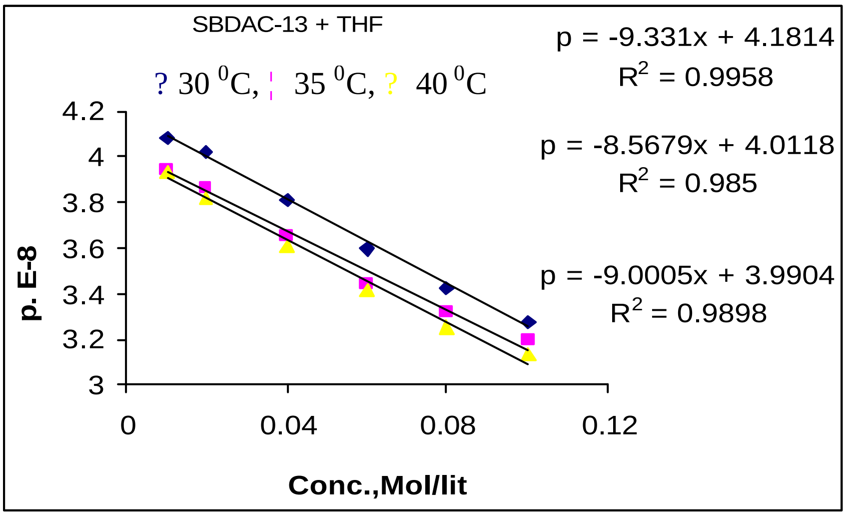

Fig 5.37: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in tetrahydrofuran.

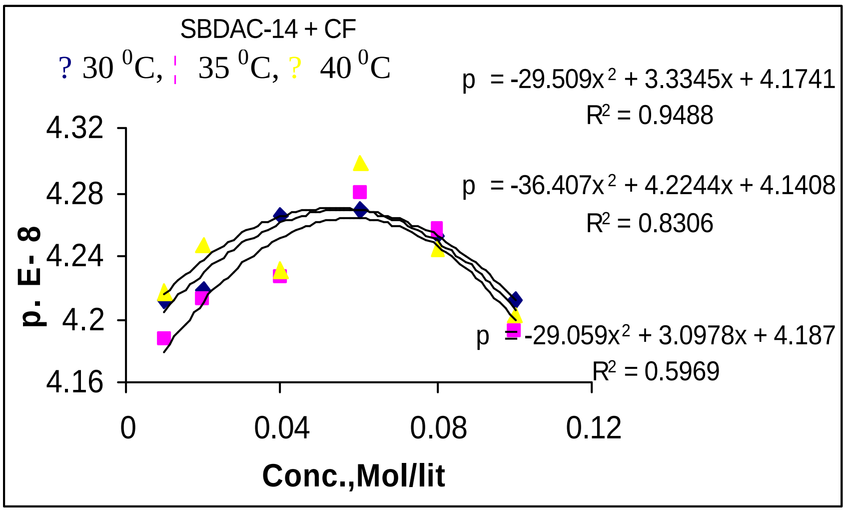

Fig 5.38: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in chloroform .

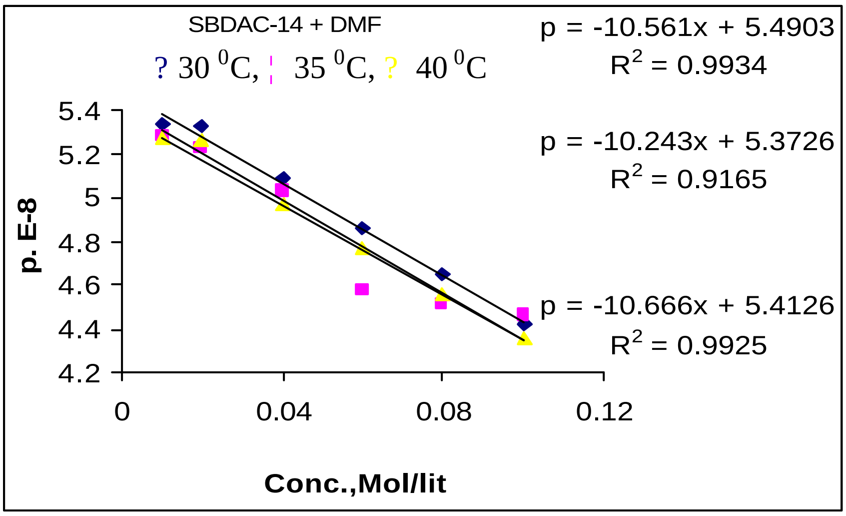

Fig 5.39: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in dimethylformamide .

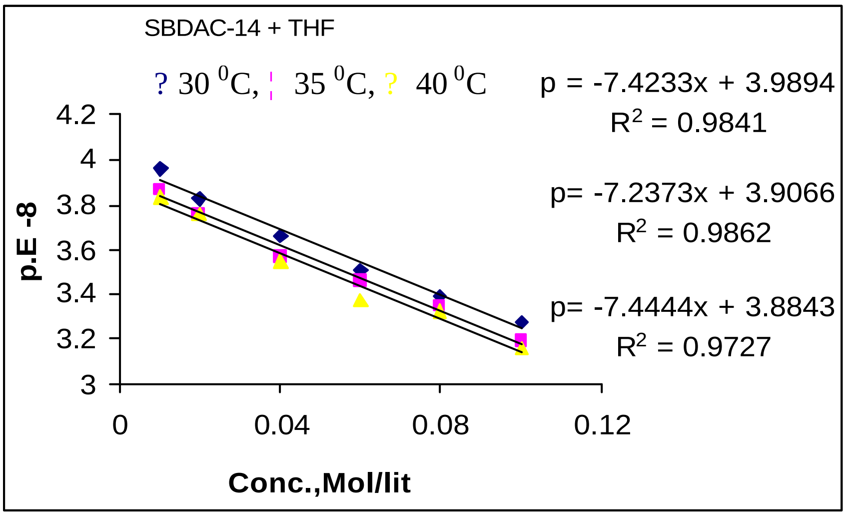

Fig 5.40: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-14 in tetrahydrofuran.

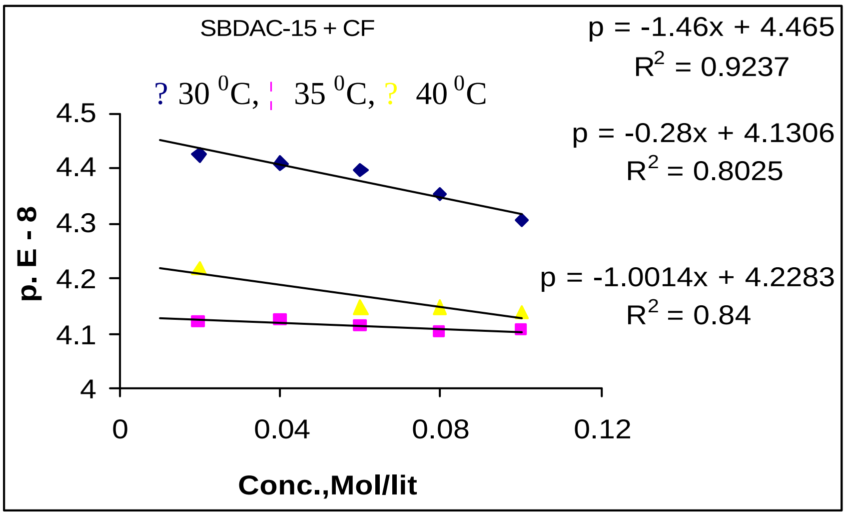

Fig 5.41: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in chloroform .

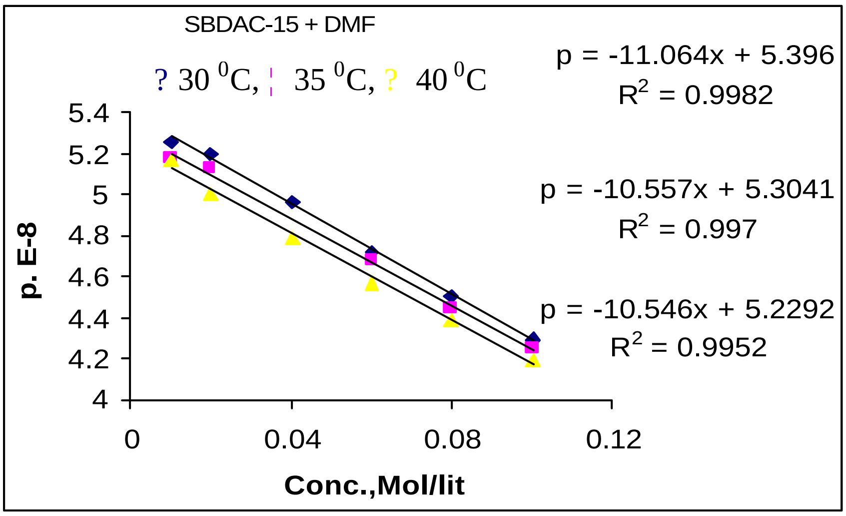

Fig 5.42: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in dimethylformamide .

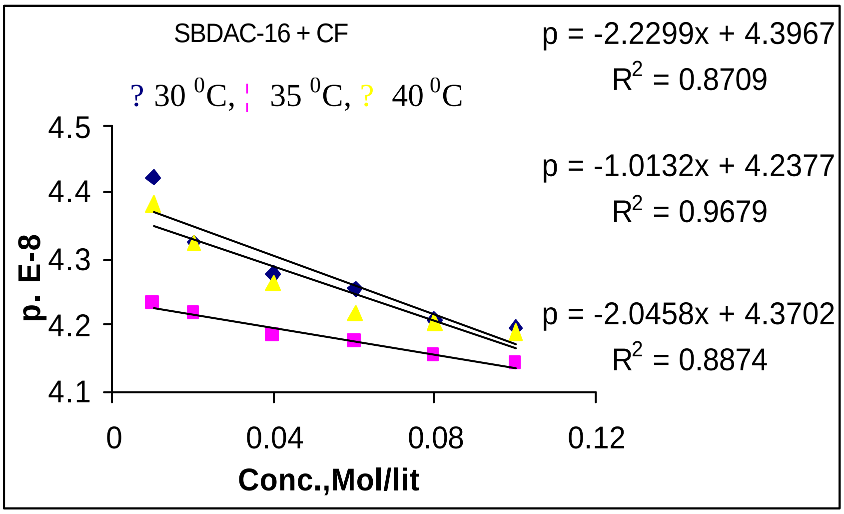

Fig 5.43: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-16 in chloroform .

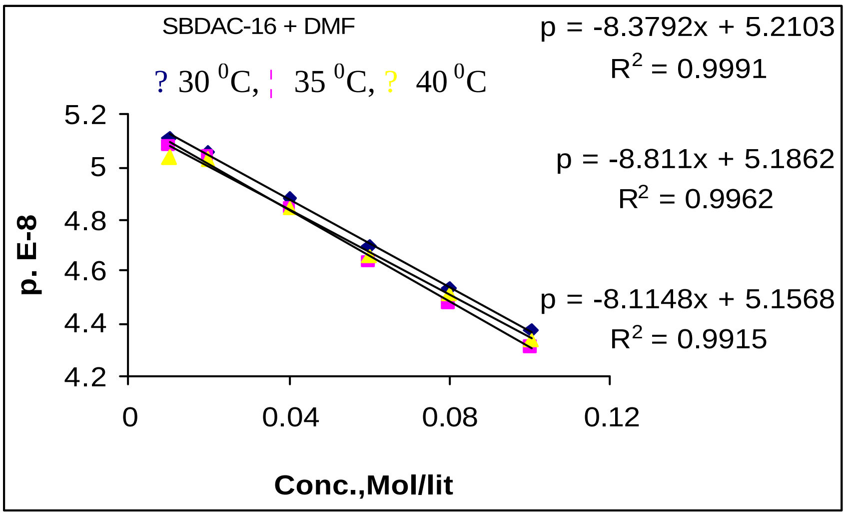

Fig 5.44: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-16 in dimethylformamide .

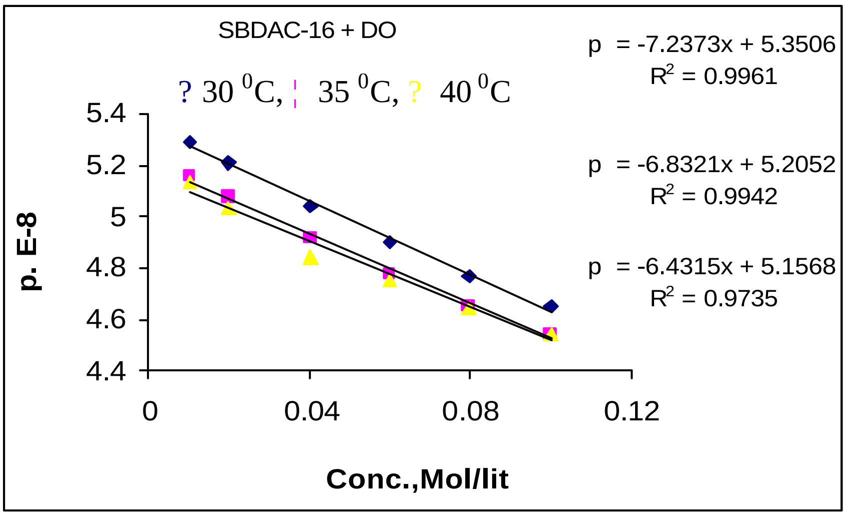

Fig 5.45: The plots of internal pressure (p) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-16 in 1,4 dioxane.

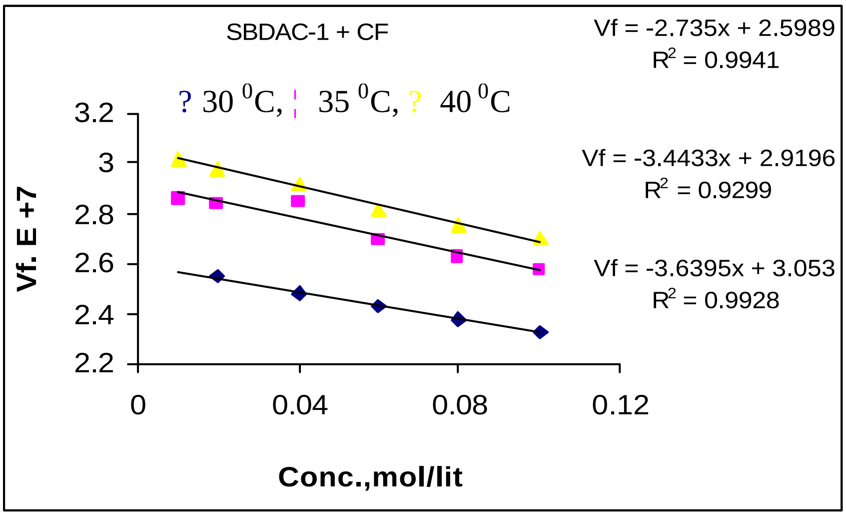

Fig 5.46: The plots of free volume (V_f) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 1 in chloroform .

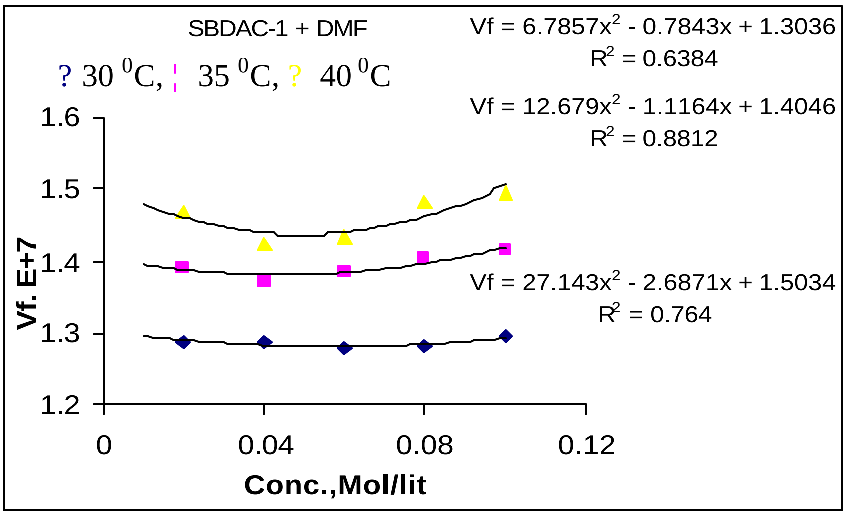

Fig 5.47: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 1 in dimethylformamide .

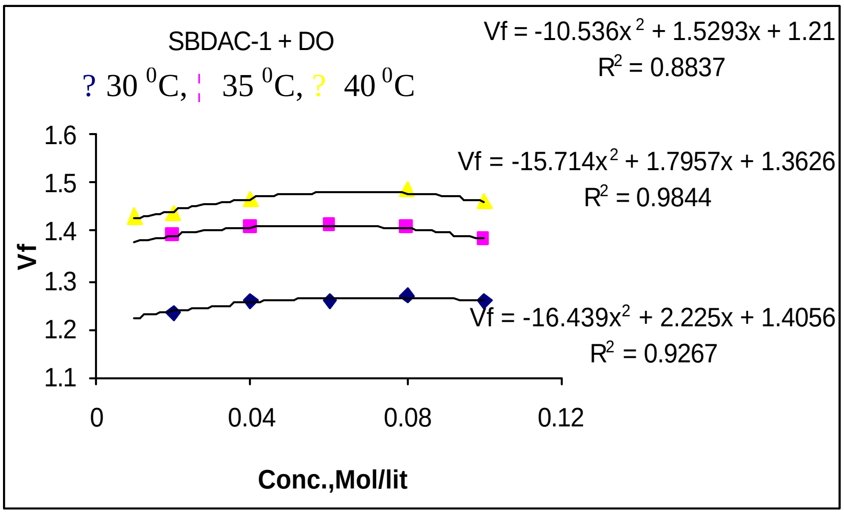

Fig 5.48: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 1 in 1,4 dioxane .

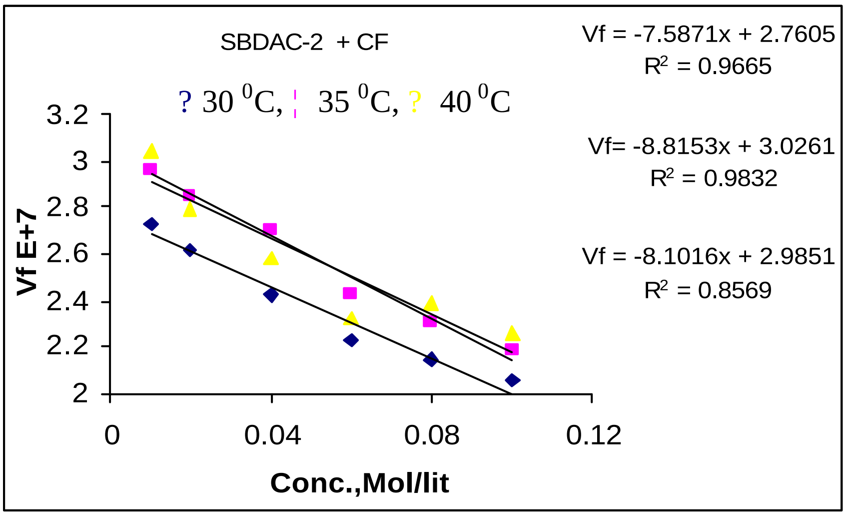

Fig 5.49: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-2 in chloroform .

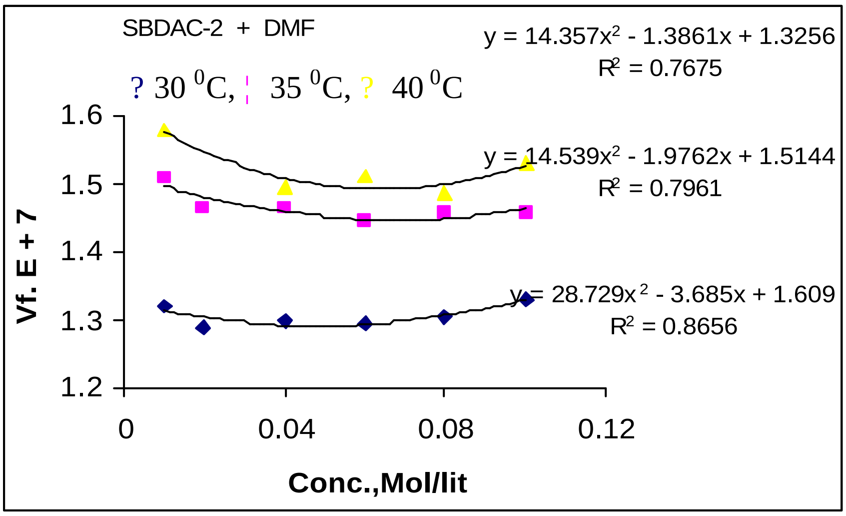

Fig 5.50: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 2 in dimethylformamide .

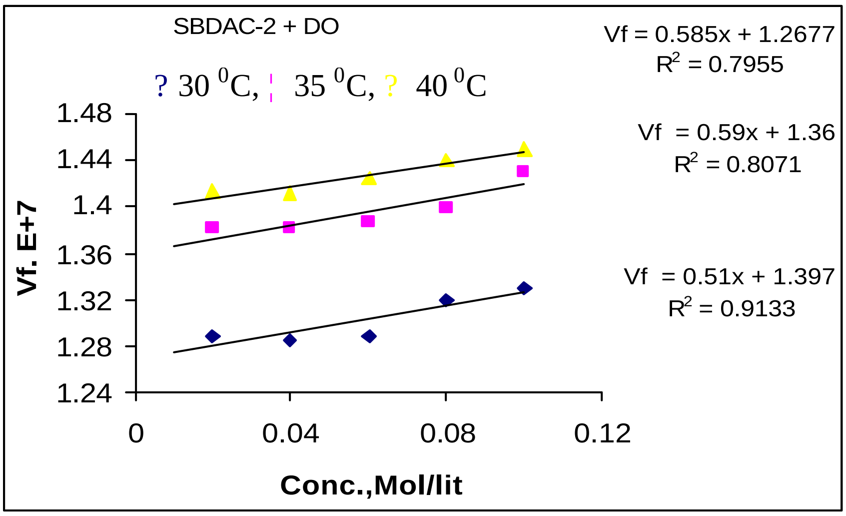

Fig 5.51: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 2 in 1,4 dioxane.

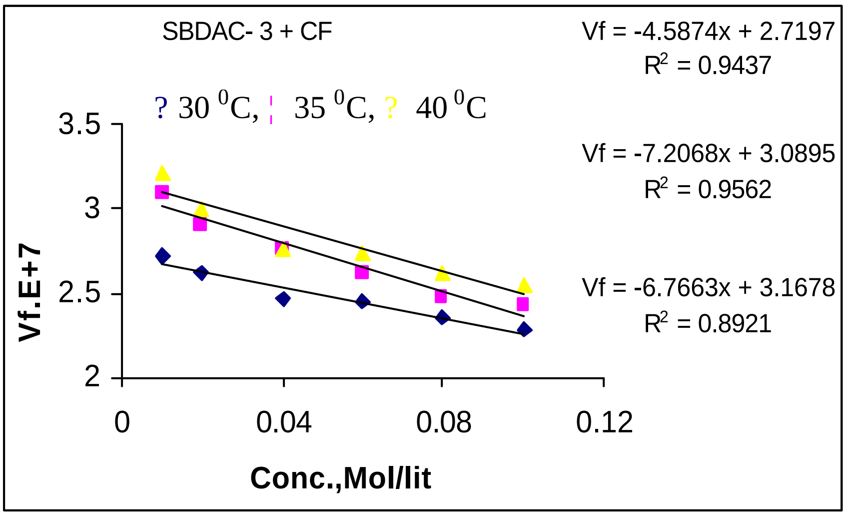

Fig 5.52: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC- 3 in chloroform .

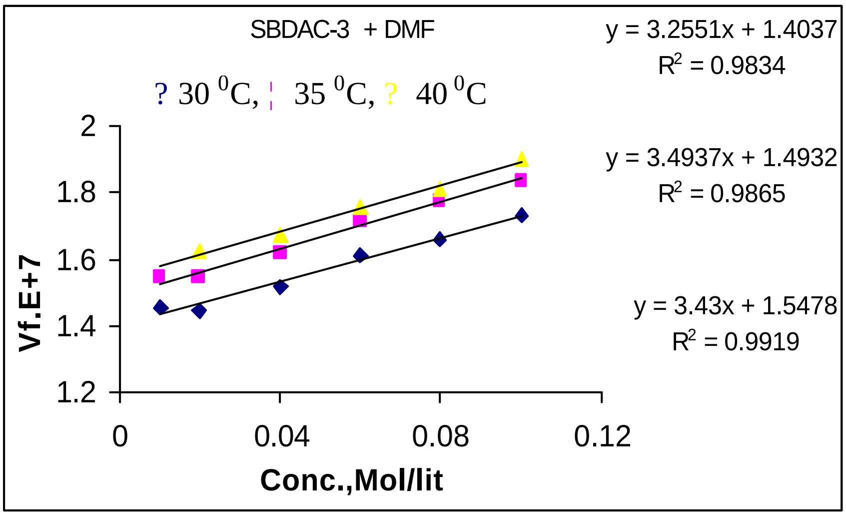

Fig 5.53: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC- 3 in dimethylformamide .

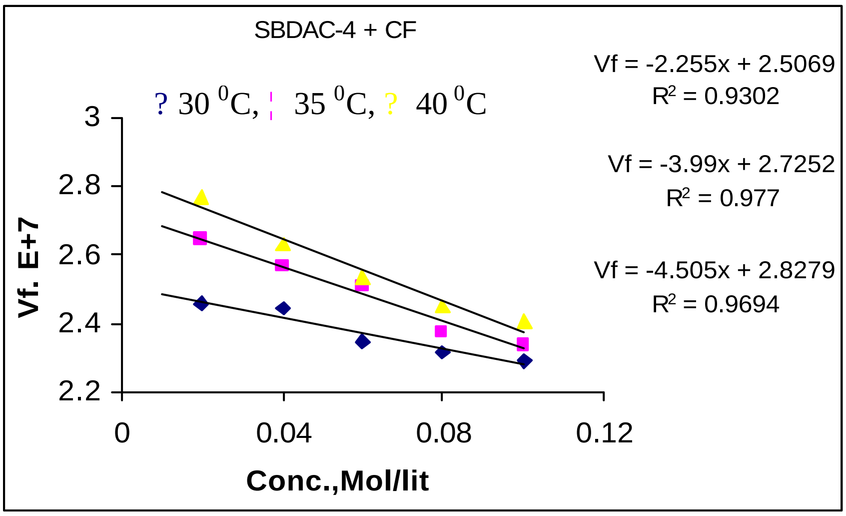

Fig 5.54: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC- 4 in chloroform .

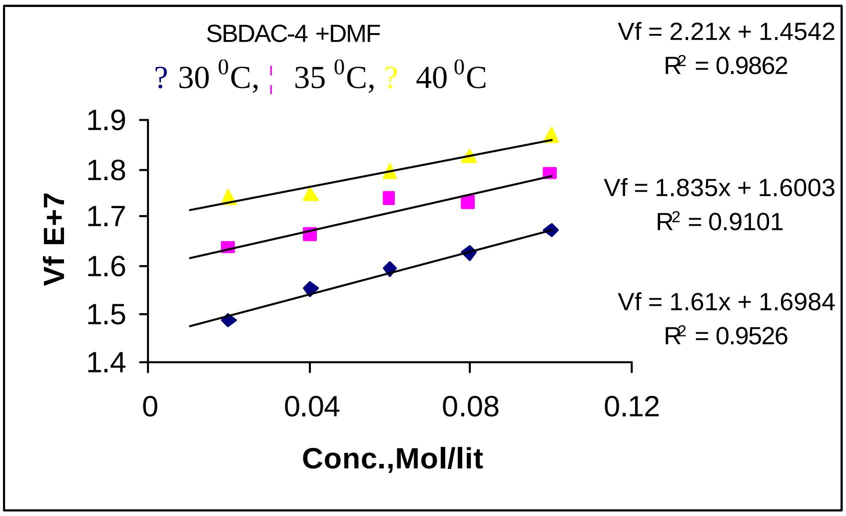

Fig 5.55 The plots of free volume (V_f) gainst concentration at 30^0, 35^0,and 40^{0}C for SBDAC-4 in dimethylformamide .

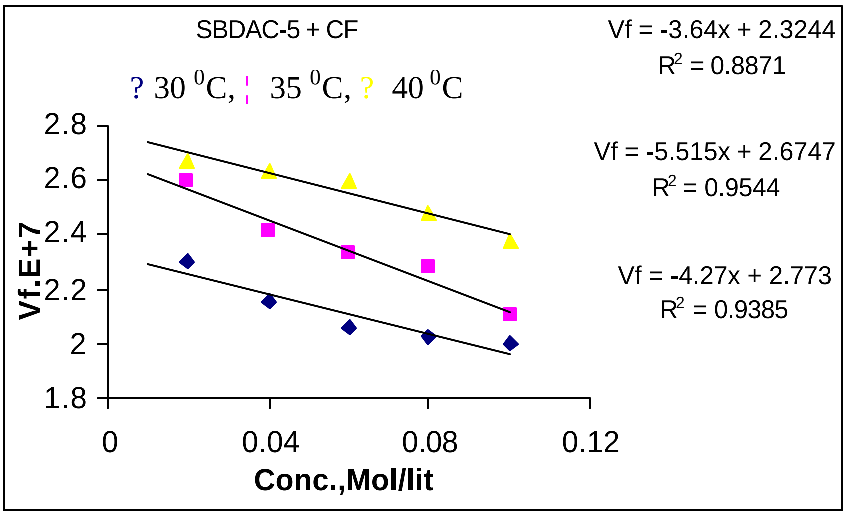

Fig 5.56: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC- 5 in chloroform .

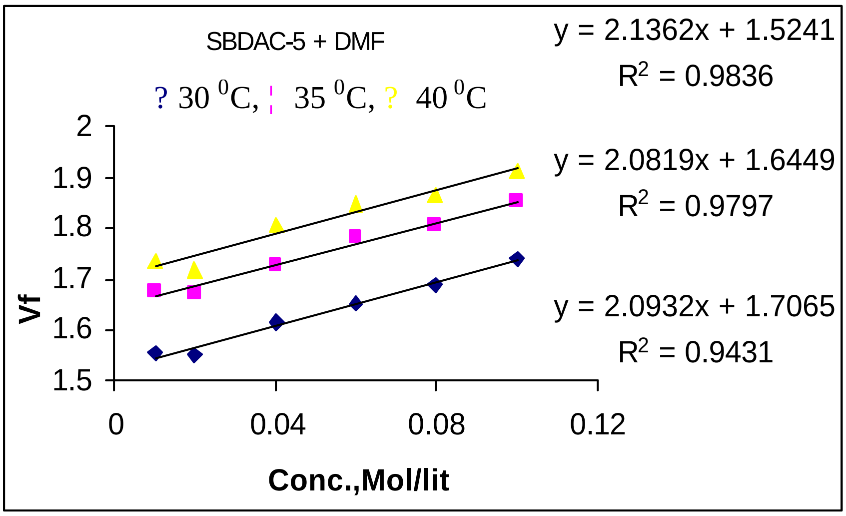

Fig 5.57: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in dimethylformamide.

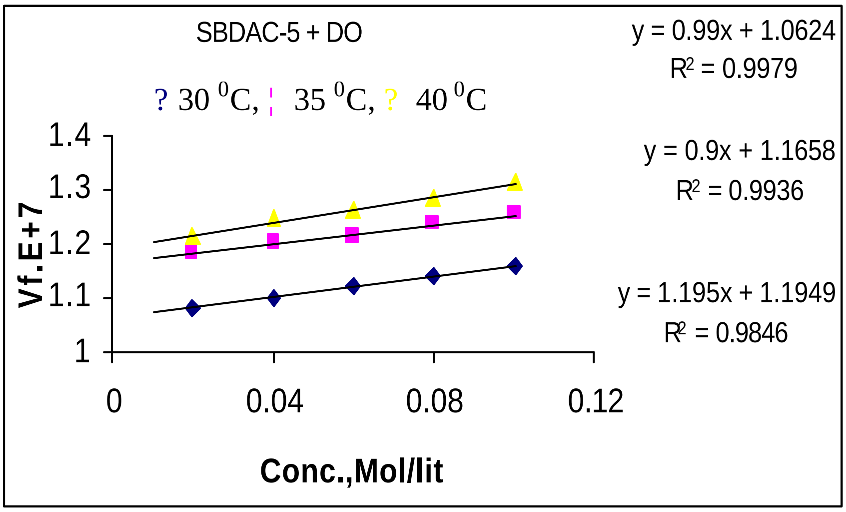

Fig 5.58 The plots of free volume (V_f) against concentration at 30^0, 35^0,and 40^0C for SBDAC-5 in dioxane

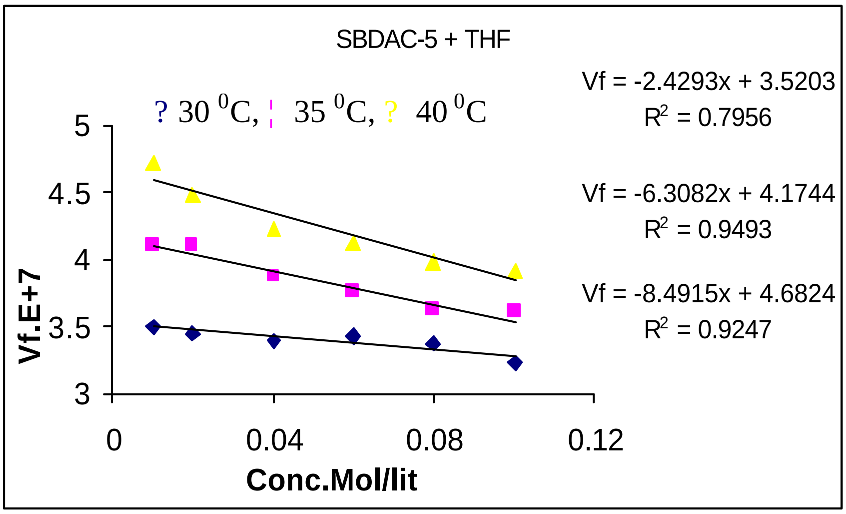

Fig 5.58: The plots of free volume (V_f) against concentration at 30^0, 35^0,and 40^0C for SBDAC- 5 in tetrahydrofuran.

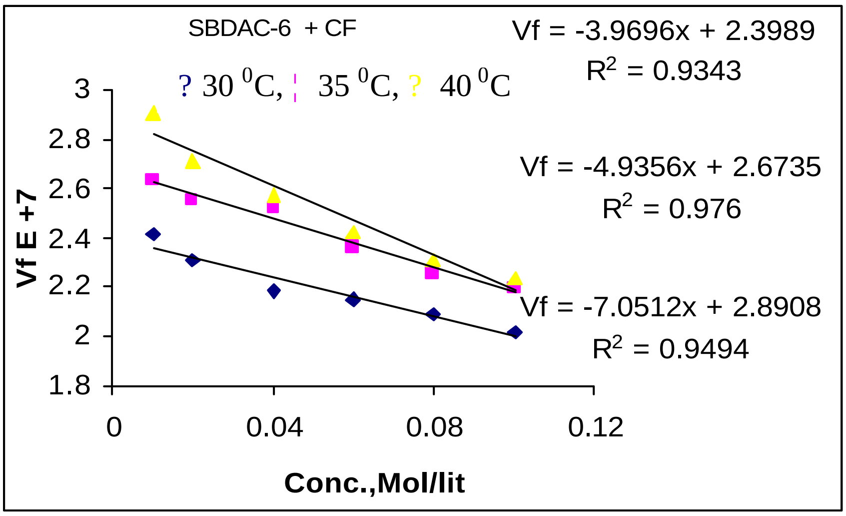

Fig 5.60: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-6 in chloroform.

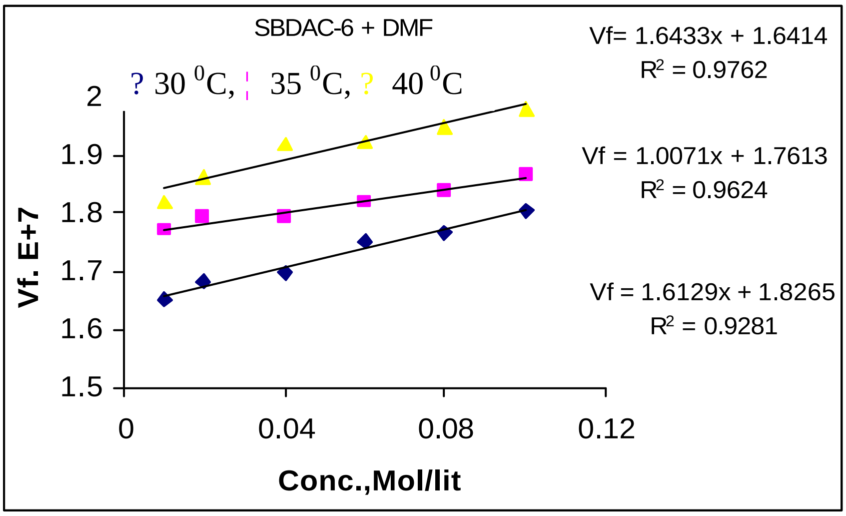

Fig 5.61: The plots of free volume (V_f) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in dimethylformamide .

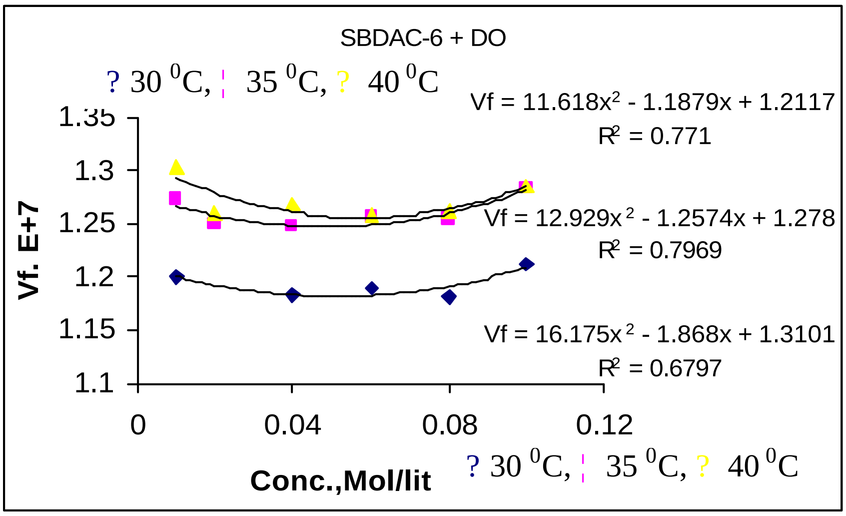

Fig 5.62:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in dioxane.

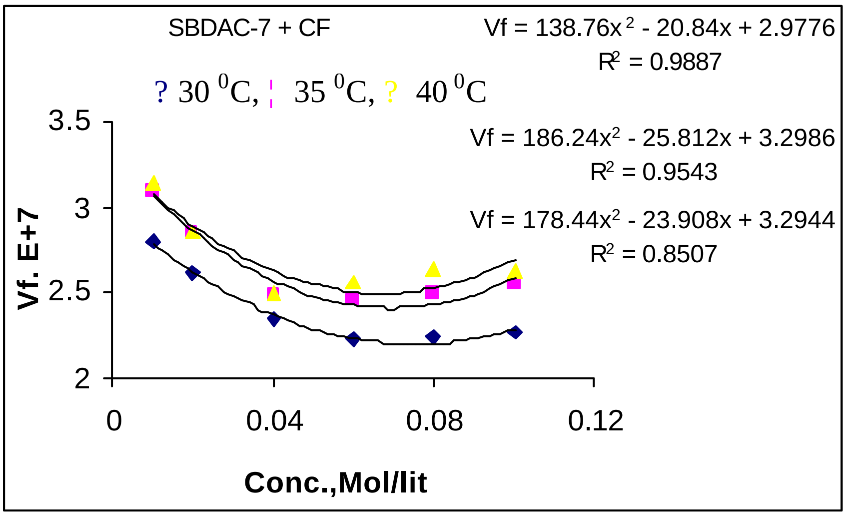

Fig 5.63: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-7 in chloroform.

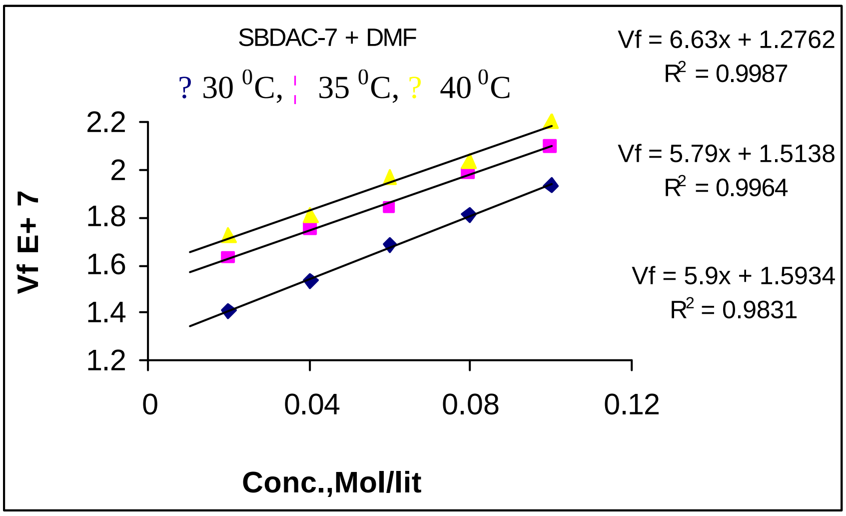

Fig 5.64: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-7 in dimethylformamide .

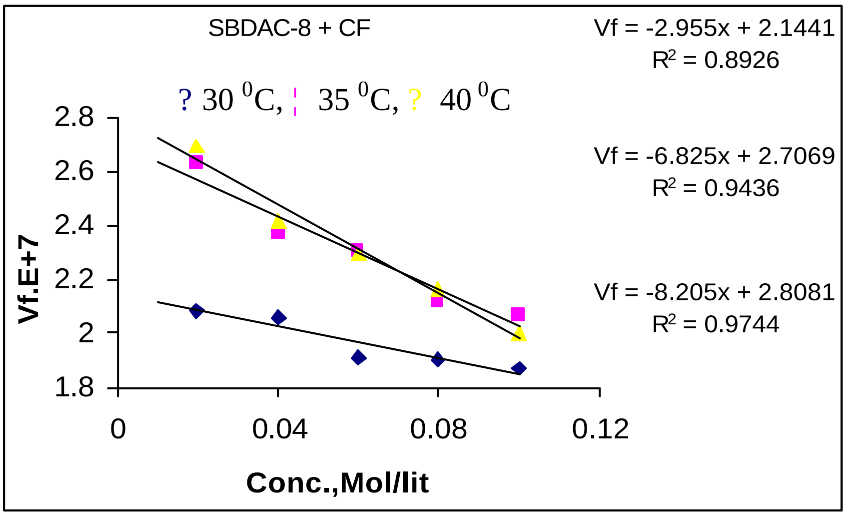

Fig 5.65:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-8 in chloroform.

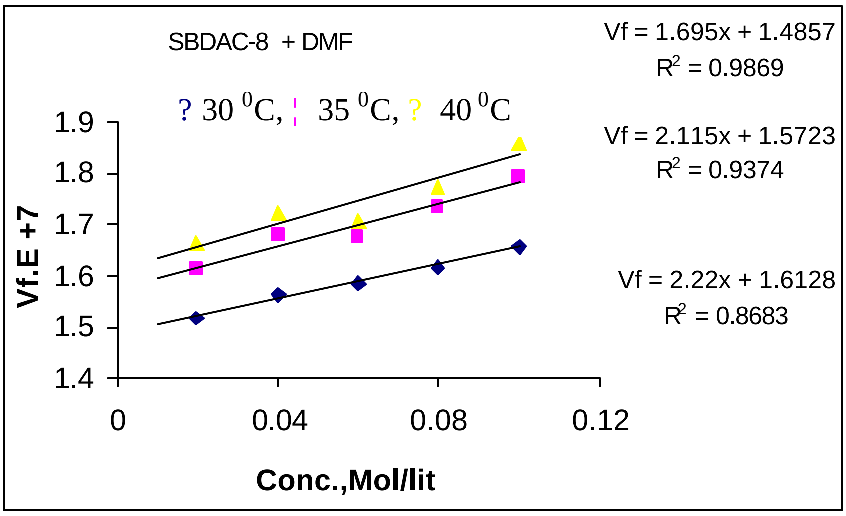

Fig 5.66:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-8 in dimethylformamide

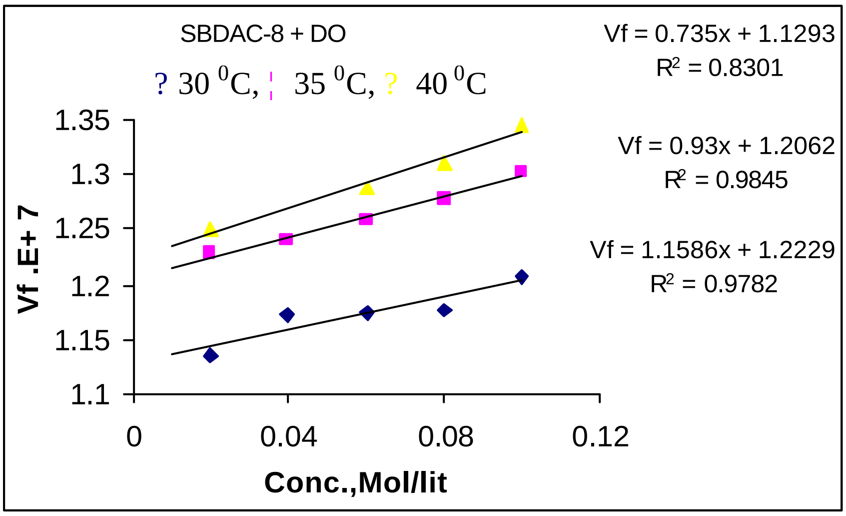

Fig 5.67:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-8 in dioxane.

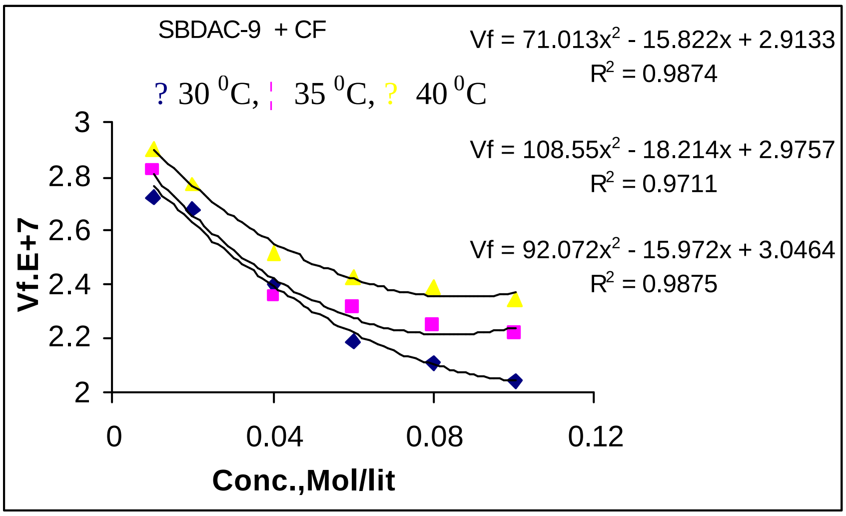

Fig 5.68:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-9 in chloroform.

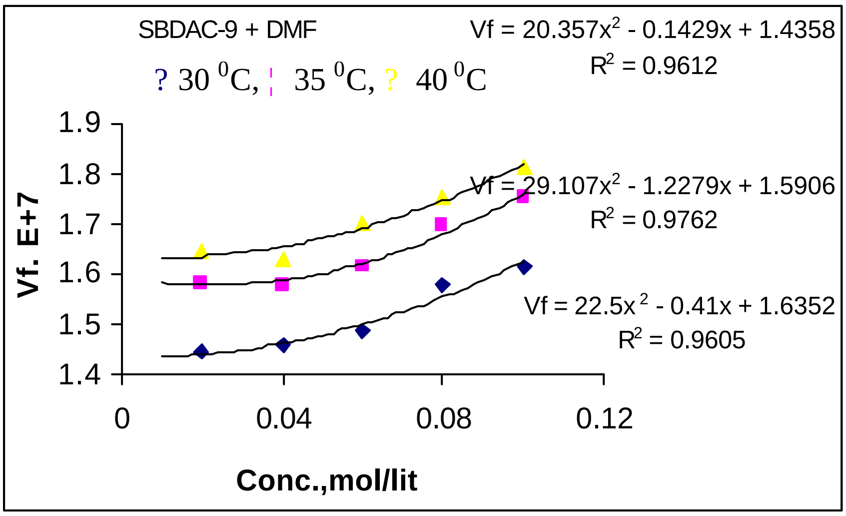

Fig 5.69:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-9 in demethylformamide.

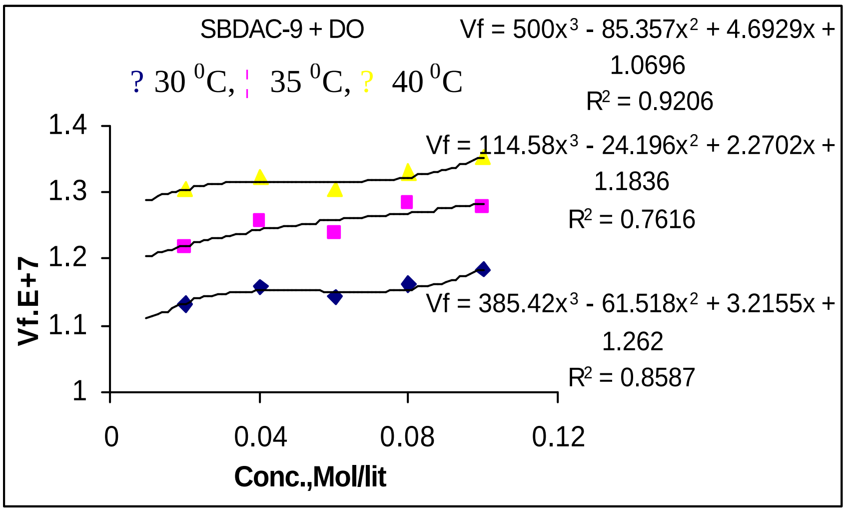

Fig 5.70:The plots of free volume (V$_f$)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-9 in dioxane.

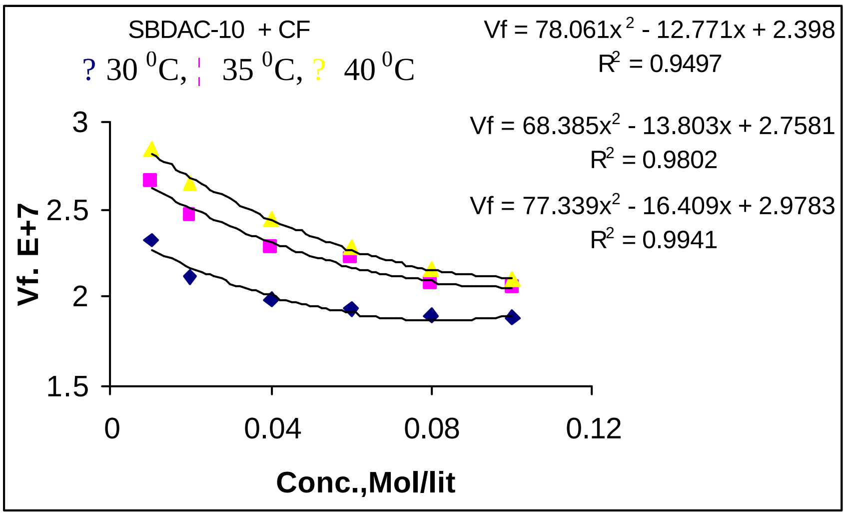

Fig 5.71:The plots of free volume (V$_f$)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-10 in chloroform.

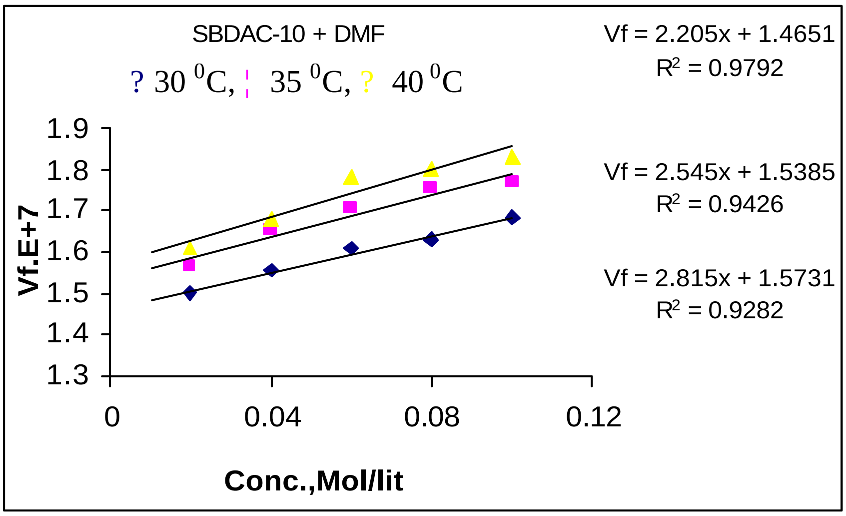

Fig 5.72 :The plots of free volume (V$_f$)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-10 in dimethylformamide .

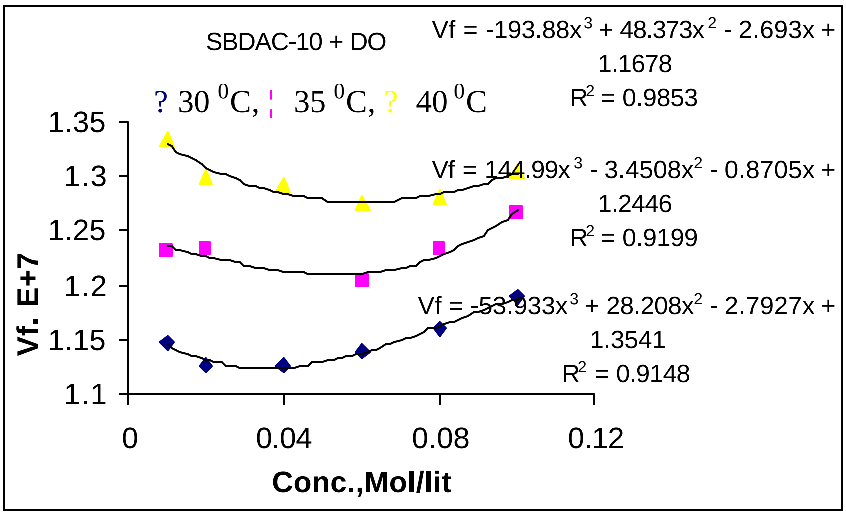

Fig 5.73: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in dioxane.

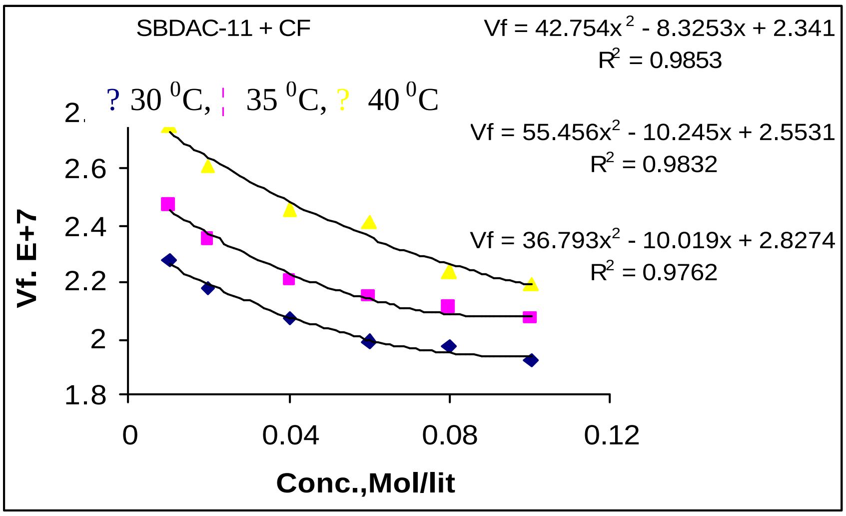

Fig 5.74: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in chloroform.

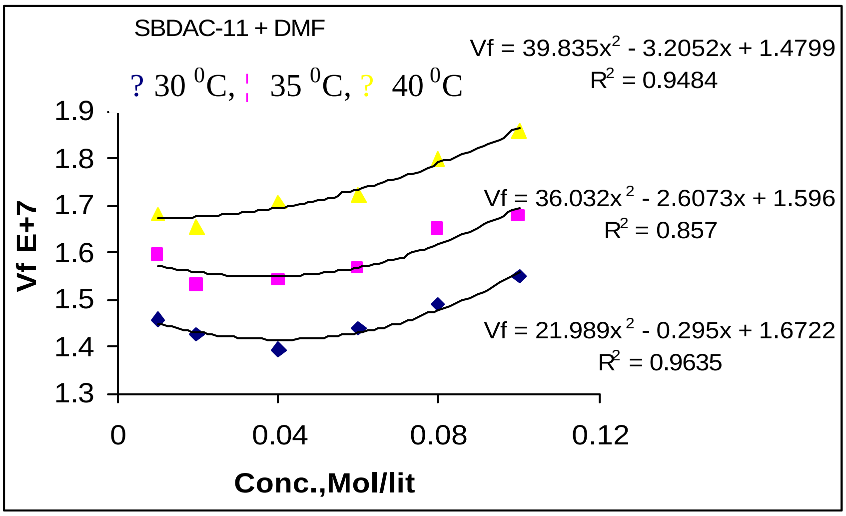

Fig 5.75: The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in dimethylformamide .

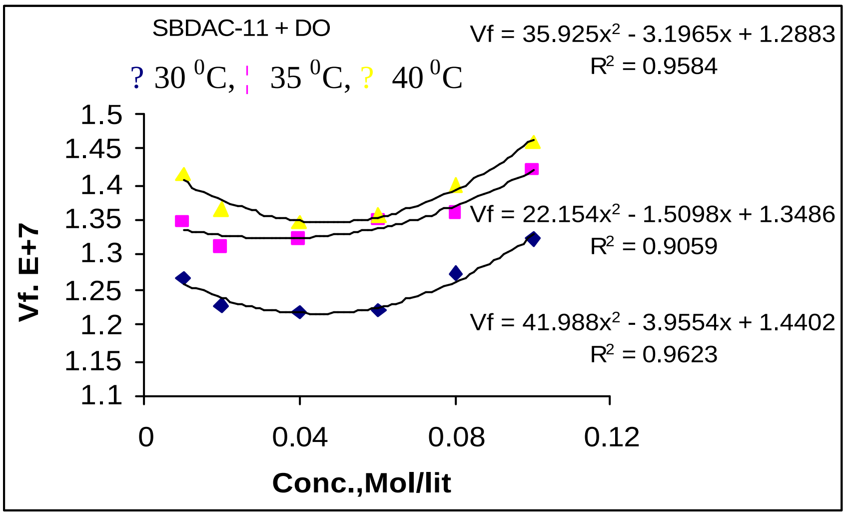

Fig 5.76:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-11 in dioxane.

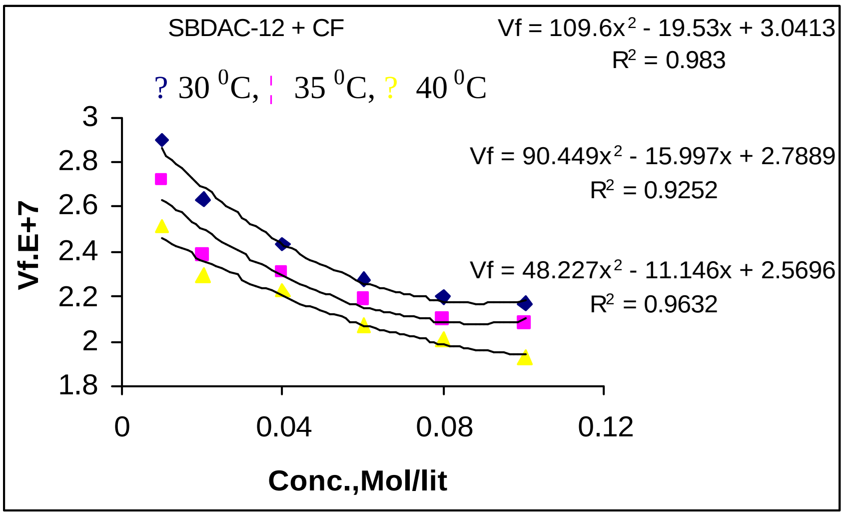

Fig 5.77:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-12 in chloroform.

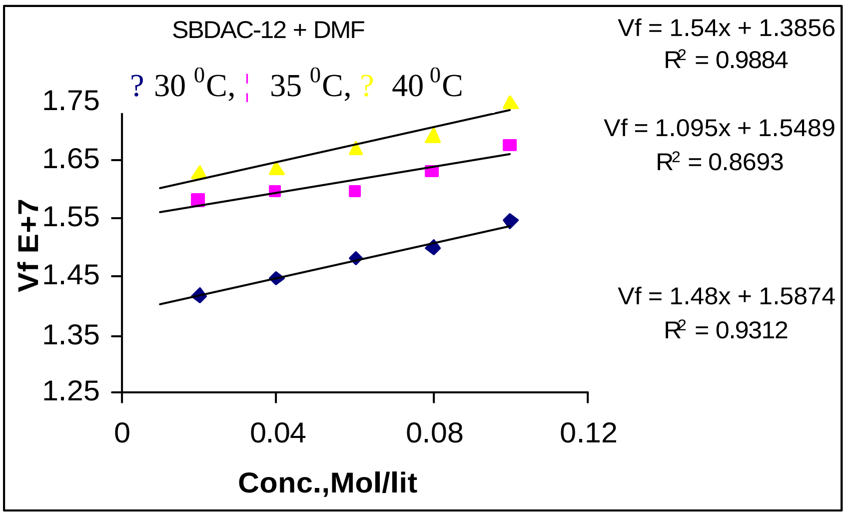

Fig 5.78:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-12 in dimethylformamide .

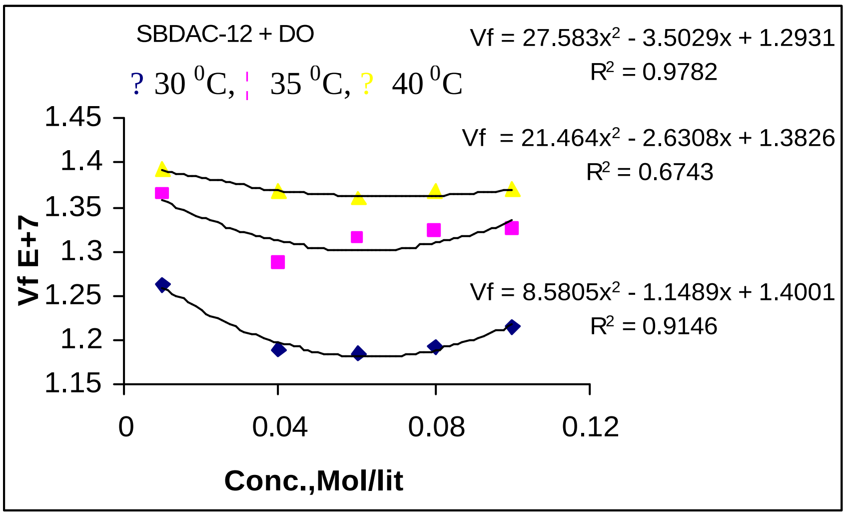

Fig 5.79:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-12 in dioxane.

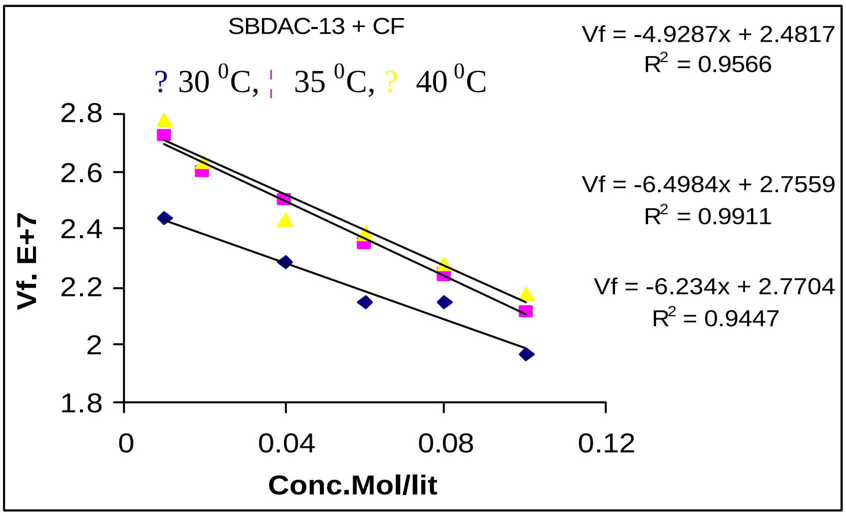

Fig 5.80:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in chloroform.

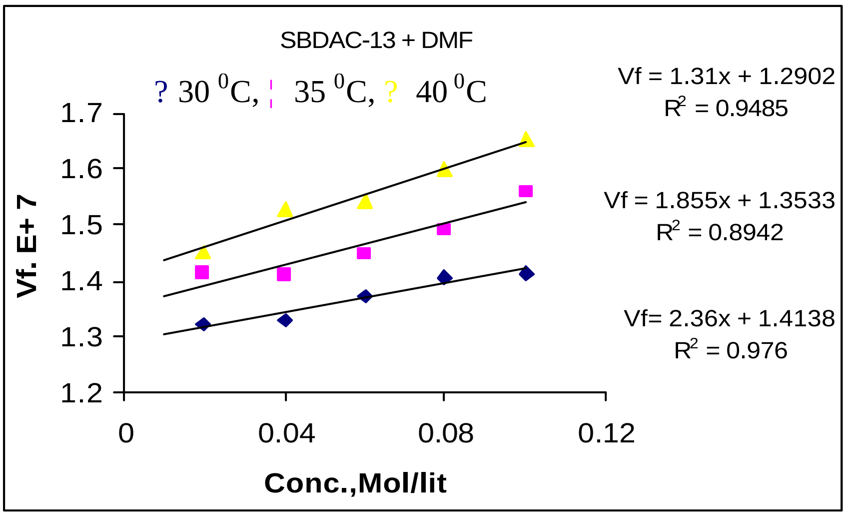

Fig 5.81:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in dimethylformamide .

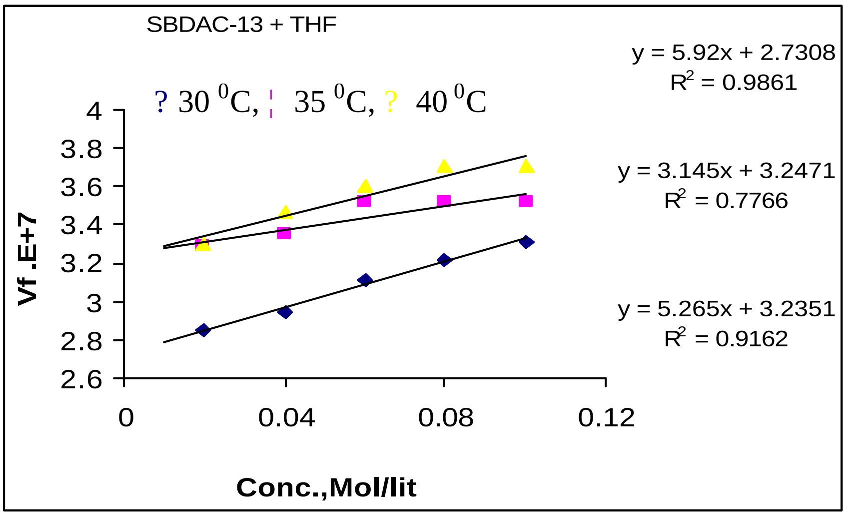

Fig 5.82:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in tetrahydrofuran.

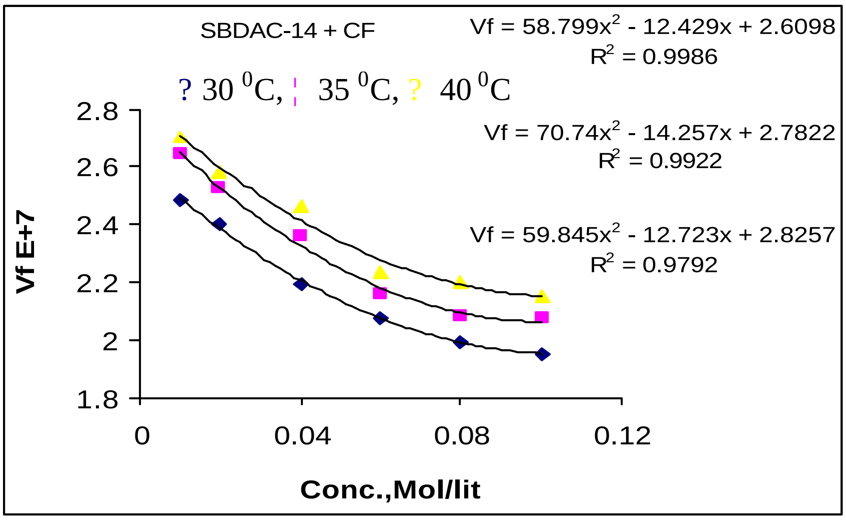

Fig 5.83:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in chloroform.

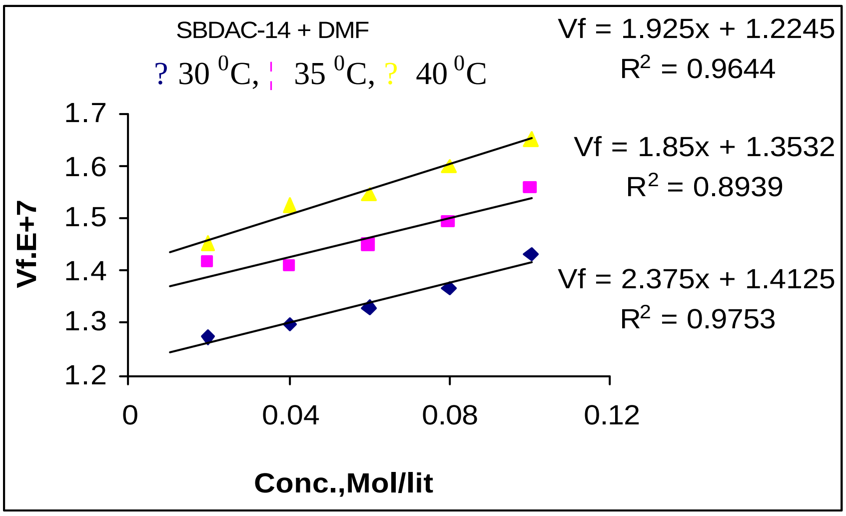

Fig 5.84:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in dimethylformamide .

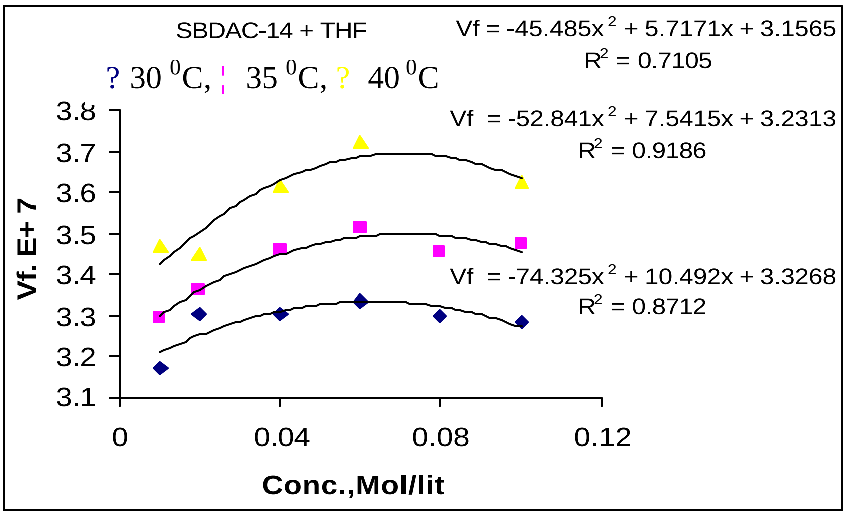

Fig 5.85:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-14 in tetrahydrofuran.

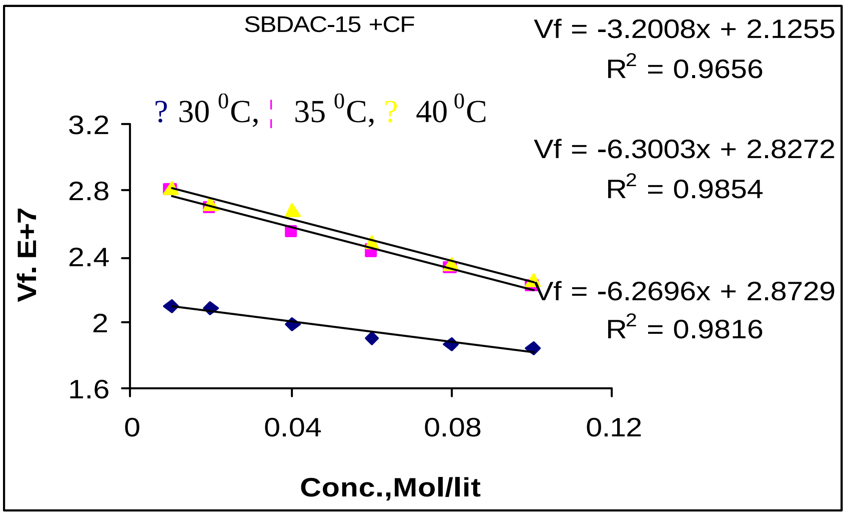

Fig 5.86:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in chloroform.

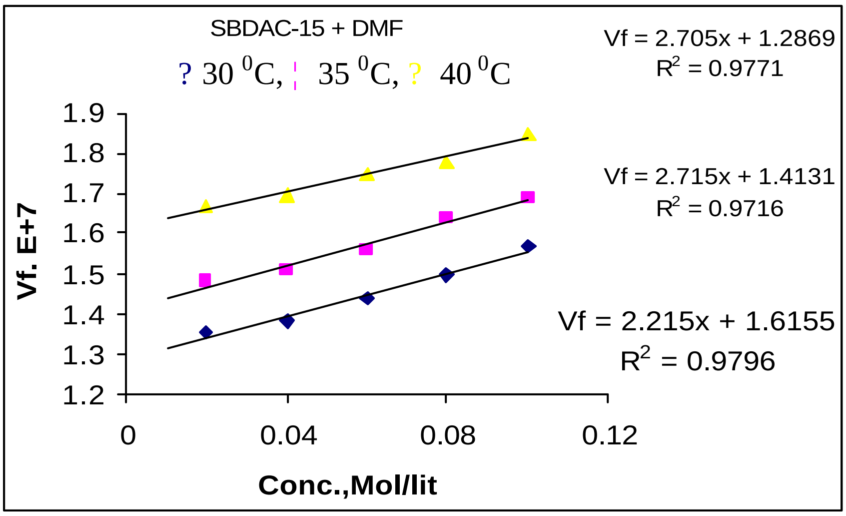

Fig 5.87:The plots of free volume (V_f)against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in dimethylformamide .

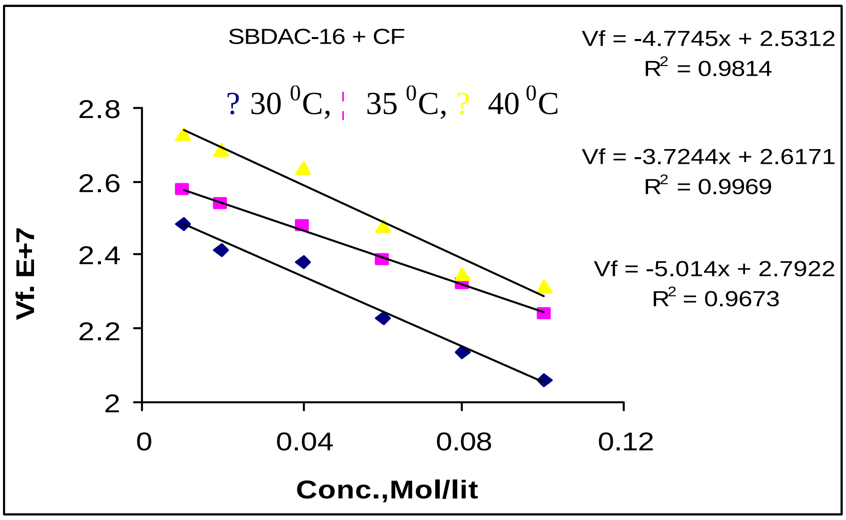

Fig 5.88:The plots of free volume (V_f) against concentration at 30^0, 35^0, and 40^0C for SBDAC-16 in chloroform.

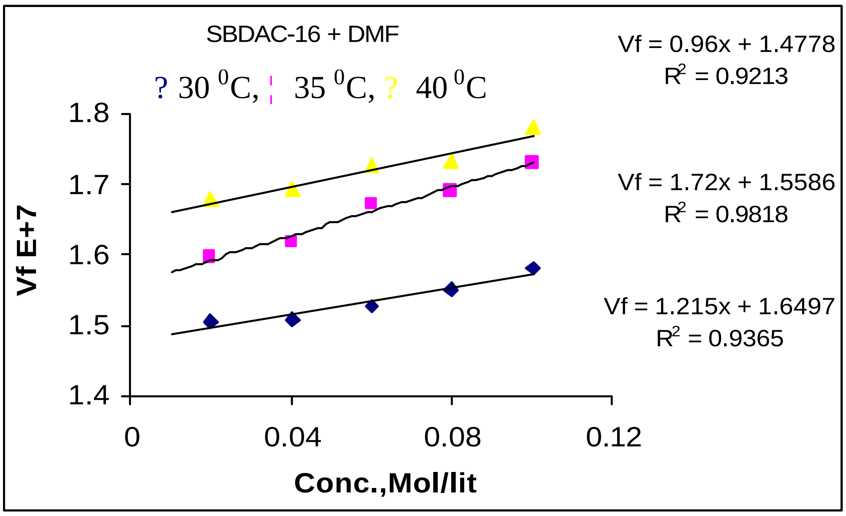

Fig 5.89:The plots of free volume (V_f) against concentration at 30^0, 35^0, and 40^0C for SBDAC-16 in dimethylformamide .

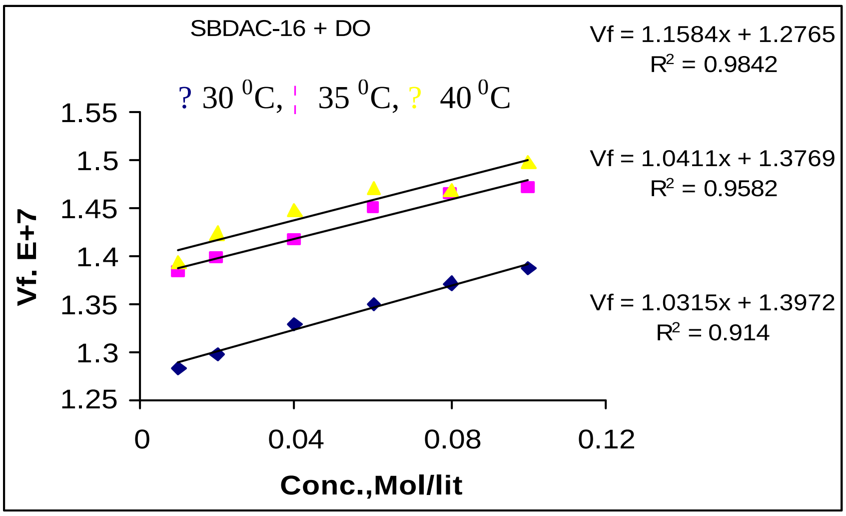

Fig 5.90:The plots of free volume (V_f) against concentration at 30^0, 35^0, and 40^0C for SBDAC-16 in dioxane.

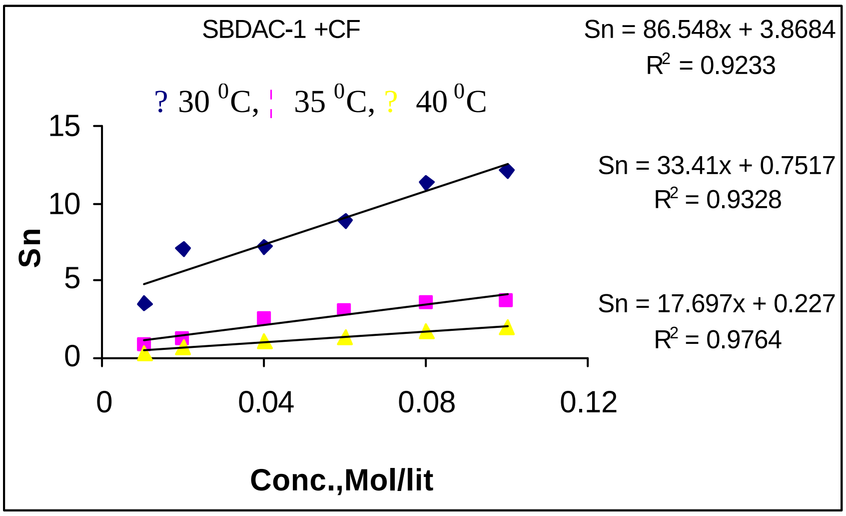

Fig 5.91:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40 for SBDAC-1 in chloroform.

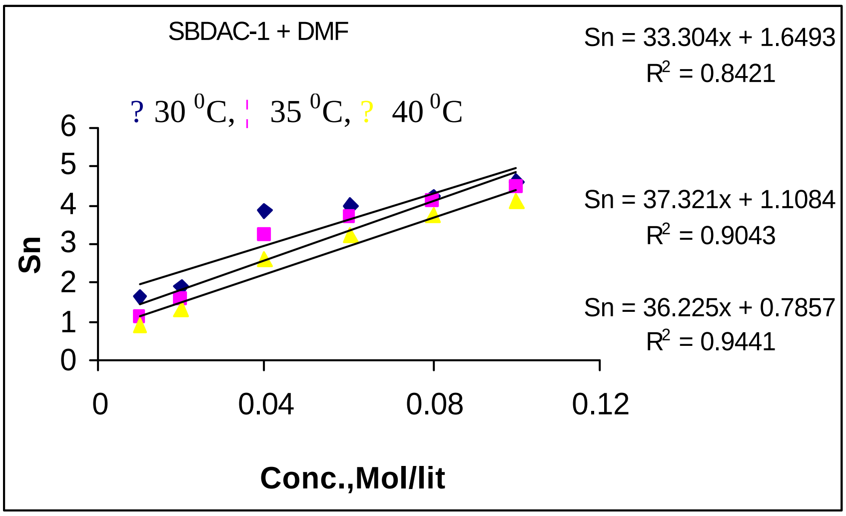

Fig 5.92:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-1 in dimethylformamide .

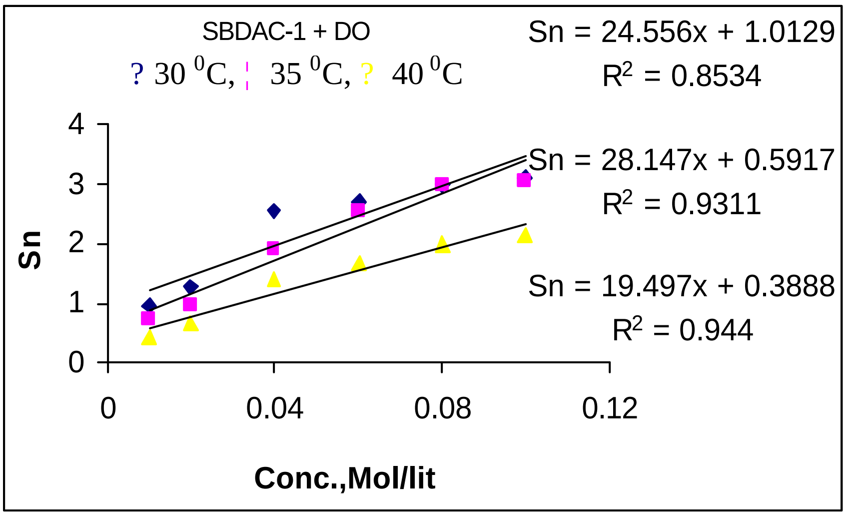

Fig 5.93:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C forSBDAC-1 in dioxane.

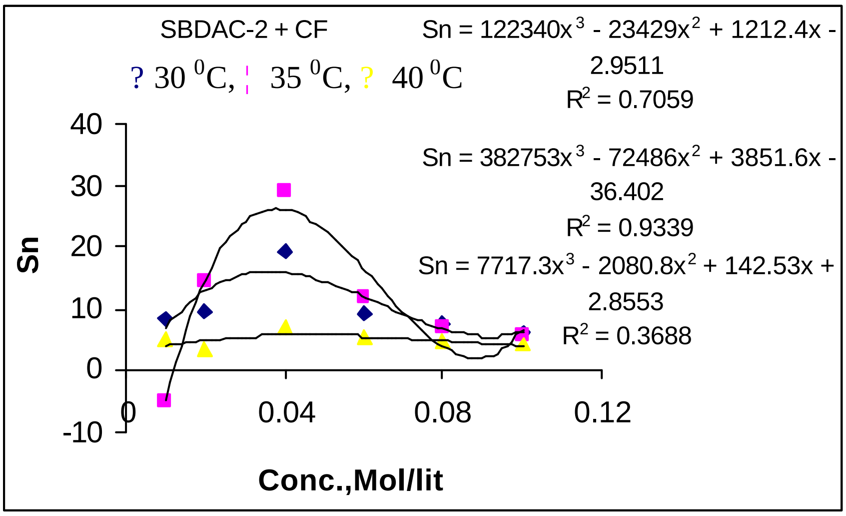

Fig 5.94: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-2 in chloroform.

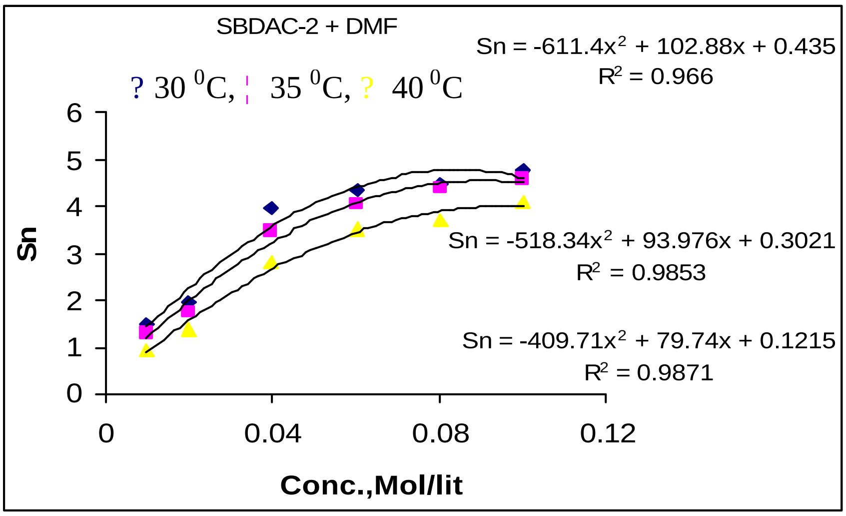

Fig 5.95:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-2 in dimethylformamide .

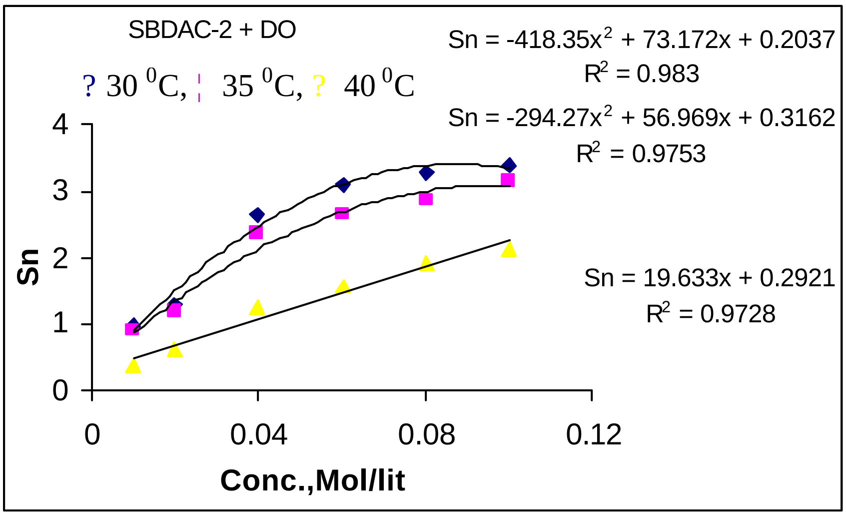

Fig 5.96:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-2 in dioxane.

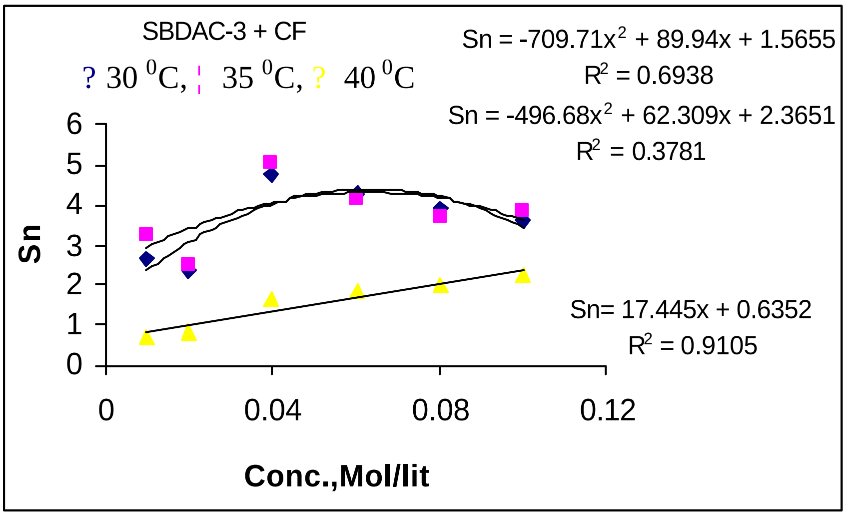

Fig 5.97:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-3 in chloroform.

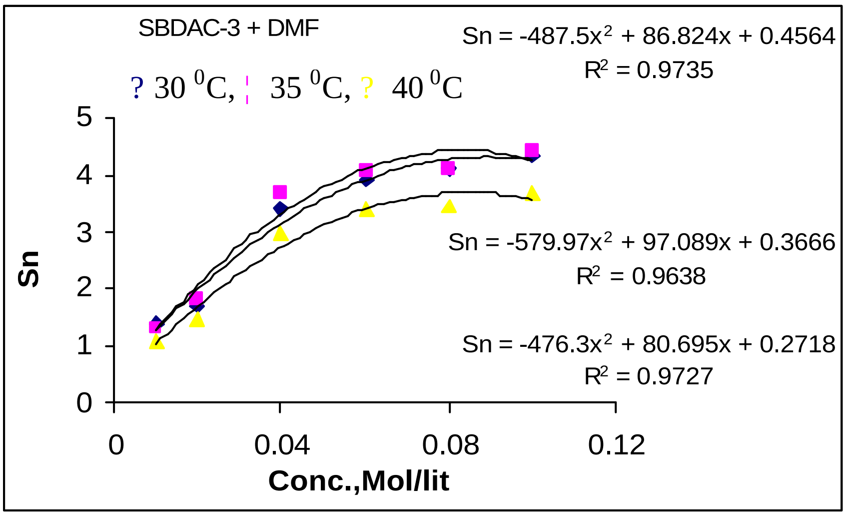

Fig 5.98:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-3 in dimethylformamide .

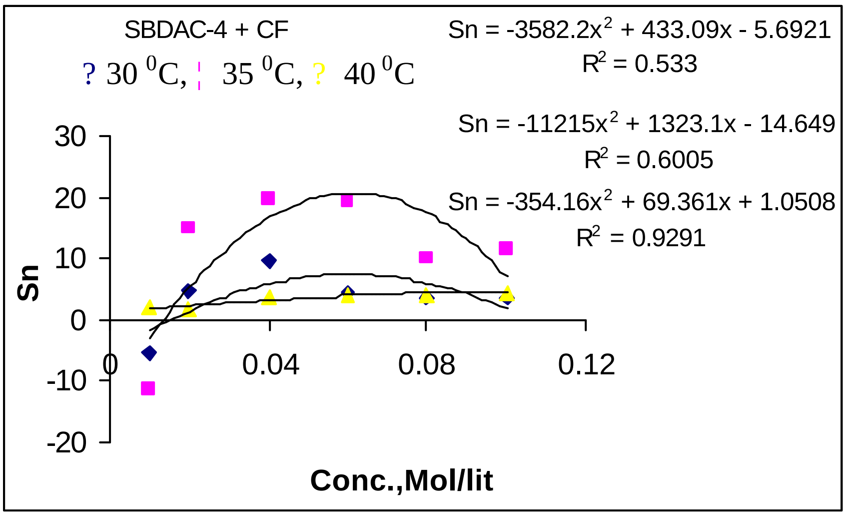

Fig 5.99:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-4 in chloroform.

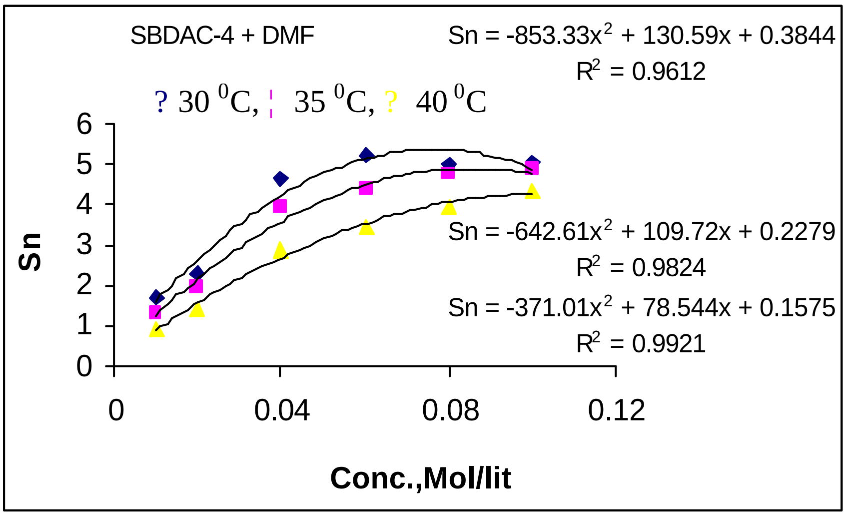

Fig 5.100: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-4 in dimethylformamide .

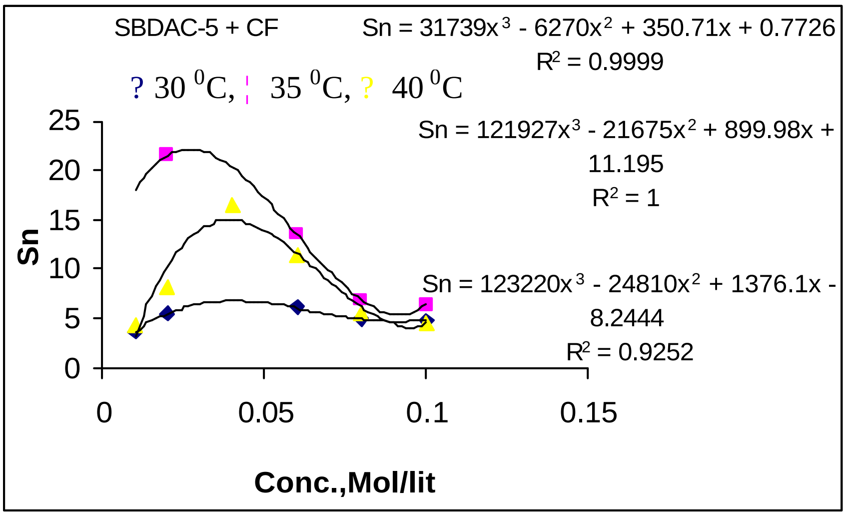

Fig 5.101: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in chloroform.

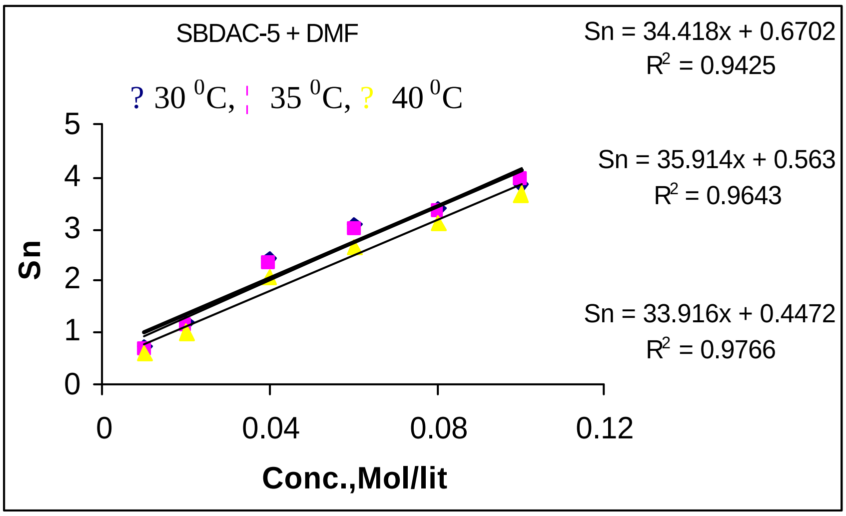

Fig 5.102: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-5 in dimethylformamide .

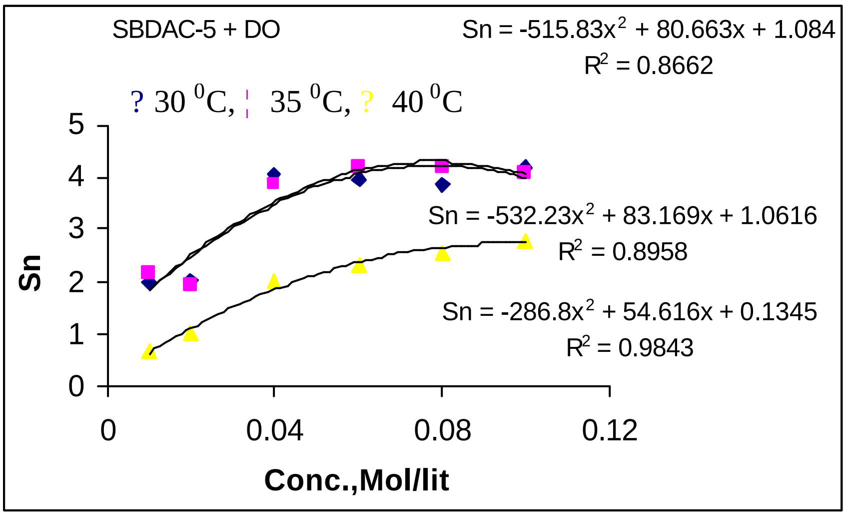

Fig 5.103:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-5 in dioxane.

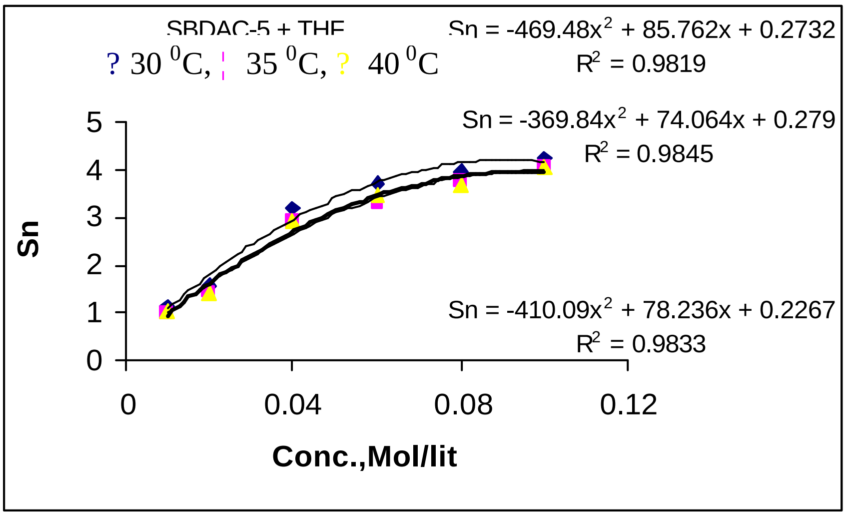

Fig 5.104:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-5 in tetrahydrofuran.

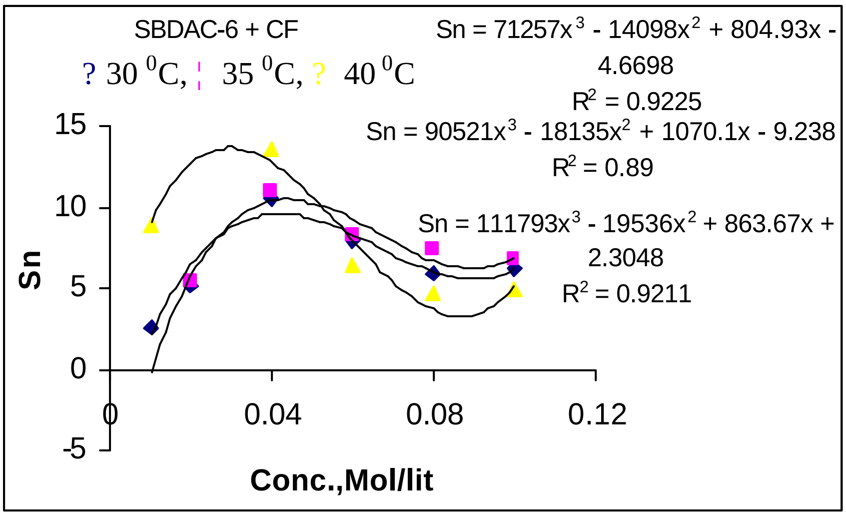

Fig 5.105:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-6 in chloroform.

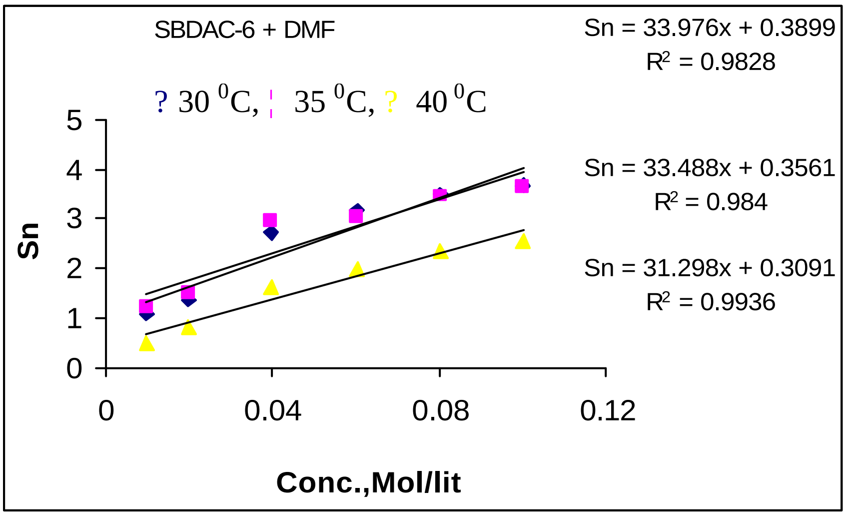

Fig 5.106:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in dimethylformamide .

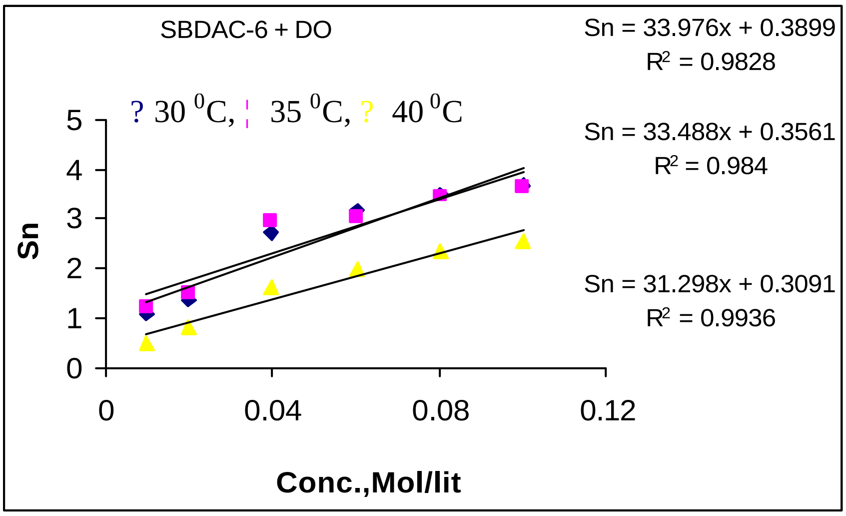

Fig 5.107:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-6 in dioxane.

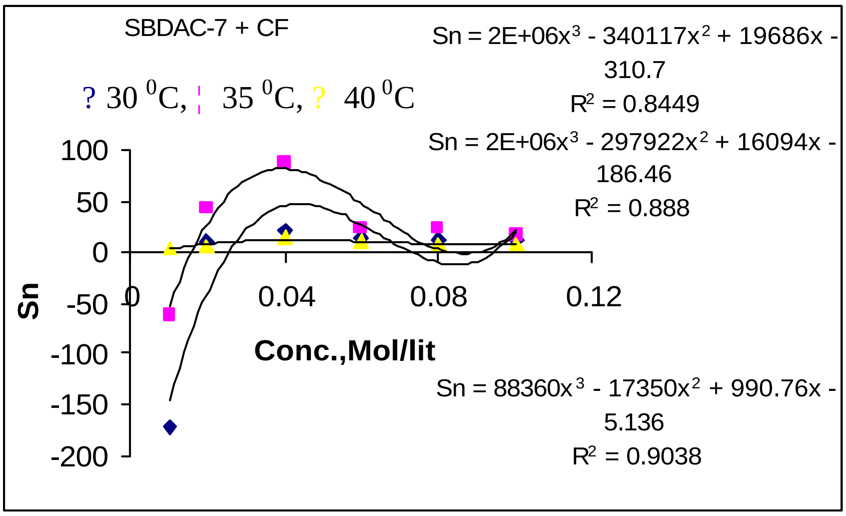

Fig 5.108:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-7 in chloroform.

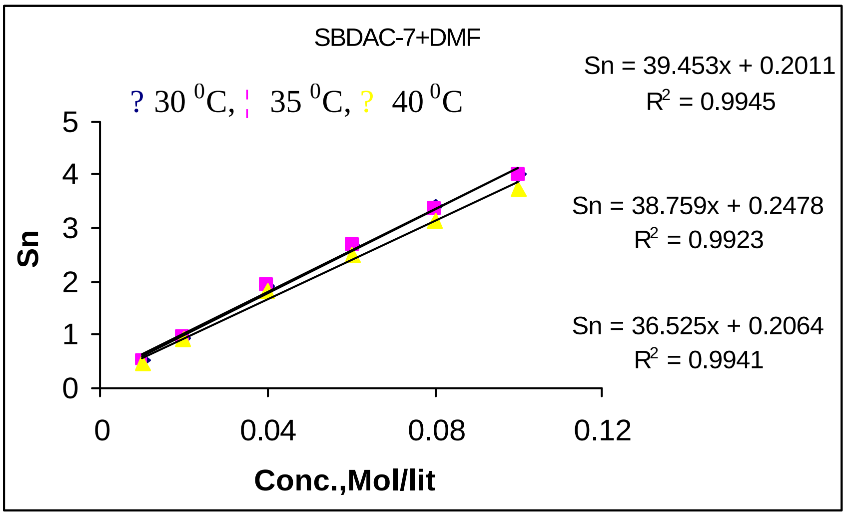

Fig 5.109:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-7 in dimethylformamide .

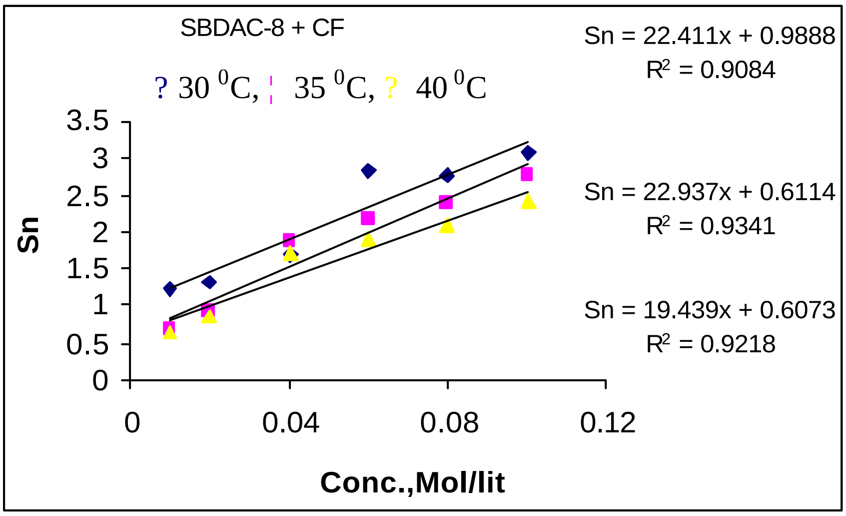

Fig 5.110:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in chloform.

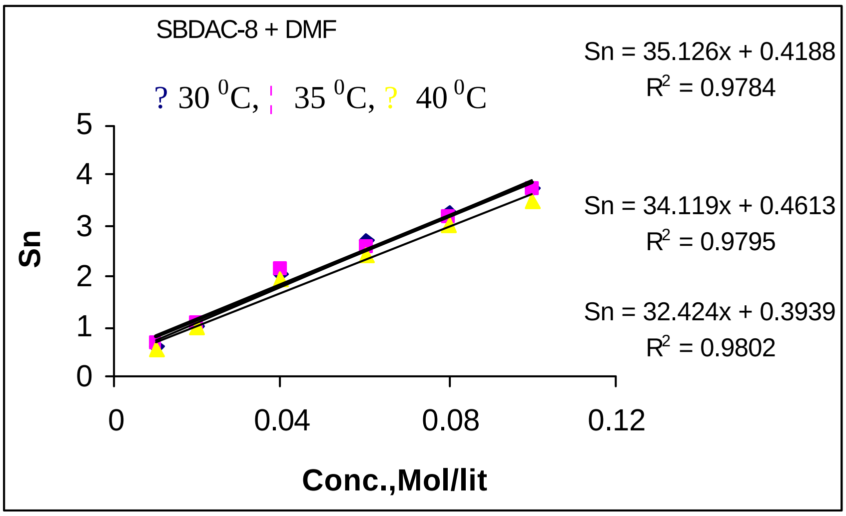

Fig 5.111:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in dimethylformamide .

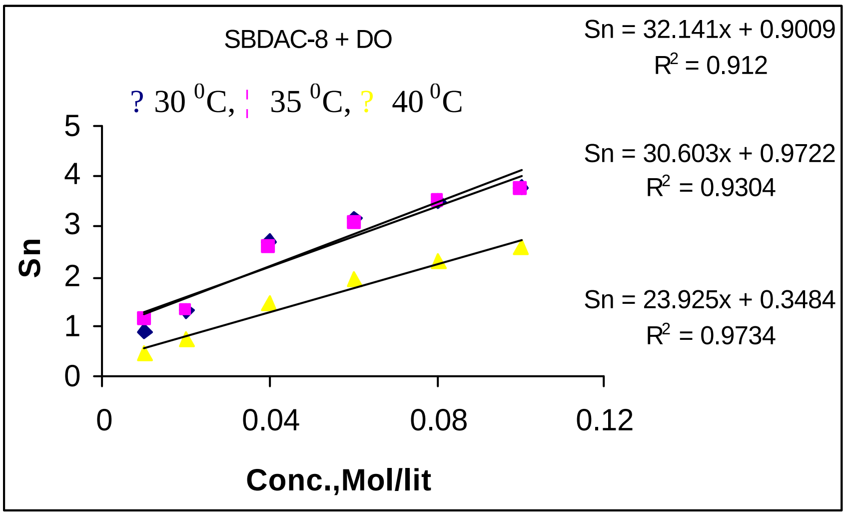

Fig 5.112: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-8 in dioxane.

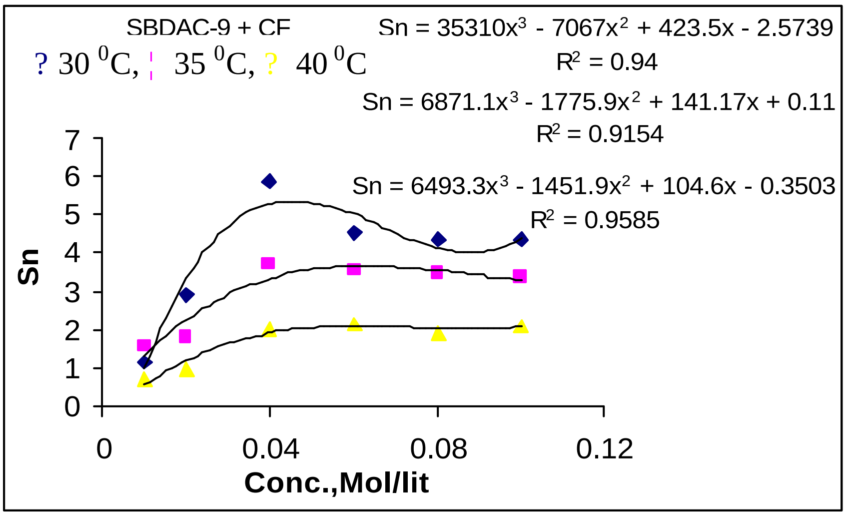

Fig 5.113: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-9 in chloroform.

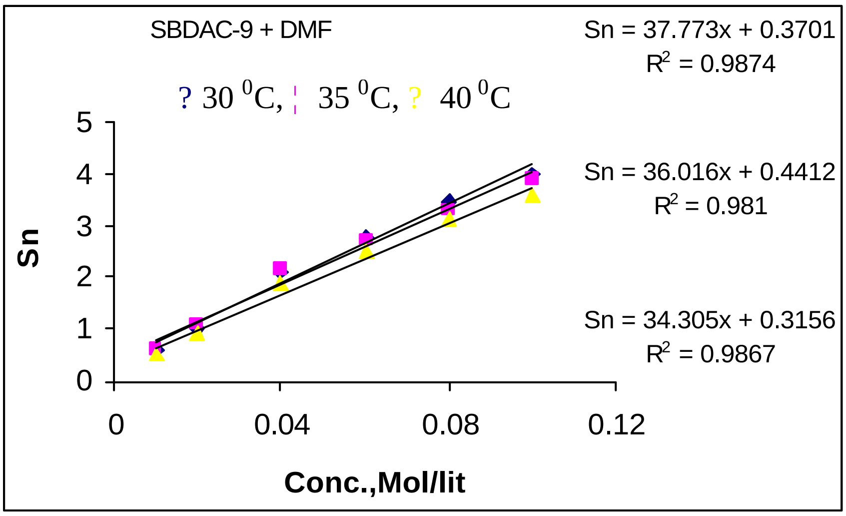

Fig 5.114: The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-9 in dimethylformamide .

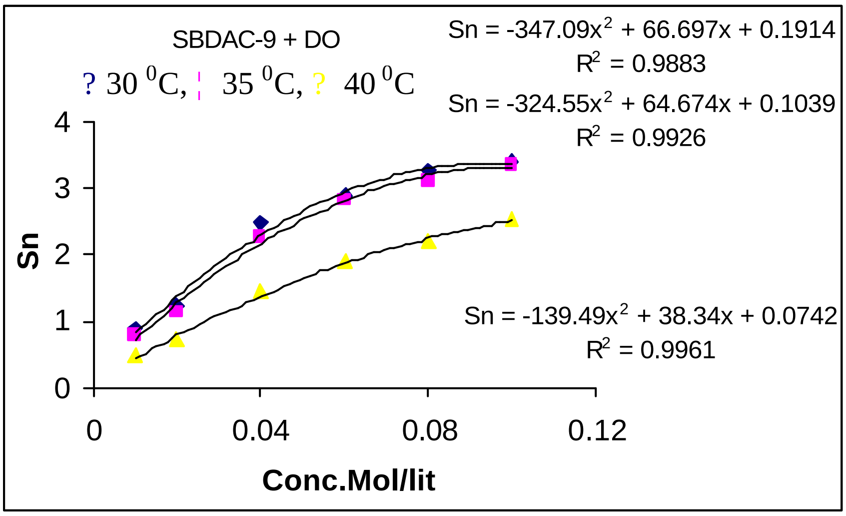

Fig 5.115:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-9 in dioxane.

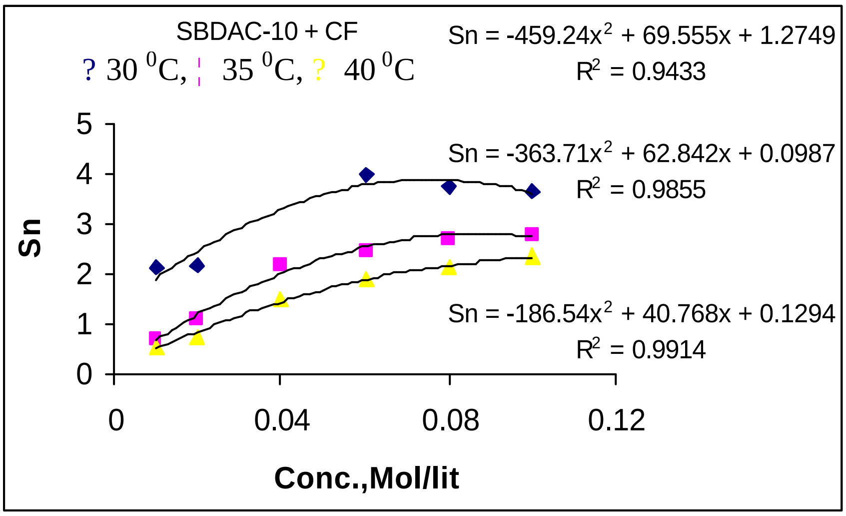

Fig 5.116:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in chloform.

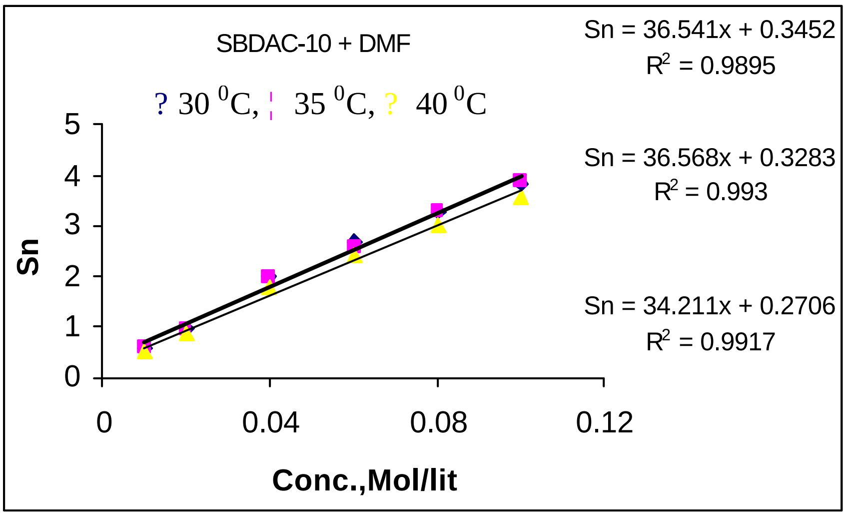

Fig 5.117:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in dimethylformamide .

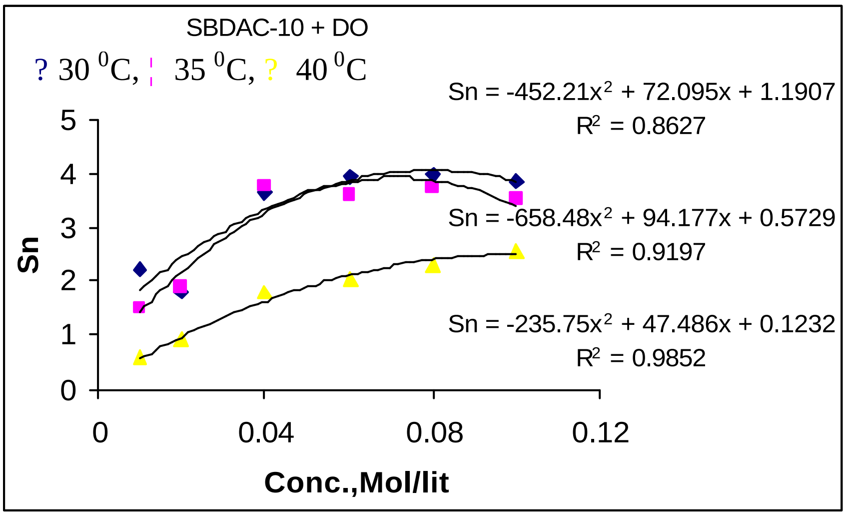

Fig 5.118:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-10 in dioxane.

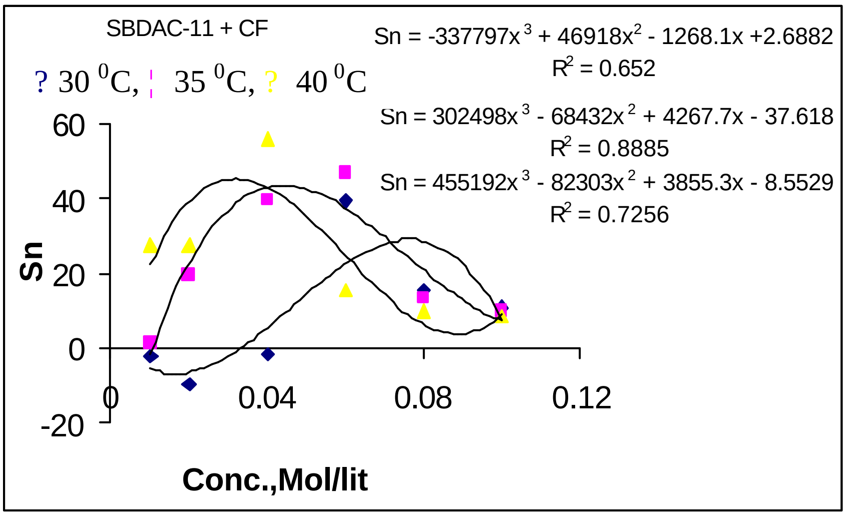

Fig 5.119:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in chloroform.

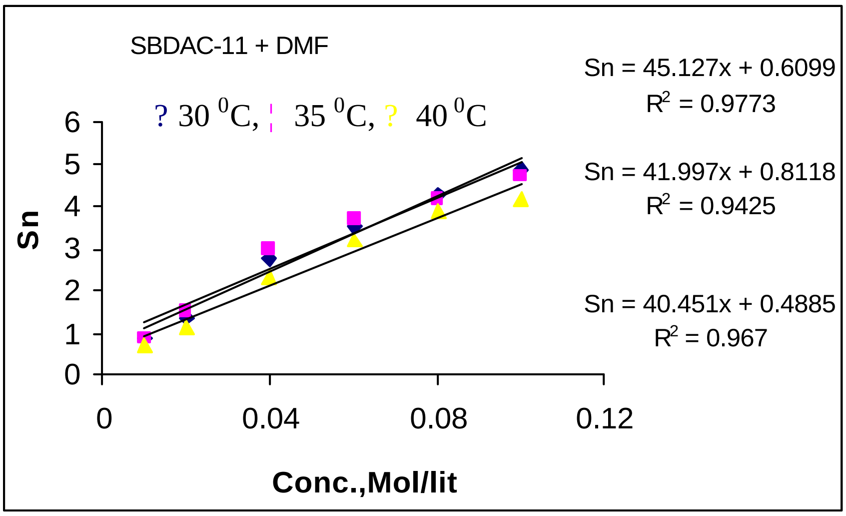

Fig 5.120:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in dimethylformamide .

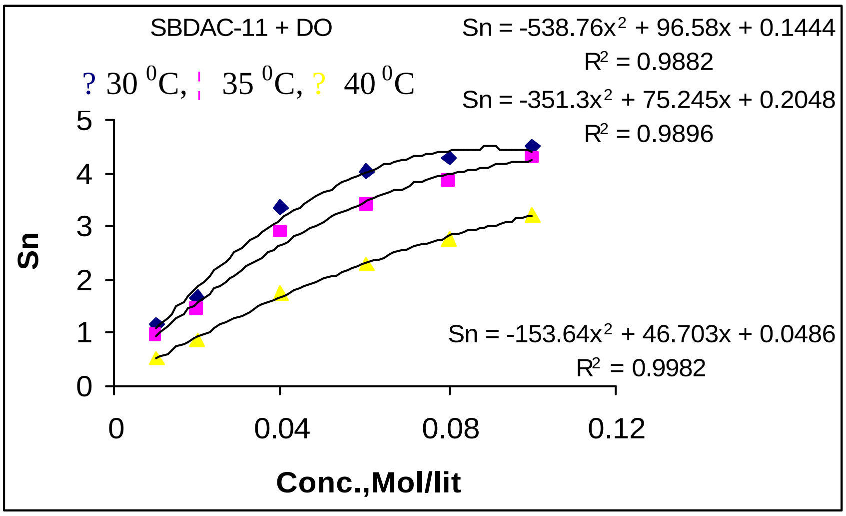

Fig 5.121:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-11 in dioxane.

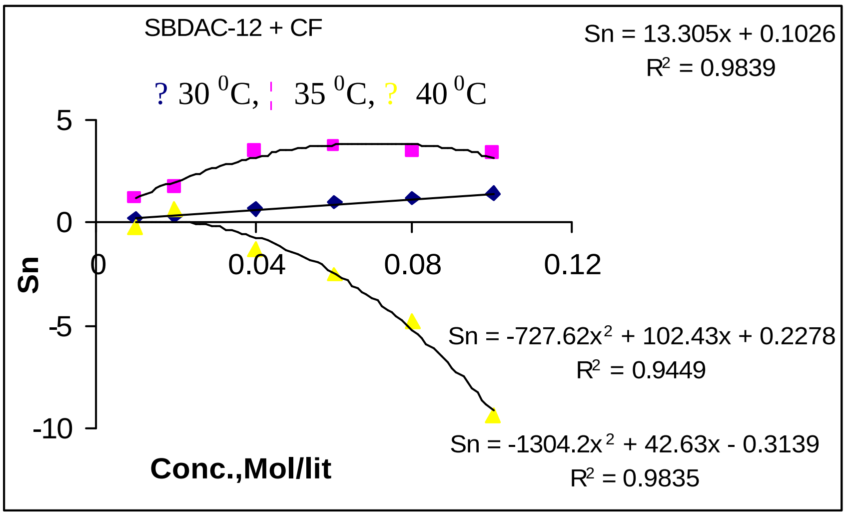

Fig 5.122:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC- in chloroform.

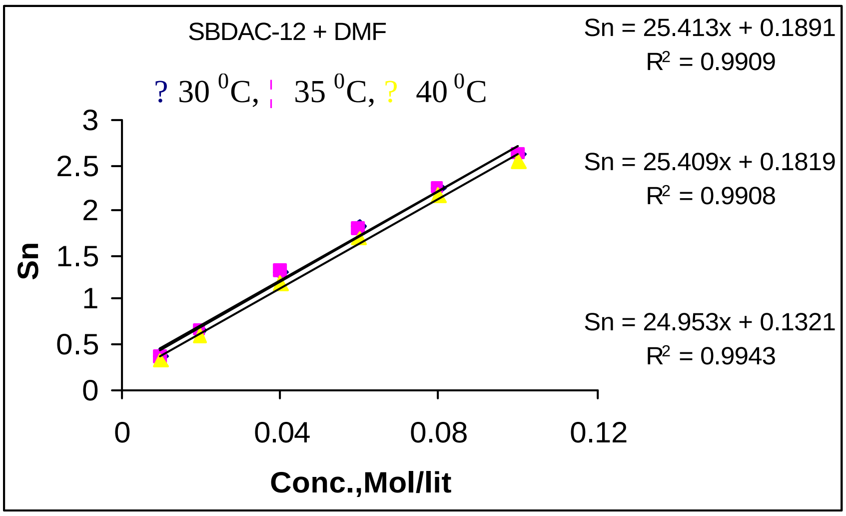

Fig 5.123:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-12 in dimethylformamide .

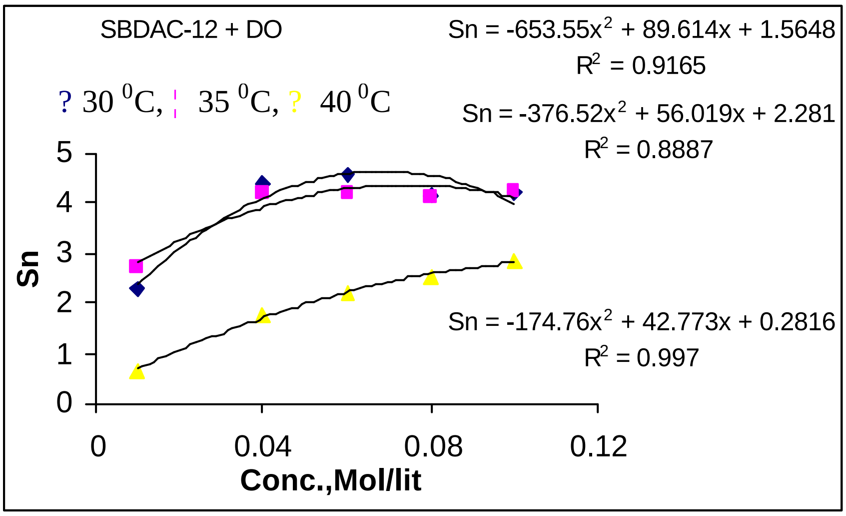

Fig 5.124:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-12 in dioxane.

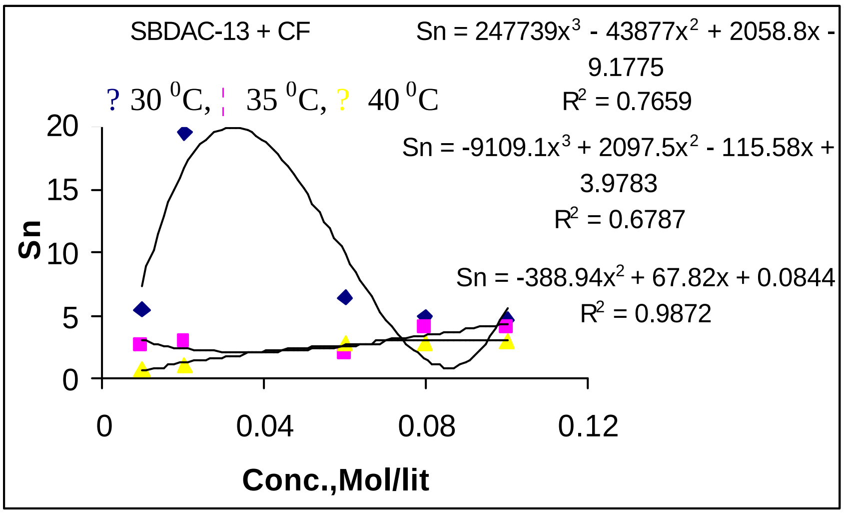

Fig 5.125:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in chloroform.

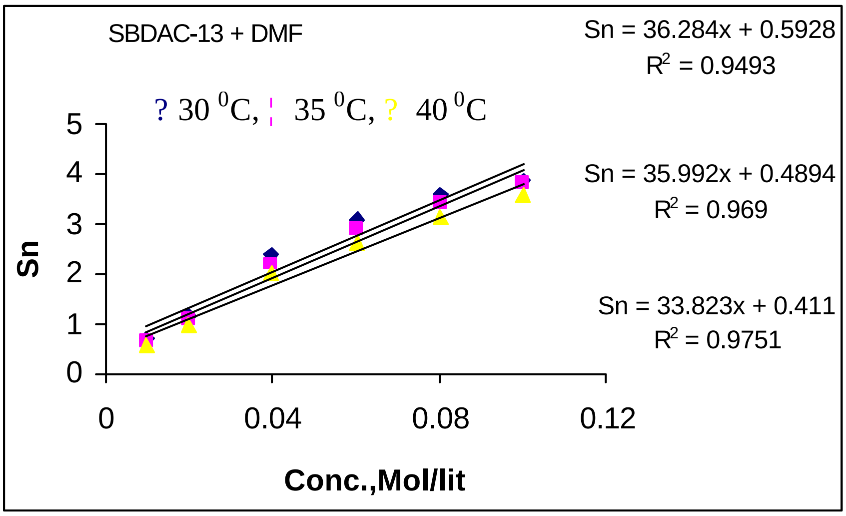

Fig 5.126:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in dimethylformamide .

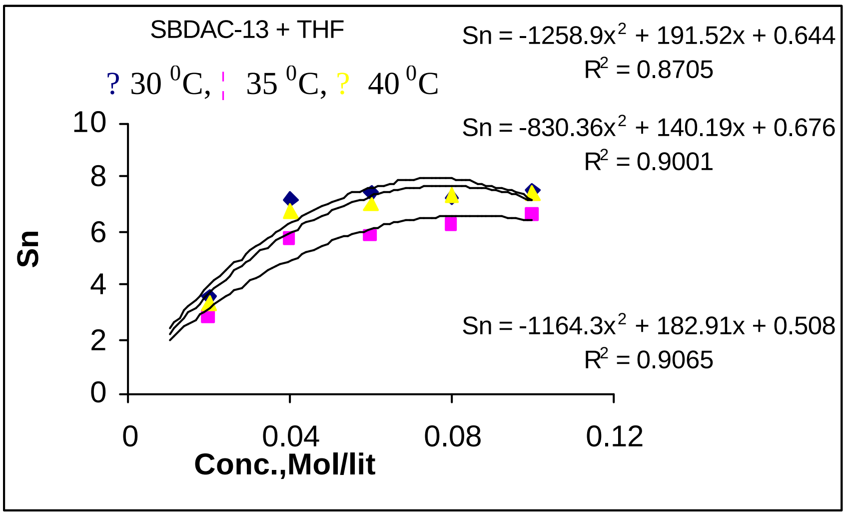

Fig 5.127:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-13 in tetrahydrofuran.

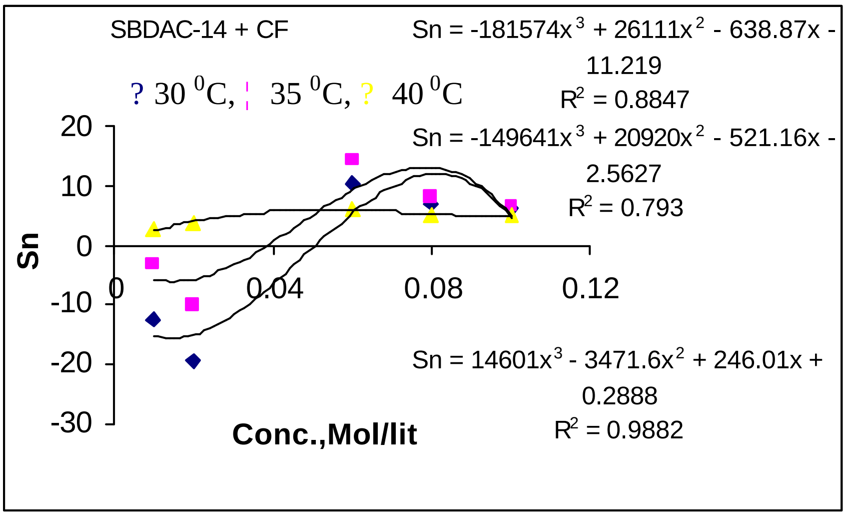

Fig 5.128:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in chloroform.

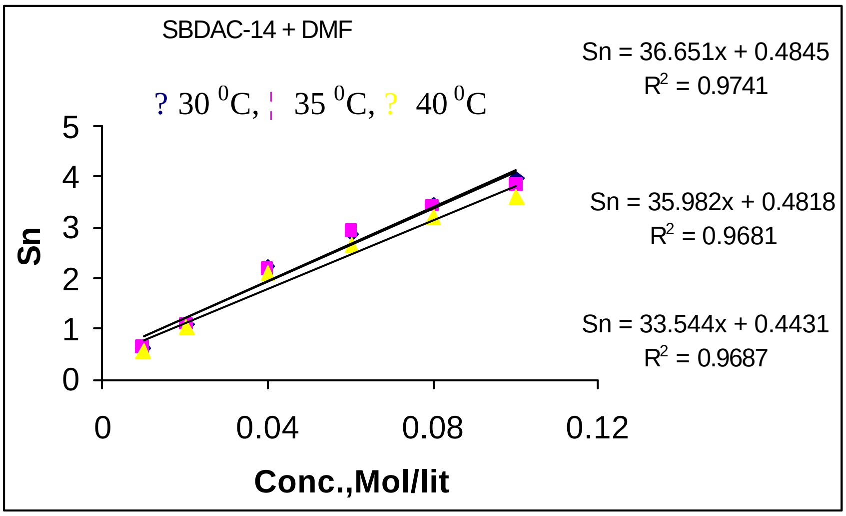

Fig 5.129:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-14 in dimethylformamide .

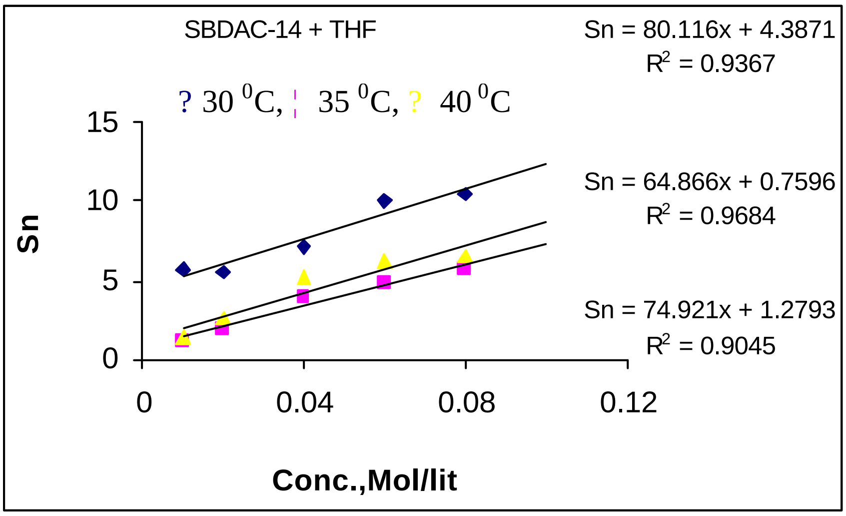

Fig 5.130:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-14 in tetrahydrofuran.

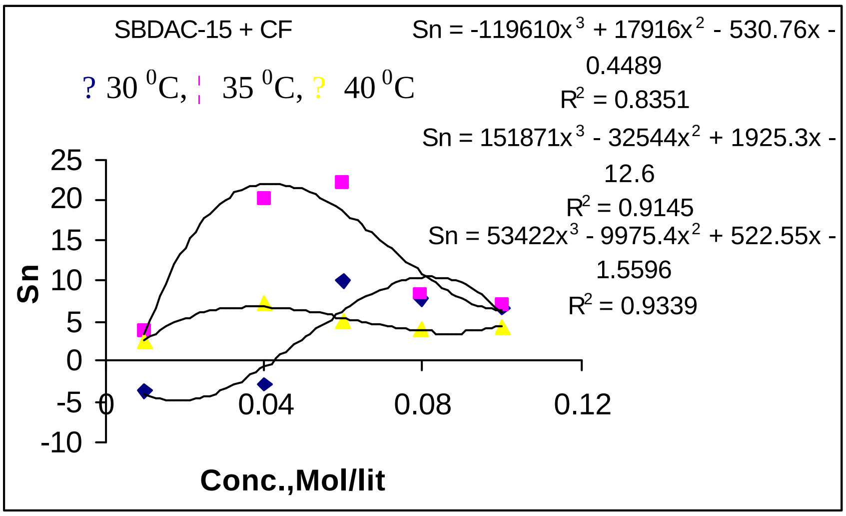

Fig 5.131:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in chloroform.

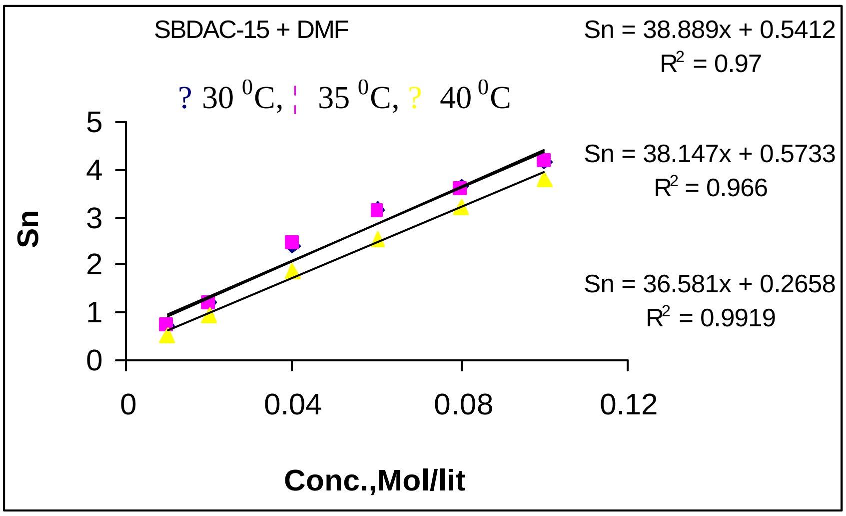

Fig 5.132:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^{0}C for SBDAC-15 in dimethylformamide .

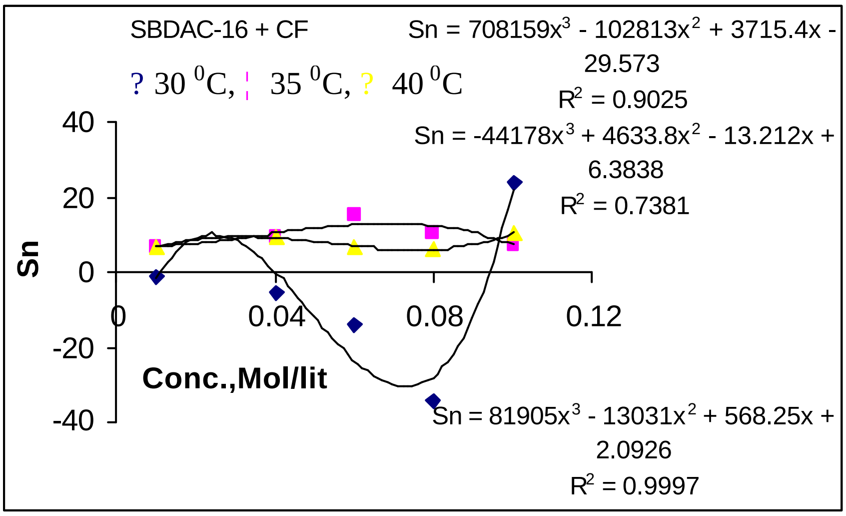

Fig 5.133:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-16 in chloroform.

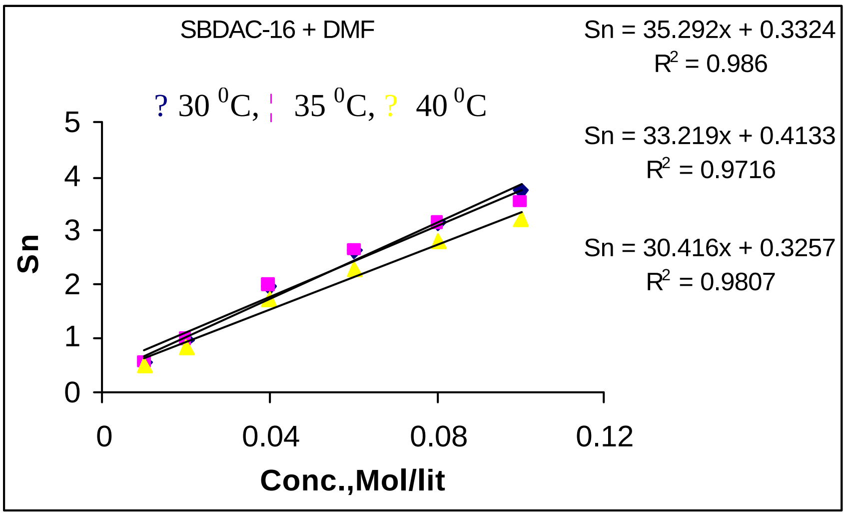

Fig 5.134:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-16 in dimethylformamide .

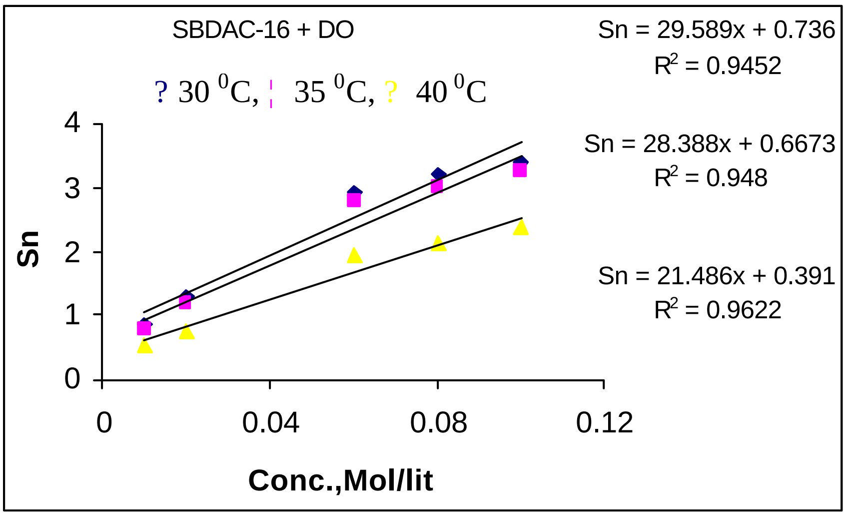

Fig 5.135:The plots of solvation number (S_n) against concentration at 30^0, 35^0,and 40^0C for SBDAC-16 in dioxane.

CHAPTER -6

A COMPREHENSIVE SUMMARY OF THE WORK

CHAPTER -6

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OF
THE WORK

CHAPTER- 6

COMPREHENSIVE SUMMARY

This chapter of the thesis deals with brief summary of the work incorporated in the thesis.

CHAPTER-1

This chapter describes the general introduction and up to date literature survey on synthesis, characterization and applications of diamines and schiff bases.

CHAPTER-2

This chapter deals with the synthesis (classical and microwave irradiated method) and reaction mechanisms of DAC and schiff bases. The purity of schiff bases is checked by TLC in appropriate solvent system. Microwave irradiation technique yielded high yield of the reaction and shorten reaction times to few minutes instead of several hours.

CHAPTER-3

This chapter of the thesis deals with the characterization of DAC and schiff bases by UV, IR , NMR and Mass spectral techniques, density, RI and microbial activity.

UV spectra were taken in two different solvents such as $CHCl_3$ and DMSO and $?_{max}$ of DAC and SBDAC-1 to 16 were determined and compared. The structure of schiff bases are supported by IR, NMR and mass spectral data..

The densities of SBDAC-1 to 16 were determined by specific volume method in benzene and DMF at room temperature and compared. The observed difference in densities is due to solvent – solute interactions, which modified the structure and hence change in densities.

Refractive index measurements were made in benzene and DMF at room temperature and discussed in light of structural aspect.

Microbial activity of SBDAC-1 to 16 was screened against different microorganisms: E.coli., B. mega., B. sub., P. vulgaris and A. niger by cup plate method. It is found that SBDAC-1 to 16 possess moderate antibacterial activity and good antifungal activity in comparison with standard drugs.

CHAPTER-4

This chapter describes kinetics of thermal degradation of some selected schiff bases (SBDAC-3, SBDAC-7, SBDAC-10, SBDAC-14, SBDAC-15 and SBDAC-16). TG thermograms were scanned at the heating rate of 10^0C/min in nitrogen atmosphere over the temperature from 35-800^0C. Schiff bases are thermally stable up to about 200-285^0C and involved two step degradation. IDT, T_{10}, T_{50}, FDT, decomposition range, % weight loss and T_{max} along with kinetic parameters (n, E_a and A) of schiff bases suggested different degradation mechanism.

CHAPTER-5

This chapter describes the acoustical properties of SBDAC-1 to 16 in different solvent at 30^0, 35^0 and 40^0C. Various acoustical parameters are determined and discussed in light of effect of solvent, concentration, temperature and nature of the substituents.

Various acoustical parameters such as isentropic compressibility ($?_S$), specific acoustical impedance (Z), Rao's molar sound function (R), Van der waals constant (b), internal pressure (π), classical absorption coefficient $(a/f^2)_{cl}$, viscous relaxation time (t), solvation number (S_n), free volume (V_f) and inter molecular free length (L_f) were evaluated according to standard equations and correlated with concentration.A good to excellent correlations are found and linear relations are expressed in the form of correlation equations. These parameters are very important for understanding the structure, solute-solvent and solute-solute interactions occurring in a particular system at a constant temperature.

The density decreased linearly with C and decreased with T in CF, while it is increased linearly with C and decreased with T in DMF, DO and THF.

? increased linearly with C and decreased with T in all solvent systems. U increased linearly with C and decreased with T except in DMF where it increased linearly with temperature. Linear increase of ?, ? and U with C indicated increase in cohesion forces due to strong molecular interactions (solute-solvent). Linear decrease in ?, ? and U with C supported decrease in cohesion forces.

It is observed that Z increased with C and decreased with T in CF, DO and THF, but in DMF it increased for SBDAC-2, 4 and 9 and decreased for 5, 8, 11, 12 and 16. $?_s$ decreased linearly with C in all solvent systems and it increased linearly with T in CF, DO and THF system, while it decreased linearly in DMF system.

R and b both increased linearly with C but a little temperature effect is observed in all solvent systems and increased linearly with T except DMF. p and V_f increased linearly or non-linearly with C and T. t increased linearly with C and decreased linearly with T in all solvent systems. $(a/f^2)_{cl}$ increased linearly with C and decreased except SBDAC-2, 7, 8, 15 to 16 in CF.

Linear or non-linear increase or decrease of acoustical parameters with C and T supported existence of strong molecular interactions. Thus, various acoustical parameters suggested the solvophilic nature of schiff bases in solvent-system investigated and it is further supported by positive values of $S_{n.}$ The decrease of S_n with C supported the presence of solute-solvent interactions. Decrease of S_n with T attributed decrease of cohesive forces.

$(a/f^2)_{cl}$, and t are dependent on ?, ? and U at constant temperature, increase of $(a/f^2)_{cl}$, and t with C can be explained in terms of motion of intermolecular forces. A contribution of acoustical relaxation is accounted due to entropy fluctuation associated in solution of dynamically formed physical entity. The presence of polar groups in the solute molecules enhanced molecular interactions.

Thus, the concentration, nature of the solvent and temperature affected the interactions occurring in the solutions. Thus, schiff bases have solvophilic nature and powerful molecular interactions exist in the solutions.

ACHIEVEMENTS

List of papers communicated and presented at conferences/seminars/symposia:

(A) List of papers communicated

1. Synthesis and characterization of high performance poly (4, 4’-cyclohexylidene diphenoxy-4, 4’-diphenylene sulfone)
   R. R. Amrutia and P. H. Parsania, Journal of Polymer Science

2. Synthesis and Physico-Chemical study of Novel Cardo Copoly (ether-sulfone-sulfonates)
   R. R. Amrutia and P. H. Parsania, J. Polym. Mater

3. Effect of temperature on various acoustical parameters of poly (4-cyclohexylidene diphenoxy-4, 4’-diphenylene sulfone) solutions
   R. R. Amrutia and P. H. Parsania, Journal of Chem. Eng. data”

(B) Papers presented at conferences / seminars / symposia / workshop

1. Synthesis and characterization of novel high performance poly (4, 4’-cyclohexylidenediphenyloxy-4, 4’-diphenylene sulfone), R. R. Amrutia and P. H. Parsania, “National Seminar Polymer Research in India – Opportunities and Challenges”- September 25, 2004 at Allahabad

2. Synthesis and characterization of novel high performance poly (4, 4’-cyclohexylidenediphenyloxy-4, 4’-diphenylene sulfone), R. R. Amrutia and P. H. Parsania, “4th International Conference on Polymers for advanced technologies-MACRO-2004”-December 14-17, 2004 at Thiruvananthapuram

3. Synthesis and Physico-Chemical study of Novel Cardo Copoly (ether-sulfone-sulfonates), R. R. Amrutia and P. H. Parsania, “National Seminar on Polymers, Surfactants and Gels” March 11-13, 2005 at Vadodara