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New heterocycles having double characters; as antimicrobial and surface active agents. Part 1: Nonionic compounds from fatty acid isothiocyanate

By **M.S.Amine., A.M.F.Eissa., A.A.El-Sawy., A.F.Shaaban,** and **R.El-Sayed***

Chemistry Department, Faculty of Science, Benha Unviversity, Benha, Egypt.
Refat_elsayed@yahoo.com

RESUMEN

Nuevos heterociclos con dobles caracterísisticas: efectos antimicrobianos y agentes de superficies.

Isocianatos de acidos grasos se utilizaron como material de partida para la síntesis de importantes heterociclos tales como triazoles, oxazoles, thoazoles, benzoxazoles y quinazolinas mediante el tratamiento de los mismos con diferentes tipos de nucleofilos tales como nucleofilos nitrogenados, oxigenados, o azufrados. Los compuestos producidos se trataron con oxido de propileno a diferentes concentraciones molares (n = 3, 5 y 7) para producir nuevos grupos de compuestos no iónicos que tuvieran la doble función de ser compuestos antimicrobianos y agentes de superficie, que se pudieran usar en la fabricación de medicinas, cosméticos, pesticidas o como antibacterianos o antifúngicos. Se determinaron sus propiedades tales como tensión superficial e interfacial, punto de turbidez, altura de espuma, tiempo de mojado, poder de emulsificación y concentración micelar crítica (CMC), asi como sus propiedades antimicrobianas y de degradabilidad.

PALABRAS-CLAVE: Agentes de superficie-Antimicrobianos- Heterociclos- Isocianatos de acidos grasos.

SUMMARY

New heterocycles having double characters; as antimicrobial and surface active agents.

Fatty acids isothiocyanate (1) was used as a starting material to synthesize some important heterocycles such as triazoles, oxazoles, thiazoles, benzoxazoles and quinazolines by treating with different types of nucleophiles such as nitrogen nucleophiles, oxygen nucleophiles, and sulfur nucleophiles. The produced compounds were subjected to propylene oxide in different moles (n = 3, 5 and 7) to produce novel groups of nonionic compounds having the double function as antimicrobial and surface active agents which can be used in the manufacturing of drugs, cosmetics, pesticides or can be used as antibacterial and/or antifungal. The physical properties as surface and interfacial tension, cloud point, foaming height, wetting time, emulsification power and the critical micelle concentration (CMC) were determined, antimicrobial and biodegradability were also determined.

KEY-WORDS: Antimicrobial-Fatty acid isothiocyanate-Heterocycles-Surface active agents

1. INTRODUCTION

The most important category of fatty nonionic surfactants are synthesized by the oxyalkylation (with ethylene oxide and propylene oxide) of organic compounds containing active hydrogene in the presence of a base (Cress, 1987), acid as well as untraditional catalysts (Sally et al., 1995). A large variety of organic fragments having a long chain hydrocarbon(Ovalles et al., 2001), alkylphenol (Barhoum et al., 2001), arylalkyl alcohols (Weibull., 1995), natural sources like rapeseed oil acid methyl ester (Hreezuch., 1995) or hydrocarbon chain have heterocyclic moiety (Hebash et al., 1995). Generally, for compounds acting as nonionic surface active agents two requirements are needed: first of all, the hydrogen containing group present should be active enough to react with alkylene oxide in the presence of the catalysts (base, acid as well as the untraditional one) and secondly, the molecular weight should be suitable to become an amphiphilic molecule with the correct hydrophilic-lipophilic balance.(Eissa, 2002).

In addition, it has been well established that most of heterocyclic moieties are of biological interest (Amin et al., 1998; Albright et al., 1981; Pegiadou-Koemtzopoulou et al 1998). This has encouraged us to synthesize novel groups of nonionic surfactants containing triazole, oxazole, thiazole, bezoxazole and quinazoline derivatives from fatty acids isothiocyanate (myristic, palmitic and stearic) (1a-c) hoping to obtain good surface properties as well as good biological activities which may be useful in the manufacturing of drugs, cosmetics or as an antibacterial and/or antifungal.

2. MATERIALS AND METHOD

The IR Spectrum was measured by Pye-Uncam SP-1000 infrared Spectrophotometer as KBr disk or Nujul mull and ^{1}HNMR was measured on [Varian EM-390] spectrometer operating at 90 MHz in DMSO as a solvent. Tetamethylsilane TMS as an internal reference and chemical shifts were expressed as δ(ppm). The mass spectra were recorded on GC/MS Finnegan-MAT.

2.1. Fatty acid isothiocyanate (1a-c)

To a stirred solution of fatty acid chloride (Gautier, 1995) (0.01mole) in dry acetone (50ml) a solid ammonium thiocyanate (0.01mole) was added. The reaction mixture was stirred for 1h at room

temperature. Ammonium chloride was precipitated during the progress of the reaction, and separated by filtration leaving a clear solution of fatty acid isothiocyanate (1a-c).

2.2. 3-Alkyl-2-phenyl-1,2,4-triazoline-5-thione (2a-c)

A solution of (1a-c) (0.01mole) and phenyl hydrazine (0.01mole) in dry acetone (30ml) was heated under reflux for 1h, concentrated and treated with a proper solvent to give solid crystals of (2a-c). Yield 65%. The IR spectrum of 2a exhibits the following bands in cm^{-1}, νNH at 3310, νC=N at 1630, νC=S at 1380, νC-H aromatic at 3024 and νCH's of alkyl chain in a region (2925-2850). The ^{1}HNMR spectrum of 2b was assigned as the following δ's , at 0.85 (t, 3H,CH_3), 1.1-1.5 (m, 26H, CH_2 in alkyl chain), (7.2-7.5) (m, 5H,ArH) and 7.8 (s, 1H, NH). The mass spectrum of 2c shows ($M^{\cdot+}$-1) at (414,3.6 %) and base peak at (m/z = 57, 100 %).

2.3. 2-Amidoalkyl-2-thiol-1,3-oxazolidine-5-one (3a-c)

To a solution of (1a-c) (0.01mole) in dry acetone, glycine (0.01mole) and few drops of pyridine were added then the reaction mixture refluxed for 3h. When a solid product was precipitated after cooling, filtered off, washed with water and crystallized from a suitable solvent to give (3a-c). Yield 58%. . The IR spectrum of 3a shows the following bands in cm^{-1}ν:NH's at 3372, 3178, νSH at 2069, νCO's at 1740 for cyclic amide and 1645 for aliphatic amide, and νCH's of alkyl chain in a region (2920-2850). The^{1}HNMR spectrum of 3b shows the following signals δ = 0.9 (t, 3H,CH_3), 1,2-1,3 (m, 26H, CH_2 in chain), 5.2 (broad s, 1H, SH) and 5.7 (brs, 1H, NH). The mass spectrum of 3a shows no molecular ion peak but shows ion peak (m/z = 300, 9.9 %) corresponding to ($M^{\cdot+}$- CO_2), and the base peak at (m/z = 59, 100 %).

2.4. N-(o-Carboxyphenyl)-N'-alkanoylthiourea (4a-c)

To a solution of (1a-c) (0.01mole) anthranilic acid (0.01mole) was added. The reaction mixture refluxed for 2h. After cooling a solid product was obtained. It was filtered and crystallized from a suitable solvent to give (4a-c).Yield 75%.The IR spectrum of 4a exhibits νNH's in a region (3430-3230), νCO of acid at 1720 and νCO of amide at 1650, νC=S at 1337 and CH's of alkyl chain in region (2920-2850) cm^{-1}. The ^{1}HNMR spectrum of (4c) shows the following δ' 0.88 (t, 3H, CH_3), (1.2-1.5) (m, 30H, CH_2 of alkyl chain), (6.5-7.2) (m, 4H, ArH), (8.2) (s, 1H, NH) and 9.1 (s, 1H, SH). The mass spectrum of 4a shows the molecular ion peak ($M^{\cdot+}$+1) at (407, 3.14 %) and base peak at (m/z = 306, 100 %).

2.5. 3-Alkanoyl-1,3-quinazolin-2-thione -4-one (5a-c).

A solution of thiourea (4a-c) (0.01mole) in acetic anhydride (50ml) was heated on a water bath for 3h. A solid product was produced during heating. At the end of the reaction period the solid product was filtered off while hot and crystallized from a proper solvent to yield (5a-c). Yield 68%. The IR spectrum of 5c shows a broad band for νNH centered at 3300, νCH's of alkyl chain in the region (2920-2850) cm^{-1}, νCO's at 1706 and 1649, νC=S at 1337, besides the characteristic bands of quinazoline nuclei at (1630-1620), (1580-1570) and (1515-1480) cm^{-1}. The mass spectrum of 5 shows a molecular ion peak at ($M^{\cdot+}$=388, 4.12 %) which fragmented into two distinguishable ion peaks -- one corresponding to the quinazoline nucleus at (m/z = 179, 1.85 %) and the other to the aliphatic part at (m/z = 209.87%). The base peak at (m/z = 87, 100 %).

2.6. Thiocarbomate derivatives (6a-c)

To a solution of (1a-c) (0.01mole) in dry acetone o-aminophenol (0.01mole) was added. The reaction mixture was refluxed for 3h. After cooling a solid product was obtained. Filtration and crystallization from a proper solvent gave solid crystals of the product (6a-c). Yield 62%. The IR spectrum of 6a shows νNH's in a region (3348-3185), νCO at 1664, νC=S at 1299, νC-O-C at 1100 and νCH's of alkyl chain in region (2920- 2850)cm^{-1}. ^{1}HNMR spectrum of 6c shows signals at δ = 0.9 (t, 3H, CH_3), 1.2-1.5 (m, 30H, CH_2 of alkyl chain), (6.8-7.2) (m, 4H, ArH), signals at 8.0, 8.5 and 9.3 (s, 3H, NH). Mass spectrum of 6a shows a molecular ion peak at ($M^{\cdot+}$ = 378, 4.1%) and a base peak at (m/z = 59, 100 %).

2.7. 2-Amidoalkyl-1,3-benzoxazole (7a-c)

Fusion of the thiocarbamate derivatives (6a-c) for 2h, H_2S evolved during the heating. The reaction mixture was left to cool. A solid product was obtained and crystallized from a suitable solvent to produce (7a-c).Yield 72%. The IR spectrum of 7c gave νNH at 3241, νCH's of aliphatic chain in a region (2920-2850), νCO of amide at 1686 and. νC=N at 1580 cm^{-1}

2.8. Synthesis of adduct (8a-c)

To a solution of (1a-c) (0.01mole) in dry acetone thioglycollic acid (0.01mole) was added. The reaction mixture was refluxed for 3h. A solid product was obtained after cooling to give the adduct (8a-c) which was crystallized from a proper solvent. Yield 70%. The IR spectrum of 8a shows the following bands, νNH and νOH's in a region (3370-3170), νCH's of alkyl chain in a region (2920-2850) cm^{-1} , band at 2100

characteristic for the linear structure of this compound, νCO's at 1710, 1610, νC=S at 1320 . The mass spectrum of 8c shows a molecular ion peak at (M^{+}+2 = 419, 4.3 %) and base peak at (m/z = 57, 100 %).

2.9. 3-Alkyanoyl-1,3-thiazolidine-2-thione -4-one (9a-c)

A solution of adduct (8a-c) (0.01mole) in acetic anhydride (30ml) was refluxed for 3h. A solid product was obtained after cooling upon which crystallization from a suitable solvent gave the product (9a-c).Yield 58%.The IR spectrum of 9a shows, νCH's of alkyl chain in the region (2920-2850), νC=S at 1329 and νCO's centered at 1675 cm^{-1}.

2.10. Conversion of the prepared compounds (2a-c to 8a-c) to nonionic surfactants (10a-c to 16a-c)

The term nonionic surfactants refers mainly to polyoxypropylene derivatives, they are usually prepared by the addition of different moles (n) of propylene oxide (n = 3,5,7) to synthesized products (2a-c to 8a-c) at any active hydrogen atoms (OH, NH, SH, COOH) using KOH as a catalyst. The processes were completed as described in (El-Sawy et al., 1990). The accurate amount of propylene oxide taken up and the average degree of propenoxylation (n) was determined from the increased mass of the reaction mixture and confirmed by a spectroscopic tool. The structures of the synthesized nonionic surfactants were confirmed via the IR and ^{1}HNMR spectra. IR spectra after the addition of the propylene oxide, showed two broad bands at 1100 and 950 cm^{-1} . Characteristic for νC-O-C ether linkage of polypropenoxy chain, besides the original bands of the compound and ^{1}HNMR spectra after the addition of propylene oxide, showed that the protons of propenoxy group were assigned as broad multiple signals in the region (3.2-3.7) ppm, in addition to the other protons of the compound.

2.11. Surface active properties

2.11.1. *Surface and interfacial tension*

Surface and interfacial tension were measured using Du-Nouy tensiometer (Findly, 1963) (Kruss,Type 8451),with a 0.1 wt% aqueous solution at room temperature (25 °C)

2.11.2. *Cloud point*

Cloud point was determined by gradually heating a 1.0 wt % solution in a controlled temperature bath and recording the time at which the clear, or nearly clear solutions become definitely turbid. The reproducibility of this temperature was checked by cooling the solutions until they became clear again (Wiel et al., 1963).

2.11.3. *Wetting time*

Wetting time was determined by immersing a sample of cotton fabric in a 1.0 wt % aqueous solution of surfactants (Mauyama et al., 1987).

2.11.4. *Foaming properties*

This was measured according to El-Sawy et al. (1987) In this procedure a 25 ml solution (1.0 wt %) was shaken vigorously for 10 seconds in a 100 ml glass stopper, graduated cylinder, at 25 °C. the solution was allowed to stand for 30 seconds, and the foam height was measured.

2.11.5. *Emulsification stability*

The emulsion was prepared from 10 ml.of a 20 m mol. aqueous solution of surfactant and 5 ml. of toluene at 40 C. The emulsifying property was determined by the time it took for an aqueous volume separating from the emulsion layer to reach 9 ml. counting from the moment of the cession shaking (Takeshi et al., 1970).

2.11.6. *Critical micelle concentration (CMC)*

The critical micelle concentration values for the prepared surfactants were determined by the electrical conductivity method (El-Sukkary et al., 1987).

2.12. Biodegradability

Samples taken daily or more frequently were filtered through Wattmann filter paper number (1) before measuring the surface tension. Surface tension measurements were made periodically each day, on each sample during degradation tests. Biodegradation (Eter et al., 1987) percent (D) for each sample was calculated using the following equation : $D = [(\gamma_t-\gamma_o)\ (\gamma_{bt}-\gamma_o)] \times 100$, where γ_t = surface tension at time t, $_o$ = surface tension at zero time, γ_{bt}= surface tension of the blank experiment at time t (without samples)

2.13. Biological activity

Antimicrobial activity of the prepared compounds was tested via a modification of the cup-plate method (Eissa and Ahmed, 2003). The activity of each of the prepared substances against four micro-rganisms representing gram +ve and –ve

Table I
Surface properties of synthesized compounds

Comp.	n	Surface Tension (dyne/cm) 0.1 %	Interfacial tension (dyne/cm) 0.1 %	Cloud Point °C 1 %	Wetting time (sec.) 0.1 %	Emulsion stability (min.)	Foam height (mm) 1 %	cmcx10^{-3} mole/l
11a	3	31	8.0	57	48	70	No foam	4.9
	5	33	9.5	70	30	72	109	4.7
	7	35	10.5	78	23	63	122	4.3
11b	3	32	8.5	55	52	80	No foam	4.5
	5	35	10.0	68	33	73	112	4.2
	7	38	11.5	77	25	64	125	3.8
11c	3	33	8.5	54	55	83	90	3.9
	5	37	11.0	66	36	75	118	3.7
	7	39	13.0	75	27	65	130	3.4
12a	3	31	9.0	79	42	111	144	5.1
	5	33	11.5	95	29	87	164	4.8
	7	37	13.0	> 100	21	82	191	4.6
12b	3	33	9.5	73	44	115	145	4.9
	5	35	12.0	87	35	91	170	4.6
	7	37	14.5	98	21	86	195	4.4
12c	3	35	10.0	71	49	120	150	4.7
	5	36	13.0	82	37	95	181	4.5
	7	38	13.5	95	24	89	200	4.2
13a	3	31	9.5	80	41	120	126	3.9
	5	33	10.0	98	35	93	151	3.7
	7	34	11.5	> 100	24	74	195	3.4
13b	3	32	10.0	75	46	125	133	3.6
	5	35	11.0	86	38	96	162	3.3
	7	37	12.5	99	29	76	198	3.0
13c	3	33	10.5	63	51	130	142	3.4
	5	37	12.0	75	41	98	168	3.1
	7	39	13.5	96	32	77	200	2.9
14a	3	30	8.0	66	47	115	No foam	4.7
	5	31	10.5	71	36	93	105	4.3
	7	34	12.0	95	20	73	123	4.0
14b	3	31	8.5	58	49	118	97	4.5
	5	33	11.0	66	38	95	115	4.2
	7	37	12.5	93	26	76	145	3.8
14c	3	32	9.0	55	53	120	117	4.3
	5	36	11.5	61	41	92	136	3.9
	7	39	14.0	81	29	80	150	3.6
15a	3	33	8.0	82	41	112	138	4.2
	5	35	9.0	94	31	82	158	4.0
	7	37	11.5	>100	17	73	189	3.8
15b	3	34	8.5	75	44	116	145	4.0
	5	36	9.5	87	35	85	165	3.8
	7	39	12.5	95	24	76	196	3.6
15c	3	35	8.5	67	48	120	157	3.8
	5	38	10.5	83	38	90	176	3.6
	7	41	13.0	94	27	80	210	3.4
16a	3	31	7.5	66	42	94	No foam	4.9
	5	32	9.5	80	30	86	99	4.6
	7	35	10.0	93	22	76	138	4.3
16b	3	37	8.0	59	44	96	97	4.7
	5	34	10.0	77	33	88	125	4.4
	7	32	11.5	86	25	78	164	4.1
16c	3	33	8.5	53	47	99	112	4.5
	5	37	11.5	72	36	90	142	4.2
	7	40	13.0	83	28	80	176	4.5
17a	3	30	7.5	76	43	106	115	5.2
	5	32	9.0	95	31	96	130	4.6
	7	34	10.5	> 100	20	75	160	4.7
17b	3	32	8.0	73	45	108	122	5.0
	5	34	9.5	92	33	97	156	4.7
	7	36	11.0	99	23	77	187	4.5
17c	3	34	8.5	70	47	110	128	4.3
	5	36	10.5	89	36	98	174	4.5
	7	38	11.5	97	25	80	192	4.8

Error of measurements was:
Surface and interfacial tensions = ± 0.1 dynes/cm.
Cloud point = ± 1 °C
Foam height = ± 2 mm
Wetting time = ± 1 sec
Emulsion = ± 1 min

bacteria, fungus and yeast (Bacillus cercus, Bacillus circulans, Asperigllus niger and Penicillum notation; respectively) was first investigated. The activity of the test substances at different concentrations towards any test organism was expressed as follows:

at concentration of 200 ppm +++
at concentration of 400 ppm ++
at concentration of 1000 ppm +

If no activity was noticed with a solution of 2000 γ/ml concentration, the substance was considered inactive and this inactivity was expressed with (-).

3. RESULTS AND DISCUSSION

Nonionic surfactants find diverse applications, both in industry and in the home. Their moderate foaming and good detergency are employed in a variety of ways in the leather industry (Eissa and Ahmed, 2003). It is used to accelerate soaking, and liming is improved by the addition of wetting agents (Rosen, 1989). In addition, nonionic surfactants are used extensively because of their good detergency, easy rinsing and low foaming in the cleaning of milk and beer bottles. The surface active and related properties of the synthesized compounds including, surface and interfacial tension, cloud point, wetting time, foaming, emulsification properties and (CMC) are given in (Table I).The biodegradability and biological activities were investigated as shown in (Tables II, III).

3.1. Surface active properties

3.1.1. *Surface and interfacial tension*

Nonionic surfactants with heterocyclic moiety, record lower values than those prepared from saturated fatty acids, which might be attributed to increasing the hydrophilicity of the molecules (El-Dougdoug et al., 1987). On the other hand, the surface activity is improved by introducing a heterocyclic nucleus in the molecules. In general, these value increase as the mass of the hydrophilic groups increase within the range under study and as the alkyl chain length increase.

3.1.2. *Cloud point*

The results indicated that the values of cloud point increase by increasing the number of propylene oxide units and decreases in the presence of an aromatic ring.

3.1.3. Wetting time

All the synthesized surfactants are efficient wetting agents. It was found that a low propylene oxide content also has the most efficient wetting promoter, and it increases as the alkyl chain length increases.

3.1.4. *Emulsifying properties*

Emulsifying properties increase with a decreasing number of propylene oxide units and increase with an increasing alkyl chain. It is interesting to note that the emulsion stability of the prepared compounds is lower than the corresponding propenoxylated fatty acid which does not contain heterocyclic moiety. These results, might lead to the application of the surfactants of choice in pesticide and cosmetic formulations.

3.1.5. *Foam power*

The foam height of the prepared surfactants increases with increasing propylene oxide unit per molecule of surfactant and the efficiency of surfactants as a foaming agent increases with an increasing alkyl chain length. A low foaming power has an application in the dyeing auxiliary industry (Somaya et al., 1987).

3.1.6. *Critical micelle concentration CMC*

CMC increase with an increasing number of propylene oxide unit adducts; it decreases with an increasing number of carbon atom in alkyl chain.

3.2. Biodegradability

The results of biodegradation reflect that, biodegradability decreases by increasing the number of propylene oxide units; or the number of methylene groups in the alkyl chain. This leads to the conclusion that a longer propylene oxide chain makes the diffusion of the molecule through the cell membrane and, therefore degradation, more difficult (Falbe, 1989).

3.3. Biological activity:

From (Table III) it can be noted that the nonionic surfactants, which contain heterocyclic moiety, afforded a double function as surface-active agents and antimicrobial activities (Eissa, 1989). So, all the prepared surfactants were tested for their bacterocidal and antifungal activities. The data of (Table II) show that, the presence of heterocyclic moiety in the prepared nonionic surfactant molecule revealed an increase in the biological activity. It is therefore clear that these surfactants were effective and inhibited the growth of all tested microorganisms.

4. CONCLUSIONS.

From the previous results, it may be concluded that: All the prepared nonionic surfactants have good

Table II
Biodegradability of the Prepared Surfactants

Comp.	n	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
11a	3	59	68	79	84	92	-	-
	5	57	65	74	80	88	96	-
	7	56	61	72	79	85	92	-
11b	3	52	67	76	83	93	-	-
	5	47	63	73	76	86	92	-
	7	45	59	69	74	83	89	96
11c	3	50	62	70	82	93	-	-
	5	45	58	68	75	87	94	-
	7	41	53	66	72	81	86	92
12a	3	63	68	77	83	92	-	-
	5	52	65	76	82	88	97	-
	7	43	57	71	79	85	94	-
12b	3	57	64	73	81	92	97	-
	5	47	59	72	79	87	94	-
	7	40	55	69	78	83	89	96
12c	3	53	62	70	97	86	92	-
	5	47	56	69	72	83	88	-
	7	43	51	76	70	79	83	94
13a	3	53	66	75	85	95	-	-
	5	49	62	72	80	86	96	-
	7	47	59	69	77	83	93	-
13b	3	50	63	71	81	93	-	-
	5	48	59	69	77	80	91	-
	7	45	57	67	74	78	88	96
13c	3	48	60	68	78	89	-	-
	5	45	56	66	73	76	88	-
	7	41	51	64	70	73	85	92
14a	3	53	61	74	83	94	-	-
	5	51	60	67	78	91	-	-
	7	49	57	62	76	88	96	-
14b	3	49	59	70	74	83	-	-
	5	48	52	63	75	87	97	-
	7	45	50	62	74	83	93	-
14c	3	49	55	62	79	87	90	-
	5	46	51	59	67	78	88	-
	7	40	48	57	63	72	85	93
15a	3	53	58	66	80	82	93	-
	5	50	56	63	71	79	86	-
	7	49	54	59	68	65	79	90
15b	3	51	56	63	77	84	95	-
	5	48	54	59	67	79	92	-
	7	45	52	57	63	75	89	-
15c	3	49	54	60	77	80	93	-
	5	48	59	57	65	76	90	-
	7	43	49	54	61	73	86	93
16a	3	55	63	73	82	78	92	-
	5	52	59	70	75	82	88	-
	7	49	54	69	73	79	83	95
16b	3	55	62	71	79	85	93	-
	5	49	57	69	73	83	90	-
	7	47	52	64	71	79	87	92
16c	3	51	60	69	77	84	91	-
	5	48	54	67	70	81	89	-
	7	44	49	65	68	77	85	92
17a	3	57	66	79	89	96	-	-
	5	55	63	73	86	95	-	-
	7	52	59	71	79	88	96	-
17b	3	55	65	77	86	95	-	-
	5	52	58	69	83	91	-	-
	7	49	83	65	74	80	90	-
17c	3	54	63	73	84	95	-	-
	5	48	55	67	79	92	-	-
	7	45	50	61	72	84	93	-

Error of calculations was: Biodegradation rate = ± 0.5 %

Tabla III
Antimicrobial activity of the synthesized nonionic surfactants

Compd.	Bacteria		Fungi	
	Bacillus cercus	*Bacillus circulans*	*Aspergillus's niger*	*Penicillum notation*
11a	-	+	+	+
11b	-	+	++	+
11c	+	+	+	++
12a	-	+	+	+
12b	-	+	++	++
12c	+	+	+	++
13a	+	+	++	+
13b	-	-	+	+
13c	-	-	+	+
14a	-	+	+	++
14b	-	-	+	+
14c	-	-	+	+
15a	-	+	+	++
15b	+	-	+	+
15c	+	-	+	+
16a	-	+	-	++
16b	-	+	+	++
16c	+	-	+	+
17a	+	+	+	++
17b	-	+	++	+
17c	+	+	+	++
9a	+	+	+	++
9b	+	+	++	+++
9c	+	-	+	++

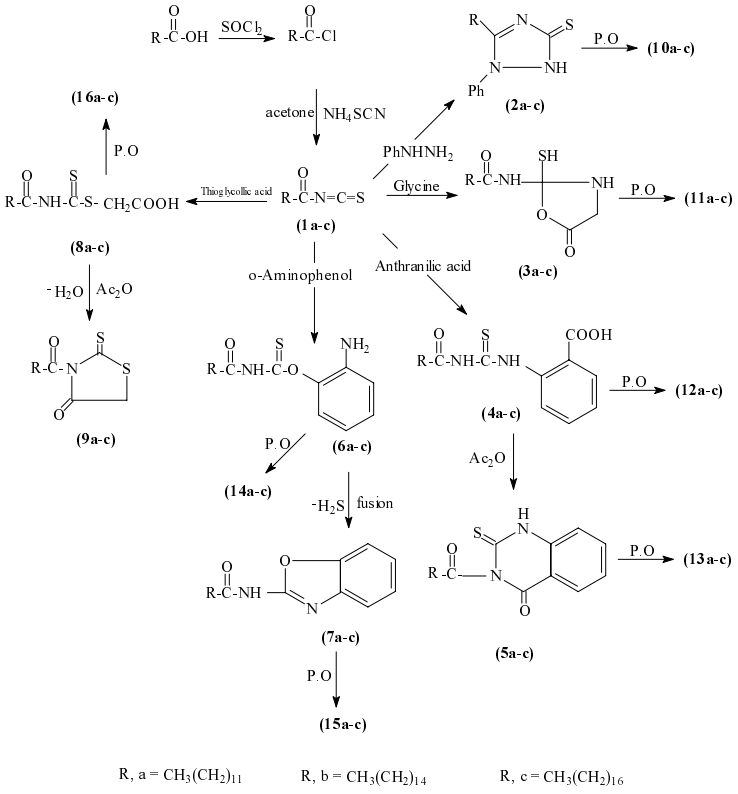

Figure 1
The synthesized compounds from 2a-c to 10a-c are propenoxylated at any active hydrogen (OH, SH, NH and COOH) give propenoxylated products from 11a-c to 17a-c respectively. The sum of moles added (n) = 3, 5 and 7 corresponding to a, b and c respectively.

emulsifiers in a non-edible medium such as insecticidesor pesticides.

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