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Research Article

Silicone Softener Synthesis and Application on Knit and Woven White Cotton Fabrics

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Abstract

Silicone Softener have wide spread applications in textile dyeing and finishing. In this paper three different samples of Silicone Softener softeners were synthesized on the basis of a new recipe with different chemical ratio and each of them have been used on knit and woven cotton white fabrics. Several tests have been done on Silicone Softener like ionic surfactant test, solid content test, stability test etc. Although, several tests were done on the Silicone Softener treated knit and woven white cotton fabrics e.g. fabric whiteness test, Tensile strength test, absorbency test. From these test results, observation and comparison it has come out that, the best silicone softener among the three, increases the fabric softness, flexibility but imparts relatively less absorbency property. It can endow the textiles with soft, fluffy style. Proper stability and durability can reduce the problem of the roller sticky, floating oil. It is colorless and transparent thick liquid and easy to dilute. It has the excellent affinity to all kinds of fabrics including cotton knit fabrics, woven cotton fabrics, jute etc. The overall results come out with great prospect for Silicone Softener "Sample C" in textile finishing.

Keywords: Application; Knit Fabric; Silicone Softener; Synthesis; Woven Fabrics; White Cotton Fabric

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1. Introduction

Silicone Softener is the most important and common chemical in textile processing. Silicone softeners mostly used to get better softness properties on textile fabrics. It improves the abrasion resistance of fabrics, mobility of fibres, tear strength of fabrics, soiling resistance and static protection. It also decreases yarn and fabric tensile strength by reducing fibre cohesion, reduce sewing thread breakage, pilling and flammability[1]. Softener can be classified by (a) Cationic softener (b) Anionic softener (c) Nonionic softener (d) Amphoteric softener and (e) Silicone softener.

Cationic softeners have the best soft handle properties. It is a common application in exhaust methods. Cationic softener usually used in home laundry products. They have the good inherent affinity to all fibres. It is mainly used for color textiles. They have a tendency to yellow in comparison with non-ionic. **Anionic softeners** are used less due to less handle properties than cationic and nonionic. They don't have the affinity to all fibers. They are suitable for padding application not exhaust. It improves good lubrication, strong antistatic effects, good rewetting, good foaming agents etc. because of their anionic groups. **Nonionic softeners** are less used than anionic softeners.

They have good dispersing agent, high lubricity. Nonionic softeners are stable to temperature and high pH conditions. They are generally poor foamers and don't yellow. **Amphoteric softeners** have high antistatic properties. They are very sensitive to skin and they have some ecological problem.

Silicone softener improve the sample to give a silk soft hand, very good lubricity, crease recovery, tear strength, abrasion resistance etc. Silicone softeners are more expensive than fatty softeners. It shows excellent durability and temperature stability[2-4]. Silicones are the most versatile polymer known. This chemical adds value to the fabric by transforming the fabric handle to match the customer perception. Silicones are the organo metallic polymers derived from the abundant raw material on earth, sand. Silicone is a generic term that refers to a class of manmade polymers based on a frame work of alternating silicon and oxygen (Siloxane Bonds) with organic substituents attached to the silicon. Methyl groups are the most important organic substituents used in the commercial silicones. The Vast majority of which are Poly dimethyl Siloxanes. The following table shows the silicone modification with different chemical compound and their derived properties (*Table 1*).

Table 1 Silicone Modifications

SILICONE MODIFICATIONS	PROPERTIES DERIVED
Amino Group	Highly exhaustible and durable softness
Hydrophilic Group	Water adsorptive
Methyl Group	Water repellence and antistatic finish
Hydrogen Group	Water repellence and soil resistance
Other Organo modifications	Drapery and wrinkle recovery property.

Their distinctive chemistry imparts a range of characteristics. A variety of silicone technologies have application in the textile industry. They include, Polydimethylsiloxanes, Amido, Amino Functional Silicones, Methyl Hydrogen Silicones, Epoxy Functional Silicones, Hydroxy functional Silicones, Silicone Polyethers and Epoxy Polyether

Silicones[5].

Silicone softener has great influence on increasing the soft hand feel of cotton fabrics, silicone softener finishing in general imparts water repellent property to the textiles. Such water repellency is provided by methyl groups which are oriented and attached to the fibre surface by silicone links[6]. Creasing of the cotton fabrics depends on the structural properties of the fibres. Crease resistance is obtained by easy care finishing which stiffens the cotton fibres by covalent cross-linking and there for resistance to bending, creasing and recovery from deforming can be promoted[7]. The process mainly consist of crosslinking of the cotton fibre hydroxyl groups with a crosslinking agent; the possibility of displacement of fibre chain molecules decreases. It has been demonstrated that the degree of crosslinking has a profound effect on the crease recovery angle and dimensional stability of cotton fabric[8].

Silicone oils plays a very significant role in textile finishing. Many important requirements like increasing the softness, hydrophobicity, whiteness, fastness and many other requirements coming from buyer could be served by applying the appropriate silicone softener. For aiming to achieve different properties on fabric different softener has been synthesized. The development of silicone softener is still going on.

2. Experimental

2.1 Materials

2.1.1 Chemicals. The polymerization was conducted with, DMC (Dimethyl Cyclo Siloxane), KH-6O_2 (N-(2-Aminoethyl) (3-aminopropyl) methyldimethoxysilane), $C_8H_{18}OSi_2$ (1, 3-Dimethyl-1, 1, 3, 3-tetra methyl disiloxane) and KOH (Potassium Hydroxide).

2.1.2 Fabrics. The synthesized silicone softener was applied on White Cotton Fabric of Knitted (Single jersey) and Woven (Plain fabric) Fabric.

2.2 Methods

2.2.1 Process of Manufacturing of Silicone Softener

Table 2 **Applied Recipe for producing Silicone Softener**

	Sample A	**Sample B**	**Sample C**
Chemical Ratio	DMC: KH-6O_2: $C_8H_{18}OSi_2$: KOH = 500: (10-50): (2-10): 0.05	DMC: KH-6O_2: $C_8H_{18}OSi_2$: KOH = 500: (10-50): (2-10): 0.05	DMC: KH-6O_2: $C_8H_{18}OSi_2$: KOH = 500: (10-50): (2-10): 0.05
Actual Amount	DMC = 500 ml, KH-6O_2 = 10 ml, $C_8H_{18}OSi_2$ = 2 ml, KOH = 0.05 gm.	DMC = 500 ml, KH-6O_2 = 25 ml, $C_8H_{18}OSi_2$ = 4 ml, KOH = 0.05 gm.	DMC = 500 ml, KH-6O_2 = 50 ml, $C_8H_{18}OSi_2$ = 10 ml, KOH = 0.05 gm.

2.2.2 Procedure. At first, materials were putted (DMC + KH-6O_2) into a three necked flask. Then it was stirred and

heated up to 90 ℃ - 95 ℃ and kept the temperature fixed for 1 hour. After 1 hour $C_8H_{18}OSi_2$ was added into the flask and continued for 10 min. After that the temperature raised to 110 ℃ and catalyst KOH was added. This temperature was maintained for 3-4 hours. Then the temperature reduced to 60 ℃ -70 ℃. Then the micro molecular under the vacuum meter condition was cleaned before the temperature raised to 120 ℃.

2.2.3 Emulsification. Silicone Softener and emulsifier mixed at 500 rpm for 5 minutes. Then added little amount of water (3-5 ml) into it and mixed for 10 minutes. Then added more water (8-10 ml). After that 1 gm. of acetic acid was added and stirred for 20 min. Again more water was added (8-10 ml) and stirred for 3 min. At last the rest of the water and acid were added.

2.3 Testing Procedure

2.3.1 Solid Content Test of Silicone Softener

Table 3 **Solid content calculation of prepared each samples of Silicone Softener**

Sample A	Sample B	Sample C
Paper weight = 1.45gm	Paper weight = 1.45gm	Paper weight = 1.45gm
Weight of Silicone Softener with paper = 6.78gm	Weight of Silicone Softener with paper = 7.97gm	Weight of Silicone Softener with paper = 6.36gm
After 3 hrs. drying weight = 2.56gm	After 3 hrs. drying weight = 2.82gm	After 3 hrs. drying weight = 2.53gm
$= \frac{2.56-1.45}{6.78-1.45} \times 100\%$	$= \frac{2.82-1.45}{7.97-1.45} \times 100\%$	$= \frac{2.53-1.45}{6.36-1.45} \times 100\%$
= 20.82%	= 21.01%	= 22%

Table 3 shows that, Silicone Softener C (Sample C), gives the heist solid contents and Silicone Softener (Sample A) gives the lowest percentage of solid content.

2.3.2 Tensile (breaking) Strength Test of Woven White Fabrics. Fabric samples are clamped in the jaws of a tensile tester and pulled apart until they break. Three samples were tested across the warp and the average breaking strength established is expressed in Newtons. BS EN ISO 13934-2 test standard has been followed for measure the tensile properties of fabrics (grab test method).

2.3.3 Fabric whiteness Test. White fabric samples were prepared for each samples of Silicone Softener. The sample fabrics were prepared as weighted 9 -10 gm. The solution of silicone softener was prepared with the ratio of Silicone Softener: Water = 1: 2. The white fabric samples were dipped into the prepared solution of 20g/l (5g solution sample and 245g water) and padded through horizontal padding mangle. Then dried at 105^0C for 5min. and kept for cooling. Before measuring the whiteness of treated fabrics at different temperature, the machine (**WSB - 3A**) was calibrated with black roll and white board & then carefully measured the whiteness at different temperatures of 105^0C, 140^0C, 160^0C & 180^0C. Each sample was tested 8 times and the average value was taken for comparison.

2.3.4 Ionic Surfactant Test of Silicone Softener. During the test procedure the Surfactants and Water ratio was maintained as 10gm: 90gm

1. Anion or Nonionic Test:

10ml Methylene blue, 10ml Chloroform ($CHCl_3$) & 5ml test solution have been taken into the test tube, covered and shook hard. Let the tube standing & layering, observed the color of layer. If the $CHCl_3$ layer turns blue it referred to the test sample is anionic or if the water becomes turbid, milky it referred to the sample is nonionic.

2. Cationic Test:

I) Bromophenol 1ml, test solution 5ml taken and mixed properly. If it turns blue, sky blue or violet or between these, it was referred to Cationic surfactants.

II) 10ml Methylene blue, 10ml Chloroform ($CHCl_3$) was taken and added known drops of anionic surfactants, when the Chloroform ($CHCl_3$) layer turns blue then added 1% density test solution and shook and dropped; if the Chloroform ($CHCl_3$) layer turns to colorless or weak to the test solution then it was referred as Cationic surfactants.

2.3.5 Stability Test of Silicone Softener.

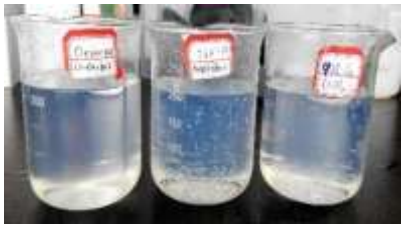
1. Thermal stability: For thermal stability test, the solution has been made as 20g/l of Silicone Softener. The prepared solution was observed under different temperature and the change in appearance was observed (*Table* **4**).

Table 4 **Experimental samples of Silicone Softener for Thermal Stability Test**

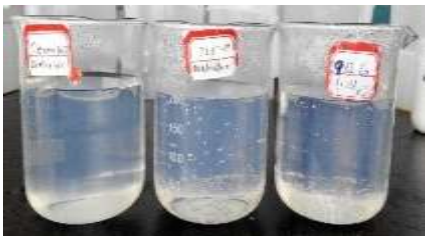
Normal Temperature

50°C

60°C



70°C



80°C

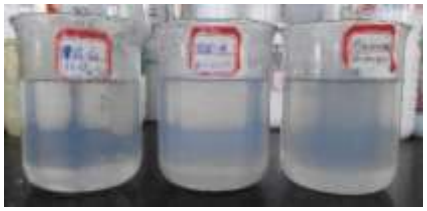
90°C

2. Alkali stability: For Alkali stability test, the solution has been made as 20g/l of Silicone Softener, 30% NaOH-0.8g and pH= (±1)12. The prepared solution was observed under different temperature and the change in appearance was observed (*Table 5*).

Table 5 **Experimental samples of Silicone Softener for Alkali Stability Test**

Normal Temperature

50°C



60°C

70°C

80°C

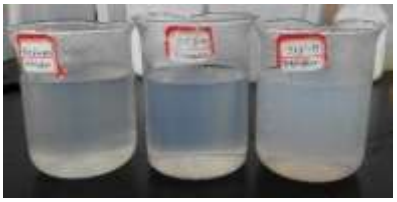
90°C

3. Dielectric stability: For thermal stability test, the solution has been made as 20g/l of Silicone Softener, 5g/l of Na2SO4 anhydrous. The prepared solution was observed under different temperature and the change in appearance was observed (*Table 6*).

Table 6 **Experimental samples of Silicone Softener for Dielectric Stability Test**

Normal Temperature

50°C



60°C

70°C

80°C

90°C

3. Result and Discussion

3.1 Ionic Surfactant Test of Silicone Softener

Table 7 **Ionic Surfactant Test of Silicone Softener**

Samples	Silicone Softener A	Silicone Softener B	Silicone Softener C
Particles	Weakly cationic	Weakly cationic	Weakly cationic

Table 7 shows that after anionic, nonionic and cationic tests, all samples have been found weakly cationic in nature. Due to its Chloroform ($CHCl_3$) layer, it turns to colorless.

3.2 Fabric whiteness Test

Table 8 **Whiteness Measurement of Silicone Softener Treated Samples of Knit and Woven Fabrics.**

Silicone Softener Samples	**105^{0}C ×5min.**	**140^{0}C ×1min**	**160^{0}C ×1min**	**180^{0}C ×1min**
Sample A	89.2	89.1	89	85.5
Sample B	89.4	89.1	89	87.9
Sample C	89.3	89.1	89	89

Table 8 shows that, at 105^{o}C, 140^{o}C and 160^{o}C all the samples of silicone softener gives almost the same result but at 180^{o}C Silicone Softener C kept the value almost same as before but other two couldn't retain the witness value as before.

3.3 Stability Test of Silicone Softener

3.3.1 Thermal Stability Test

Table 9 **Thermal Stability Test**

Samples	**Room Temp.**	**50^{0}C**	**60^{0}C**	**70^{0}C**	**80^{0}C**	**90^{0}C**
Sample A	No change	No change	No change	No change	No change	No change
Sample B	No change	No change	No change	No change	No change	No change
Sample C	No change	No change	No change	No change	No change	No change

Note: Each time the temperature has been raised to the next temperature level, after 5 minutes interval and the observation was done within this 5 minutes.

3.3.2 Alkali Stability Test

Table 10 Alkali Stability Test

Samples	Room Temp.	50^{0}C	60^{0}C	70^{0}C	80^{0}C	90^{0}C
Sample A	No change	No change	No change	Semi-Transparent	Sediment	Sediment
Sample B	No change	No change	No change	Semi-Transparent	Semi-Transparent	Milky light
Sample C	No change	No change	No change	Semi-Transparent	Semi-Transparent	Milky (sediment-little)

Note: Each time the temperature has been raised to the next temperature level, after 20 minutes interval and the observation was done within this 20 minutes.

3.3.3 Dielectric Stability Test

Table 11 **Dielectric Stability Test**

Samples	Room Temp.	50^{0}C	60^{0}C	70^{0}C	80^{0}C	90^{0}C
Sample A	No change	No change	No change	Transparent	Sediment & semi-transparent	Sediment
Sample B	No change	No change	No change	Transparent	Semi-Transparent	Semi-Transparent
Sample C	No change	No change	No change	Milky	Milky	Milky

Note: Each time the temperature has been raised to the next temperature level, after 20 minutes interval and the observation was done within this 20 minutes.

Above stability test we found that comparatively the sample- Silicone Softener C has the best stability of alkali & dielectric than others sample. So we knew that Silicone Softener C has the best stability.

3.4 Hands Feel Evaluation of Silicone Softener Treated Knit and Woven White Cotton Fabrics

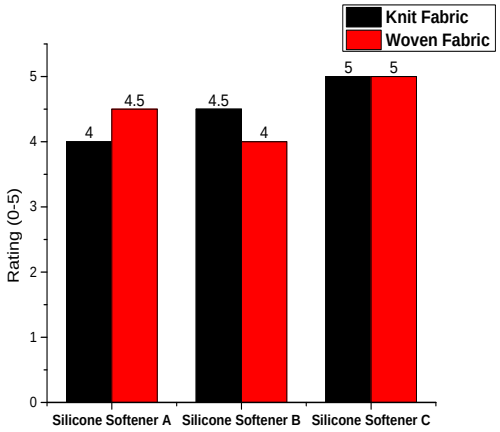


Figure 1 **Column Diagram of Hand Feel Evaluation**

Figure 1 indicates that, hand feel evaluation is high for silicone softener C in both knit and woven white fabrics. So silicone softener C is best among all of softener A and softener B.

3.5 Absorbency Test of Silicone Softener treated Knit and Woven White Cotton Fabrics

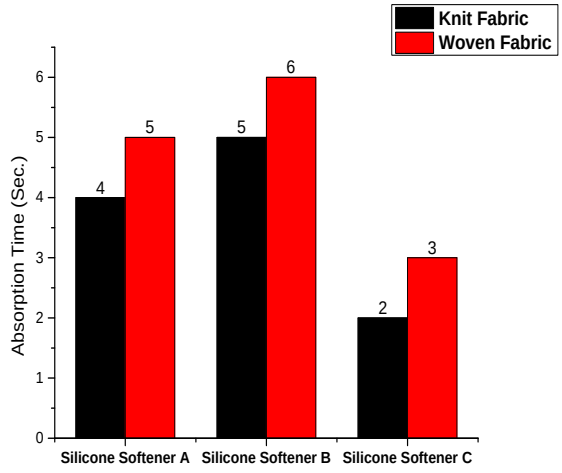


Figure 2 **Column Diagram of Absorbency Test**

Here, *Figure 2* shows that, the absorption time is less for silicone softener C in both knit and woven white cotton fabrics and it indicates that fabric samples treated with silicone softener C imparts hydro phobic properties in the fabric, cause greater time to absorb water.

3.6 Tensile Strength Woven White Cotton Fabrics

Table 12 Tensile Strength Result of Woven White Cotton Fabric

Particulars	Silicone Softener A	Silicone Softener B	Silicone Softener C
Strength (N)	380	417	479
Elongation (mm)	7.6	8.6	8.6

From *Table 12* it is clearly visible that woven fabric treated with Silicone Softener Sample C, gives the highest Tensile Strength (479N) with highest Elongation (8.6 mm).

4. Conclusions

This paper contains two parts, one part contains, synthesis of the silicone softener and evaluation of those three Silicone Softener samples and in the second part evaluation was done on the effect of those silicone softeners on Woven and Knit White Cotton fabrics.

By evaluating the properties of three different samples of silicone softener, it has come out that in most of the case Silicone Softener C (Sample C) gives the best result. In case of Ionic surfactant test and thermal stability all of the samples of silicone softener gives the same result. In case of alkali stability and dielectric stability Sample C gives comparatively best output.

On the other hand, during evaluating the effect of Silicone softener on knit and woven white cotton fabric, it has come out that Sample C gives the best results like, the best hand feel property, good tensile strength (479 N) and elongation (8.6 mm) comparing to other silicone softener (Sample A & Sample B) treated fabrics. In case of white ness test Sample C stands with the best value (Whiteness value: 89, 180^{O}C×1min.). In case of absorbency test silicone softener C shows a very good hydrophobic property or low absorbency property, which can be count down as imparting one of the good aesthetic properties.

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