RESULTS AND
PART (I)

Nonionic surfactants containing heterocyclic moiety from fatty acid isothiocyanate

Various heterocyclic compounds like triazolines, thiazoles, oxazolidines, benzoxazoles, thiazolidines, oxadiazines and triazine are reported to be biologically active \(^{(203-206)}\). This encourage us to synthesis a novel groups of nonionic surfactants containing heterocycles as triazole, oxazole, benzoxazole and thiazole derivatives from low cost long chain fatty acids (myristic, palmitic and stearic) isothiocyanate treated with different nucleophiles as phenyl hydrazine, glycine, anthranilic acid (nitrogen nucleophile), \(\alpha\)-aminophenol (oxygen nucleophile) and thioglycolic acid (sulphur nucleophile) to produce a novel groups of nonionic surfactants having a double function, antimicrobial and surface active agents by the reaction of these compounds with different moles of propylene oxide (3, 5 and 7).

Synthesis of fatty acid isothiocyanate.

Long chain of fatty acids (myristic, palmitic and stearic) isothiocyanate (3a-c) are prepared from its acid chloride (2a-c) (these were prepared from the corresponding straight chain myristic, palmitic and stearic acids (1a-c) and thionyl chloride according to Gautier\(^{(207)}\)) the reaction of these acid chloride with ammonium thiocyanate in dry acetone \(^{(208-212)}\). The produced thiocyanate rearranges spontaneously to the isothiocyanate (3a-c) as the following
The isothiocyanate (3a-c) were prepared in situ during the reaction to prevent its decomposition.

**Synthesis of heterocyclic compounds from fatty acid isothiocyanate**

1-**Synthesis of 1,2,4-triazoliny1-5-thione derivatives via the reaction of isothiocyanate (3a-c) with phenyl hydrazine**

When the solution of isothiocyanate (3a-c) in acetone (prepared in situ) was treated with phenyl hydrazine, a compound with low melting point was separated. The reaction takes place via the addition of phenyl hydrazine to isothiocyanate (3a-c) to give intermediate which undergoes cyclization followed by dehydration to give 3-alkyl-2-phenyl-1,2,4-triazoliny1-5-thione (4a-c).

\[
\text{R.,a = } C_{13}H_{27}, \quad \text{R.,b = } C_{15}H_{31}, \quad \text{R.,c = } C_{17}H_{35}
\]
IR spectrum of (4c) shows bands in cm\(^{-1}\) for \(\nu\)NH at 3229, \(\nu\)C=N at 1600, \(\nu\)C=S at 1390 and \(\nu\)CH\(^{\text{as}}\) of alkyl chain in region (2920-2850) and the characteristic band of triazole ring (213) in region (1520-1450-1410). (cf. fig.1). \(^1\)HNMR spectrum of (4b) was assigned as the following \(\delta \)s at 0.8 (t, 3H, terminal CH\(_3\)), 1.1-1.3 (m, 28H, CH\(_2\) in alkyl chain), (7.0-7.3) (m, 5H, ArH) and 7.8 (s, 1H, NH) which disappeared by addition of \(\text{D}_2\text{O}\). (cf. fig.24). Mass spectrum of (4c) shows \((M^+ - 1)\) at (414, 3.6 %) and base peak at m/z = 57, 100 %. (cf. fig.40. chart 1). 

![Diagram](chart.png)
2-Synthesis of 1,3-oxazolidine derivatives via the reaction of isothiocyanate (3a-c) with glycine.

Glycine reacts with isothiocyanate (3a-c) in the presence of pyridine as a base to produce thiourea derivatives which cyclicized to 2-amidoalkyl-2-thiol-1,3-oxazolidin-5-one (5a-c).

\[
\begin{align*}
\text{O} & \quad \text{R-C-N=C=S} + \text{H}_2\text{NCH}_2\text{COOH} \xrightarrow{\text{pyridine}} \text{O} \\
& \quad \downarrow \\
& \quad \text{R-C-NH-C-NH-CH}_2\text{COOH} \\
& \quad \text{SH} \\
& \quad \text{O} \\
\end{align*}
\]

\[\text{(3a-c)}\]

\[\text{R}_{a} = \text{C}_{13}\text{H}_{27}, \quad \text{R}_{b} = \text{C}_{15}\text{H}_{31}, \quad \text{R}_{c} = \text{C}_{17}\text{H}_{35}\]

\[\text{(5a-c)}\]

IR spectrum of (5a) which shows the following bands in cm\(^{-1}\) for \(\nu\text{NH}^{\text{a}}\) at 3392, 3188, \(\nu\text{SH}\) at 2049, \(\nu\text{C}=\text{O}^{\text{a}}\) at 1780 for cyclic amide and 1643 for aliphatic amide, and \(\nu\text{CH}^{\text{a}}\) of alkyl chain in region (2920-2850). (cf. fig.2).

\(^1\text{H} \text{NMR spectrum of (5b) shows signals at } \delta = 0.8 \text{ (t, 3H, terminal CH}_3\text{), } 1.2-1.3 \text{ (m, 28H, CH}_2\text{ in chain), } 5.4 \text{ (broad s, 1H, SH) and 5.8 (broad s, 1H, NH).}(\text{cf. fig.25}.)\)

Mass spectrum of (5a) shows no molecular ion peak but shows ion peak \(\text{m}/\text{z} = 298, \text{ 9.9 }\% \text{ corresponding to } \text{M}^{+} - \text{CO}_2, \text{ and the base peak m}/\text{z} = 59, 100 \% \text{ corresponding to HSCN group.}(\text{cf. fig.41.chart 2}).\)
Chart 2:  

```
CH₃(CH₂)₁₂-C-NH-O-SH-NH-CH₂⁺
(Unstable molecule)

-44 \[\rightarrow\] -CO₂
SH

CH₃(CH₂)₁₂-C-NH-C-NH=CH₂⁺
m/z = 298, 9.96%

-42 \[\rightarrow\] -CONH
SH

CH₃(CH₂)₁₂-C-NH=CH₂⁺
m/z = 256, 11.25%

-57 \[\rightarrow\] -CH₃(CH₂)

(CH₂)₉-C-NH=CH₂⁺
m/z = 199, 11.25%

-15 \[\rightarrow\] CH₃

(CH₂)₉C=N⁺
m/z = 184, 3.62%

\[(CH₂)₉\]  \[\rightarrow\] HSCN

m/z = 126, 2.58 %  m/z = 59, 100%
```
3-Synthesis of quinazoline-2-thione-4-one derivatives via the reaction of isothiocyanate (3a-c) with anthranilic acid followed by cyclization.

Addition of anthranilic acid to isothiocyanate (3a-c) leads to formation of N-(O-carboxyphenyl)-N'(alkanoyl) thiourea (6a-c).

\[
\begin{align*}
\text{R}, a = C_{13}H_{27}, & \quad \text{R}, b = C_{15}H_{31}, \quad \text{R}, c = C_{17}H_{35} \\
\end{align*}
\]

IR spectrum of (6a) exhibits \(\nu\text{OH}\) of acid and \(\nu\text{NH}^+\) in region (3500-3300), \(\nu\text{C}=\text{O}\) of acid at 1700 and \(\nu\text{C}=\text{O}\) of amide at 1640, \(\nu\text{C}=\text{S}\) at 1340 and \(\text{CH}^+\) of alkyl chain in region (2920-2850) cm\(^{-1}\) (cf. fig.3).

\(^1\text{HNMR}\) spectrum of (6c) shows \(\delta\)' at 0.8 (t, 3H, terminal CH\(_3\)), (1.2-1.5) (m, 32H, CH\(_2\) of alkyl chain), (6.5-7.2) (m, 4H, ArH), (8.8) (s, 1H, NH), 9.3 (s, 1H, SH) and 9.7 (s, 1H, OH). (cf. fig. 26).

Mass spectrum of (6a) shows ion peak (M\(^+\) +1) at (407, 3.14 %) and base peak at m/z = 306, 100 %. (cf. fig.42).
\[ \text{Chart 3} \]
Cyclization of thiourea derivatives (6a-c) with acetic anhydride afforded 3-alkanoyl-1,3-quinazoline-2-thione -4-one (7a-c).

\[
\text{O} \quad \text{R-C-NH-C-NH} \quad \text{COOH} \quad \xrightarrow{\text{Ac}_2\text{O}} \quad \text{R-C-NH-C-NH} \quad \text{N} \quad \text{O} \\
(6a-c) \quad (7a-c)
\]

\[R_{a} = C_{13}H_{27}, \quad R_{b} = C_{13}H_{31}, \quad R_{c} = C_{17}H_{35}\]

IR spectrum of (7c) which shows \(\nu\text{NH} \) at 3340, \(\nu\text{C}=\text{S} \) at 1367, \(\nu\text{C}=\text{O}^{\text{ss}} \) at 1766 and 1689, \(\nu\text{CH}^{\text{ss}} \) of alkyl chain in region (2920-2850) cm\(^{-1}\), beside the characteristic bands\(^{210}\) of quinazoline nuclei at (1630-1620), (1580-1570) and (1515-1480) cm\(^{-1}\).

Mass spectrum of (7a) shows a molecular ion peak at \(M^+ = 388\), 4.12 % which fragment to two ion peaks one corresponding to 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 % (cf. fig. 43, chart 4).
Chart 4
4-Synthesis of 1,3-benzoxazole derivatives via the reaction of o-Aminophenol with isothiocyanate (3a-c) followed by Cyclization.

The isothiocyanate (3a-c) were attacked by the oxygen-atom of o-aminophenol to form the thiocarbamate derivatives (8a-c).

\[
\begin{align*}
\text{O} & \text{C} & \text{N} & \text{C} & \text{S} & + & \text{HO} & \text{NH}_2 & \rightarrow & \text{O} & \text{C} & \text{NH} & \text{C} & \text{O} & \text{S} & \text{NH}_2 \\
& & & & & & & & & & & & & & & & & \text{R.a} = C_{13}H_{27}, & \text{R.b} = C_{15}H_{31}, & \text{R.c} = C_{17}H_{35} \\
(3a-c) & & (8a-c)
\end{align*}
\]

IR spectrum of (8a) shows, νNH\textsuperscript{18} in region (3338,3170), νC=O at 1694, νC=S at 1235, νC-O-C at 1100 and νCl\textsuperscript{18} of alkyl chain in region (2920-2850) cm\textsuperscript{-1}. (cf. fig.4).

\textsuperscript{1}H NMR spectrum of (8c) which shows signals at δ 0.9 (t, 3H, terminal CH\textsubscript{3}), 1.2-1.5 (m, 32H, CH\textsubscript{2} of alkyl chain), 6.9-7.3 (m, 4H, ArH) and signals at 8.0, 8.5 and 9.3 (s, 3H, NH). (cf. fig. 27).

Mass spectrum of (8a) shows a molecular ion peak at M\textsuperscript{+} = 378, 4.1% and base peak at m/z = 59, 100% corresponding to NHCS group. (cf. fig. 44.chart 5)
When the adduct (10a-c) were cyclized by acetic anhydride, the 3-alkanoyl-1,3-thiazolidine-2-thione-4-one (11a-c) were produced.

IR spectrum of (11a) shows νC=S at 1299, νC=O’ centered at 1693 and νCH’ of alkyl chain in region (2920-2850) cm⁻¹ (cf. fig. 6).
Preparation of nonionic surfactants from the synthesized heterocyclic products

The terms of nonionic surfactants refers chiefly to polyoxypropylene derivatives, they are usually prepared by the addition of different moles (n) of propylene oxide \( (n = 3, 5 \text{ and } 7) \) to synthesized products which contain one or more active hydrogen atoms to yield polypropenoxylation products. This reaction is one of the principal processes used to introduce hydrophilic functional groups into an hydrophobic organic moiety.

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 leather industry. It is used to accelerate soaking, and liming is improved by the addition of wetting agents\(^{(215)}\). Also nonionic surfactants are used extensively because of their good detergency, easy rinsing and low foaming in cleaning of milk and beer bottles.

The structures of the synthesized nonionic surfactants were confirmed via IR and \(^1\)HNMR spectra e.g.

IR spectrum of (4a) after the addition of propylene oxide, showed, two broad bands at 1132 cm\(^{-1}\) and 923 cm\(^{-1}\) characteristic for \(\nu\text{C-O-C} \) ether linkage of polypropenoxyl chain, beside the original bands of the compound. (cf.fig. 8).

\(^1\)HNMR spectrum of (4a) after the addition of propylene oxide, showed, the protons of propenoxyl group were assigned as a broad multiple signals in the region (3.2-3.7) ppm, beside the other protons of the compound. (cf.fig. 28)
Surface active properties of nonionic surfactants

The surface active and related properties, including, surface and interfacial tension, cloud point, wetting, emulsification properties, foaming and CMC were investigated systematically in order to evaluate the possible application of these products in the different industrial fields.

1- Surface and interfacial tension.

The surface and interfacial tension of the prepared nonionic surfactants are recorded in (Table 2). It is evident that, the surfactants with heterocyclic moiety recorded lower values than those prepared from saturated fatty acids, which might be attributed to increasing the hydrophilicity of the molecules as found by \(^{(102)}\). On the other hand, the surface activity is improved by introducing heterocyclic nucleus in the molecules. In generally, these value increases as the mass of hydrophilic groups increase within the range under study and as the alkyl chain length increase as found by\(^{(50)}\).

2- Cloud point.

The most efficient use of nonionic surfactants in aqueous systems is by understanding a property called cloud point, which is the temperature at which the aqueous solution of the prepared nonionic surfactants shows turbidity on heating. The cloud points of the synthesized surfactant are shown in (Table 2). The results indicate that the values of cloud point increase by increasing the number of propylene oxide units as found by\(^{(57)}\) and decreases by the presence of aromatic ring as found by \(^{(216)}\). So compounds (5a-c) and (10a-c) showed high cloud points.

3- Wetting time.

Nonionic surfactants are among the most powerful wetting agents. All the synthesized surfactants are efficient wetting agents (Table 2). It was
reported that nonionic with a low propylene oxide content have been found to be the most efficient wetting promoter, and increased as the alkyl chain length increased as found by\textsuperscript{(217)}.

4- Emulsifying properties.

Studies are still being carried out on the utilization of surfactant in emulsion formulation, which is of immense importance to technological development. The data in (Table 2) show that greater emulsifying properties were obtained with derivatives containing propylene oxide units incorporated into their structure, where the emulsifying properties increase with decreasing number of propylene oxide units and increase with increasing of alkyl chain as found by\textsuperscript{(82)}. It is very interest noted that the emulsion stability of the prepared compounds is lower than the corresponding propoxylated fatty acid which not containing the heterocyclic moiety as found by\textsuperscript{(50)}, these results, might lead to the application of the surfactants of choice in pesticide and cosmetic formulation.

5- Foam power.

Low foaming power is the characteristic property of nonionic surfactants, which permits some recent applications for these in dyeing auxiliary textile industry. It was reported that; nonionic surfactants have low foam, on the other hand, the foam height of the prepared surfactants increases with increasing propylene oxide unit per molecule of surfactant and the efficiency of surfactants as a foamer increases with increasing alkyl chain length as found by\textsuperscript{(218)}.

6- Critical micelle concentration CMC.

The critical micelle concentration (CMC) of the synthesized surfactants was determined by the surface tension method. The data
reflect that, the values of CMC increase with increasing number of propylene oxide unit adducts; it decreases with increasing the number of carbon atom in alkyl chain as found by\textsuperscript{(132)} as shown in (Table 2).

**Biodegradability.**

Biodegradation die-away test in river water gave good or excellent results (Table 3). The results of biodegradation reflect that; the biodegradability decreases with increasing the number of propylene oxide units; or the number of methylene groups in the alkyl chain as found by\textsuperscript{(219)}. This leads to the conclusion that a longer propylene oxide chain makes the diffusion of the molecule through the cell membrane and thus also the degradation, more difficult.

**Biological activity.**

Nonionic surfactants which contain heterocyclic moiety afforded a double function as surface-active agents and antimicrobial activities\textsuperscript{(102)}. So, all the prepared surfactants were tested for their antibacterial activities against the test organisms as represented Gram +ve and –ve bacteria (Bacillus cereus, Bacillus circulans and Antifungal activity against, Aspergillus niger and penicillium notatum respectively), are given in (Table 4), the data 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.
Table (1): Physical properties of prepared compounds before addition of propylene oxide

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>4a</td>
<td>C₂H₁₃N₂S</td>
<td>359</td>
<td>Benz.</td>
<td>62</td>
<td>Yellow</td>
<td>70.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.35</td>
</tr>
<tr>
<td>4b</td>
<td>C₂H₇N₂S</td>
<td>387</td>
<td>EtOH</td>
<td>65</td>
<td>Yellow</td>
<td>71.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.56</td>
</tr>
<tr>
<td>4c</td>
<td>C₂H₄₁N₂S</td>
<td>415</td>
<td>Tol.</td>
<td>68</td>
<td>Yellow</td>
<td>72.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.66</td>
</tr>
<tr>
<td>5a</td>
<td>C₁₇H₃₃N₂O₂S</td>
<td>344</td>
<td>EtOH</td>
<td>55</td>
<td>Pale</td>
<td>59.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.06</td>
</tr>
<tr>
<td>5b</td>
<td>C₁₉H₃₆N₂O₂S</td>
<td>372</td>
<td>MeOH</td>
<td>58</td>
<td>Pale</td>
<td>61.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>61.67</td>
</tr>
<tr>
<td>5c</td>
<td>C₂₁H₄₆N₂O₂S</td>
<td>400</td>
<td>Benz.</td>
<td>52</td>
<td>Pale</td>
<td>63.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>63.41</td>
</tr>
<tr>
<td>6a</td>
<td>C₂₂H₅₈N₂O₂S</td>
<td>406</td>
<td>AcOH</td>
<td>65</td>
<td>Yellow</td>
<td>65.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65.30</td>
</tr>
<tr>
<td>6b</td>
<td>C₂₄H₇₄N₂O₂S</td>
<td>434</td>
<td>EtOH</td>
<td>62</td>
<td>Yellow</td>
<td>66.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66.70</td>
</tr>
<tr>
<td>6c</td>
<td>C₂₅H₆₂N₂O₂S</td>
<td>462</td>
<td>EtOH</td>
<td>68</td>
<td>Yellow</td>
<td>67.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.81</td>
</tr>
<tr>
<td>7a</td>
<td>C₂₂H₅₈N₂O₂S</td>
<td>388</td>
<td>AcOH</td>
<td>60</td>
<td>Brown</td>
<td>68.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.24</td>
</tr>
<tr>
<td>7b</td>
<td>C₂₄H₇₄N₂O₂S</td>
<td>416</td>
<td>AcOH</td>
<td>63</td>
<td>Brown</td>
<td>69.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.41</td>
</tr>
<tr>
<td>7c</td>
<td>C₂₆H₆₀N₂O₂S</td>
<td>444</td>
<td>AcOH</td>
<td>65</td>
<td>Brown</td>
<td>70.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.45</td>
</tr>
<tr>
<td>8a</td>
<td>C₂₁H₄₂N₂O₂S</td>
<td>378</td>
<td>Tol.</td>
<td>70</td>
<td>Red</td>
<td>66.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>brown</td>
<td>67.12</td>
</tr>
<tr>
<td>8b</td>
<td>C₂₃H₄₄N₂O₂S</td>
<td>406</td>
<td>Benz.</td>
<td>73</td>
<td>Red</td>
<td>67.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>brown</td>
<td>68.20</td>
</tr>
<tr>
<td>8c</td>
<td>C₂₃H₄₂N₂O₂S</td>
<td>434</td>
<td>Zyl.</td>
<td>75</td>
<td>Red</td>
<td>69.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>brown</td>
<td>69.43</td>
</tr>
</tbody>
</table>
### Table (1): Cont.

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>9a</td>
<td>C₂₁H₃₂N₂O₂</td>
<td>344</td>
<td>Benz.</td>
<td>60</td>
<td>Yellow</td>
<td>73.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>73.61</td>
</tr>
<tr>
<td>9b</td>
<td>C₂₁H₃₂N₂O₂</td>
<td>372</td>
<td>Benz.</td>
<td>55</td>
<td>Yellow</td>
<td>74.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>74.70</td>
</tr>
<tr>
<td>9c</td>
<td>C₂₅H₄₀N₂O₂</td>
<td>400</td>
<td>Tol.</td>
<td>58</td>
<td>Yellow</td>
<td>75.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.41</td>
</tr>
<tr>
<td>10a</td>
<td>C₁₅H₁₃NO₅S₂</td>
<td>361</td>
<td>MeOH</td>
<td>70</td>
<td>Pale yellow</td>
<td>56.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56.91</td>
</tr>
<tr>
<td>10b</td>
<td>C₁₉H₃₅NO₅S₂</td>
<td>389</td>
<td>MeOH</td>
<td>73</td>
<td>Pale yellow</td>
<td>58.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59.03</td>
</tr>
<tr>
<td>10c</td>
<td>C₂₁H₃₉NO₅S₂</td>
<td>417</td>
<td>EtOH</td>
<td>76</td>
<td>Pale yellow</td>
<td>60.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.91</td>
</tr>
<tr>
<td>11a</td>
<td>C₁₇H₂₉NO₅S₂</td>
<td>343</td>
<td>EtOH</td>
<td>55</td>
<td>Brown</td>
<td>59.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59.71</td>
</tr>
<tr>
<td>11b</td>
<td>C₁₉H₃₃NO₅S₂</td>
<td>371</td>
<td>Benz.</td>
<td>58</td>
<td>Red brown</td>
<td>61.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>61.68</td>
</tr>
<tr>
<td>11c</td>
<td>C₂₁H₃₇NO₅S₂</td>
<td>399</td>
<td>MeOH</td>
<td>60</td>
<td>Red brown</td>
<td>63.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>63.41</td>
</tr>
<tr>
<td>12a</td>
<td>C₂₁H₃₄N₂OS</td>
<td>362</td>
<td>Benz.</td>
<td>65</td>
<td>Gray</td>
<td>69.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.35</td>
</tr>
<tr>
<td>12b</td>
<td>C₂₃H₃₈N₂OS</td>
<td>390</td>
<td>EtOH</td>
<td>67</td>
<td>Gray</td>
<td>70.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.1</td>
</tr>
<tr>
<td>12c</td>
<td>C₂₅H₄₂N₂OS</td>
<td>418</td>
<td>EtOH</td>
<td>70</td>
<td>Gray</td>
<td>71.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.11</td>
</tr>
</tbody>
</table>
Table (2): Surface properties of nonionic surfactants.

<table>
<thead>
<tr>
<th>Comp.</th>
<th>n</th>
<th>Surface Tension (dyne/cm) 0.1 %</th>
<th>Interfacial tension (dyne/cm) 0.1 %</th>
<th>Cloud Point °C 1 %</th>
<th>Wetting time (sec.) 0.1 %</th>
<th>Emulsion stability (min.) 1 %</th>
<th>Foam height (mm)</th>
<th>Cmcx10⁻³ mol/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>3</td>
<td>31</td>
<td>8.0</td>
<td>57</td>
<td>48</td>
<td>70</td>
<td>No foam</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>9.5</td>
<td>70</td>
<td>30</td>
<td>72</td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>35</td>
<td>10.5</td>
<td>78</td>
<td>23</td>
<td>63</td>
<td></td>
<td>4.9</td>
</tr>
<tr>
<td>4b</td>
<td>3</td>
<td>32</td>
<td>8.5</td>
<td>55</td>
<td>52</td>
<td>80</td>
<td>No foam</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>10.0</td>
<td>68</td>
<td>33</td>
<td>73</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>11.5</td>
<td>77</td>
<td>25</td>
<td>64</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>4c</td>
<td>3</td>
<td>33</td>
<td>8.5</td>
<td>54</td>
<td>55</td>
<td>83</td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>37</td>
<td>11.0</td>
<td>66</td>
<td>36</td>
<td>75</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>13.0</td>
<td>75</td>
<td>27</td>
<td>65</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>5a</td>
<td>3</td>
<td>31</td>
<td>9.0</td>
<td>79</td>
<td>42</td>
<td>111</td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>11.5</td>
<td>95</td>
<td>29</td>
<td>87</td>
<td></td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>13.0</td>
<td>&gt; 100</td>
<td>21</td>
<td>82</td>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td>5b</td>
<td>3</td>
<td>33</td>
<td>9.5</td>
<td>73</td>
<td>44</td>
<td>115</td>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>12.0</td>
<td>87</td>
<td>35</td>
<td>91</td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>14.5</td>
<td>98</td>
<td>21</td>
<td>86</td>
<td></td>
<td>4.9</td>
</tr>
<tr>
<td>5c</td>
<td>3</td>
<td>35</td>
<td>10.0</td>
<td>71</td>
<td>49</td>
<td>120</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>36</td>
<td>13.0</td>
<td>82</td>
<td>37</td>
<td>95</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>13.5</td>
<td>95</td>
<td>24</td>
<td>89</td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td>6a</td>
<td>3</td>
<td>31</td>
<td>9.5</td>
<td>80</td>
<td>41</td>
<td>120</td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>10.0</td>
<td>98</td>
<td>35</td>
<td>93</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>11.5</td>
<td>&gt; 100</td>
<td>24</td>
<td>74</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>6b</td>
<td>3</td>
<td>32</td>
<td>10.0</td>
<td>75</td>
<td>46</td>
<td>125</td>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>11.0</td>
<td>86</td>
<td>38</td>
<td>96</td>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>12.5</td>
<td>99</td>
<td>29</td>
<td>76</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>6c</td>
<td>3</td>
<td>33</td>
<td>10.5</td>
<td>63</td>
<td>51</td>
<td>130</td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>37</td>
<td>12.0</td>
<td>75</td>
<td>41</td>
<td>98</td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>13.5</td>
<td>96</td>
<td>32</td>
<td>77</td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>7a</td>
<td>3</td>
<td>30</td>
<td>8.0</td>
<td>66</td>
<td>47</td>
<td>115</td>
<td>No foam</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>31</td>
<td>10.5</td>
<td>71</td>
<td>36</td>
<td>93</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>12.0</td>
<td>95</td>
<td>20</td>
<td>73</td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td>7b</td>
<td>3</td>
<td>31</td>
<td>8.5</td>
<td>58</td>
<td>49</td>
<td>118</td>
<td></td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>11.0</td>
<td>66</td>
<td>38</td>
<td>95</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>12.5</td>
<td>93</td>
<td>26</td>
<td>76</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>7c</td>
<td>3</td>
<td>32</td>
<td>9.0</td>
<td>55</td>
<td>53</td>
<td>120</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>36</td>
<td>11.5</td>
<td>61</td>
<td>41</td>
<td>92</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>14.0</td>
<td>81</td>
<td>29</td>
<td>80</td>
<td></td>
<td>4.3</td>
</tr>
</tbody>
</table>

n = number of moles of propylene oxide
Table (3): Biodegradability of the Prepared Surfactants.

<table>
<thead>
<tr>
<th>No.</th>
<th>n</th>
<th>1st day</th>
<th>2nd day</th>
<th>3rd day</th>
<th>4th day</th>
<th>5th day</th>
<th>6th day</th>
<th>7th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>3</td>
<td>59</td>
<td>68</td>
<td>79</td>
<td>84</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>57</td>
<td>65</td>
<td>74</td>
<td>80</td>
<td>88</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>56</td>
<td>61</td>
<td>72</td>
<td>79</td>
<td>85</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>4b</td>
<td>3</td>
<td>52</td>
<td>67</td>
<td>76</td>
<td>83</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>63</td>
<td>73</td>
<td>76</td>
<td>86</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>59</td>
<td>69</td>
<td>74</td>
<td>83</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>4c</td>
<td>3</td>
<td>50</td>
<td>62</td>
<td>70</td>
<td>82</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>45</td>
<td>58</td>
<td>68</td>
<td>75</td>
<td>87</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>41</td>
<td>53</td>
<td>66</td>
<td>72</td>
<td>81</td>
<td>86</td>
<td>92</td>
</tr>
<tr>
<td>5a</td>
<td>3</td>
<td>63</td>
<td>68</td>
<td>77</td>
<td>83</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>52</td>
<td>65</td>
<td>76</td>
<td>82</td>
<td>88</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>57</td>
<td>71</td>
<td>79</td>
<td>85</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>5b</td>
<td>3</td>
<td>57</td>
<td>64</td>
<td>73</td>
<td>81</td>
<td>92</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>59</td>
<td>72</td>
<td>79</td>
<td>87</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>40</td>
<td>55</td>
<td>69</td>
<td>78</td>
<td>83</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>5c</td>
<td>3</td>
<td>53</td>
<td>62</td>
<td>70</td>
<td>97</td>
<td>86</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>56</td>
<td>69</td>
<td>72</td>
<td>83</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>51</td>
<td>76</td>
<td>70</td>
<td>79</td>
<td>83</td>
<td>94</td>
</tr>
<tr>
<td>6a</td>
<td>3</td>
<td>53</td>
<td>66</td>
<td>75</td>
<td>85</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>62</td>
<td>72</td>
<td>80</td>
<td>86</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>59</td>
<td>69</td>
<td>77</td>
<td>83</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>6b</td>
<td>3</td>
<td>50</td>
<td>63</td>
<td>71</td>
<td>81</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>59</td>
<td>69</td>
<td>77</td>
<td>80</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>57</td>
<td>67</td>
<td>74</td>
<td>78</td>
<td>88</td>
<td>96</td>
</tr>
<tr>
<td>6c</td>
<td>3</td>
<td>48</td>
<td>60</td>
<td>68</td>
<td>78</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>45</td>
<td>56</td>
<td>66</td>
<td>73</td>
<td>76</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>41</td>
<td>51</td>
<td>64</td>
<td>70</td>
<td>73</td>
<td>85</td>
<td>92</td>
</tr>
<tr>
<td>7a</td>
<td>3</td>
<td>53</td>
<td>61</td>
<td>74</td>
<td>83</td>
<td>94</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>60</td>
<td>67</td>
<td>78</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>57</td>
<td>62</td>
<td>76</td>
<td>88</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>7b</td>
<td>3</td>
<td>49</td>
<td>59</td>
<td>70</td>
<td>74</td>
<td>83</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>52</td>
<td>63</td>
<td>75</td>
<td>87</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>50</td>
<td>62</td>
<td>74</td>
<td>83</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>7c</td>
<td>3</td>
<td>49</td>
<td>55</td>
<td>62</td>
<td>79</td>
<td>87</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>46</td>
<td>51</td>
<td>59</td>
<td>67</td>
<td>78</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>40</td>
<td>48</td>
<td>57</td>
<td>63</td>
<td>72</td>
<td>85</td>
<td>93</td>
</tr>
</tbody>
</table>
### Table (3): Cont.

<table>
<thead>
<tr>
<th>No.</th>
<th>n</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; day</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; day</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; day</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>6&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>7&lt;sup&gt;th&lt;/sup&gt; day</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a</td>
<td>3</td>
<td>53</td>
<td>58</td>
<td>66</td>
<td>80</td>
<td>82</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>50</td>
<td>56</td>
<td>63</td>
<td>71</td>
<td>79</td>
<td>86</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>54</td>
<td>59</td>
<td>68</td>
<td>65</td>
<td>79</td>
<td>90</td>
</tr>
<tr>
<td>8b</td>
<td>3</td>
<td>51</td>
<td>56</td>
<td>63</td>
<td>77</td>
<td>84</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>54</td>
<td>59</td>
<td>67</td>
<td>79</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>52</td>
<td>57</td>
<td>63</td>
<td>75</td>
<td>89</td>
<td>-</td>
</tr>
<tr>
<td>8c</td>
<td>3</td>
<td>49</td>
<td>54</td>
<td>60</td>
<td>77</td>
<td>80</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>59</td>
<td>57</td>
<td>65</td>
<td>76</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>49</td>
<td>54</td>
<td>61</td>
<td>73</td>
<td>86</td>
<td>93</td>
</tr>
<tr>
<td>9a</td>
<td>3</td>
<td>55</td>
<td>63</td>
<td>73</td>
<td>82</td>
<td>78</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>52</td>
<td>59</td>
<td>70</td>
<td>75</td>
<td>82</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>54</td>
<td>69</td>
<td>73</td>
<td>79</td>
<td>83</td>
<td>95</td>
</tr>
<tr>
<td>9b</td>
<td>3</td>
<td>55</td>
<td>62</td>
<td>71</td>
<td>79</td>
<td>85</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>57</td>
<td>69</td>
<td>73</td>
<td>83</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>52</td>
<td>64</td>
<td>71</td>
<td>79</td>
<td>87</td>
<td>92</td>
</tr>
<tr>
<td>9c</td>
<td>3</td>
<td>51</td>
<td>60</td>
<td>69</td>
<td>77</td>
<td>84</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>54</td>
<td>67</td>
<td>70</td>
<td>81</td>
<td>89</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>44</td>
<td>49</td>
<td>65</td>
<td>68</td>
<td>77</td>
<td>85</td>
<td>92</td>
</tr>
<tr>
<td>10a</td>
<td>3</td>
<td>57</td>
<td>66</td>
<td>79</td>
<td>89</td>
<td>96</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>55</td>
<td>63</td>
<td>73</td>
<td>86</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>52</td>
<td>59</td>
<td>71</td>
<td>79</td>
<td>88</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>10b</td>
<td>3</td>
<td>55</td>
<td>65</td>
<td>77</td>
<td>86</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>52</td>
<td>58</td>
<td>69</td>
<td>83</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>83</td>
<td>65</td>
<td>74</td>
<td>80</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td>10c</td>
<td>3</td>
<td>54</td>
<td>63</td>
<td>73</td>
<td>84</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>55</td>
<td>67</td>
<td>79</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>50</td>
<td>61</td>
<td>72</td>
<td>84</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>12a</td>
<td>3</td>
<td>55</td>
<td>67</td>
<td>75</td>
<td>85</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>52</td>
<td>59</td>
<td>71</td>
<td>82</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>50</td>
<td>56</td>
<td>61</td>
<td>75</td>
<td>88</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>12b</td>
<td>3</td>
<td>53</td>
<td>64</td>
<td>72</td>
<td>83</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>57</td>
<td>67</td>
<td>78</td>
<td>87</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>52</td>
<td>56</td>
<td>71</td>
<td>81</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td>12c</td>
<td>3</td>
<td>50</td>
<td>62</td>
<td>68</td>
<td>79</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>55</td>
<td>63</td>
<td>72</td>
<td>80</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>49</td>
<td>45</td>
<td>65</td>
<td>77</td>
<td>91</td>
<td>-</td>
</tr>
</tbody>
</table>
Table (4): Antimicrobial activity of nonionic surfactants.

<table>
<thead>
<tr>
<th>Compd.</th>
<th>Bacteria</th>
<th>Fungi</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacillus <em>cercus</em></td>
<td><em>Bacillus circulans</em></td>
<td><em>Aspergillus</em> <em>niger</em></td>
</tr>
<tr>
<td>4a</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4b</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>4c</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5a</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5b</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>5c</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6a</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>6b</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>6c</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>7a</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7b</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>7c</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>8a</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8b</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>8c</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>9a</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>9b</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9c</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>10a</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>10b</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>10c</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11a</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11b</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>11c</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>12a</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12b</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>12c</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

(+++) Very strong inhibition, (++) strong inhibition, (+) moderate inhibition.
PART (2)

Nonionic surface active agents containing heterocyclic moiety from fatty acid hydrazide

The hydrazide of long chain fatty acid (myristic, palmitic and stearic) was used as commercial starting material to synthesis some important heterocycles as pyrazoles, thiazoles, oxadiazoles, benzoxa-zoles, pyridazine and which utilized to prepare a novel groups of nonionic surface active agents having a double function with antimicrobial and surface active properties.

Synthesis of fatty acid hydrazides.

Fatty acid hydrazide (13a-c) was prepared from its acid chloride (2a-c) through its reaction with hydrazine hydrate

\[
\text{R-C-Cl} + \text{NH}_2\text{NH}_2 \xrightarrow{\text{acetone}} \text{R-C-NH-NH}_2
\]

(2a-c) \quad (13a-c)

\[\text{R, a = C}_{13}\text{H}_{27}, \quad \text{b = C}_{15}\text{H}_{31}, \quad \text{c = C}_{17}\text{H}_{35}\]

IR spectrum of (13a) shows the following bands in cm\(^{-1}\), band’s at 3422, 3330 and 3190 for vNH\(^{a}\), strong band at 2359 for the linear structure of the molecule, band at 1691 for vC=O of amide and (2920-2850) for vCH\(^{a}\) of alkyl chain (cf. fig. 9).
Synthesis of heterocyclic compounds from fatty acid hydrazides.

1- Synthesis of pyridazine derivatives via:

α-Reaction of fatty acid hydrazide (13a-c) with β-benzoyl acrylic acid and/or β-benzoyl propionic acid

When a solution of fatty acid hydrazide (13a-c) in n-butanol was treated with β-benzoyl acrylic acid and / or β-benzoyl propionic acid produced 2-alkanoyl-6-phenyl-pyridazine-3-one (14a-c) and/or 2-alkanoyl-6-phenyl-4,5-dihydro pyridazine-3-one (15a-c).

\[
\begin{align*}
R\cdot C\cdot \text{-}NH\cdot NH\_2 + Ph\cdot C\cdot CH\_2\cdot CH\cdot COOH & \xrightarrow{n\text{-butanol}} R\cdot C\cdot \text{-N} \\text{-}N \\text{-}O \\
(13a-c) \\
+ Ph\cdot C\cdot CH\_2\cdot CH\cdot COOH & \xrightarrow{n\text{-butanol}} R\cdot C\cdot \text{-N} \\text{-}N \\text{-}O \\
(15a-c)
\end{align*}
\]

\[R, \ a = C_{13}H_{27}, \ b = C_{15}H_{31}, \ c = C_{17}H_{35}\]

IR spectrum of (14a) exhibits, \(\nu\text{C} = \text{O}^s\) at 1701, 1625, \(\nu\text{C} = \text{N}\) at 1588, \(\nu\text{CH}^s\) of alkyl chain in region (2920-2850) and the characteristic band (220) of pyridazine ring in region (1560-1490) cm\(^{-1}\) (cf. fig.10).
b-Reaction of fatty acid hydrazide (13a-c) with maleic anhydride and/or succinic anhydride.

Fatty acid hydrazide (13a-c) reacts with maleic anhydride and/or succinic anhydride in acetic anhydride to give 2-alkanoyl-pyridazine-3,6-dione (16a-c) and/or 2-alkanoyl-4,5-dihydro-pyridazine-3,6-dione (17a-c).

\[
\begin{align*}
&
\text{R-C-NH-NH}_2 + \begin{array}{c}
\text{C}_2\text{O} \\
\text{AcOH}
\end{array} \rightarrow \begin{array}{c}
\text{N} \\
\text{O} \\
\text{R-C-N}
\end{array} \\
&
\text{(13a-c)}
\end{align*}
\]

\[
\begin{align*}
&
\text{R-C-NH-NH}_2 + \begin{array}{c}
\text{C}_2\text{O} \\
\text{AcOH}
\end{array} \rightarrow \begin{array}{c}
\text{N} \\
\text{O} \\
\text{R-C-N}
\end{array} \\
&
\text{(17a-c)}
\end{align*}
\]

\[
R, a = \text{C}_{13}l_{27}, \quad b = \text{C}_{15}l_{31}, \quad c = \text{C}_{17}l_{35}
\]

IR spectrum of (17c) exhibits, νNH at 3339, νC=O at 1703 and 1594, νCH olefinic at 1525 and νCH aliphatic in region (2920-2850) cm⁻¹ (cf. fig. 11).

\[
^1H \text{ NMR spectrum of (16c) shows signals, } \delta 0.9 \text{ for (t, 3H, terminal CH}_3), \delta 1.3 \text{ (s, 32H, CH}_2 \text{ of alkyl chain), } \delta 6.1 \text{ (s, 1H, CH olefinic ), } \delta 9.5 \text{ (s, 1H, NH) which disappeared by addition of D}_2\text{O (cf. fig. 29).}
\]

Mass spectrum of (17c) shows molecular ion peak at M⁺-2 = 378, 0.6 % and show ion peat at m/z = 113, 3.67% corresponding to dihydro-pyridazine dione nucleus.
2-Synthesis of oxadiazole derivatives via the reaction of fatty acid hydrazide (13a-c) with carbon disulphide.

Carbon disulphide reacts with fatty acid hydrazide (13a-c) using potassium hydroxide as catalyst in ethyl alcohol to produce 5-alkyl-2-thion-1,3,4-oxadiazole (18a-c).

\[
\begin{align*}
\text{R-C-NH-NH}_2 + \text{CS}_2 & \xrightarrow{\text{KOH, EtOH}} \text{R-} \begin{array}{c}
\text{O} \\
\text{N-\ldots-NH}
\end{array} \text{S} \\
(13a-c) & \quad (18a-c)
\end{align*}
\]

\[R, a = C_{13}H_{27}, \quad b = C_{15}H_{31}, \quad c = C_{17}H_{35}\]

IR spectrum of (18c) exhibits, νNH at 3228, νC=N at 1598, νC=S at 1414 and νCH* aliphatic in region (2920-2850) and the characteristic bands (220) of oxadiazole ring in region (1190-1150, 1030-1000 and 890-825) cm\(^{-1}\). (cf. fig.12).

Mass spectrum of (18c) shows molecular ion peak at \(M^+ + 1 = 341\), 3.6% which fragmented to ions one corresponding to the side chain of alkyl at 239, 1.8% and the other corresponding to oxadiazole nucleus at \(m/z = 101, 14.0\%\) (cf. fig. 47, Chart 8).
3- Synthesis of oxadiazine derivatives via the reaction of fatty acid hydrazide (13a-c) with chloroacetic acid.

Addition of chloroacetic acid to fatty acid hydrazide (13a-c) in dry ethyl alcohol gives intermediate which undergoes cyclization followed by dehydration to give 2-alkyl-1,3,4-oxadiazine-6-one (19a-c).

\[
R-\text{C-NH-NH}_2 + \text{ClCH}_2\text{COOH} \xrightarrow{\text{EtOH}} R-\text{C-NH-NH-CH}_2\text{COOH}
\]

(13a-c)

\[
\xrightarrow{\text{Ac}_2\text{O} \cdot \text{H}_2\text{O}}
\]

(19a-c)

\[R, a = C_{13}H_{27}, \ b = C_{15}H_{31}, \ c = C_{17}H_{35}\]
Results and Discussion

IR spectrum of (19b) shows band for νNH at 3437, νC=H at 1598, νC=O at 1654, νC-O of cyclic ether at 1105 and νCH₈ aliphatic in region (2920-2850) cm⁻¹.

¹HNMR spectrum of (19c) shows signals at δ 0.9 (t, 3H, terminal CH₃), δ 1.2-1.6 (m, 32H, CH₂ of alkyl chain), δ 4.3 (s, 1H, NH) which disappeared by addition D₂O. (cf. fig.30).

Mass spectrum of (19a) show ion peak at M₊ + 2 = 284, 2.7 % and ion peak at m/z = 99, 7.3 % corresponding of oxapyridazine nucleus beside the base peak at m/z = 57, 100 % (cf. fig. 48, Chart 9).
4- Synthesis of phthalazine derivatives via the reaction of fatty acid hydrazide (13a-c) with phthalic anhydride.

The reaction of fatty acid hydrazides (13a-c) with phthalic anhydride in acetic anhydride leads to the formation of 2-alkanoylphthalazine-1,4-dione (20a-c).

\[
\begin{align*}
\text{R-C-NH-NH}_2 + & \xrightarrow{\text{Ac}_2\text{O} - \text{H}_2\text{O}} \text{R-C-N} & \text{O} \\
(13a-c) & & (20a-c)
\end{align*}
\]

\[R, a = C_{13}H_{27}, \quad b = C_{13}H_{31}, \quad c = C_{17}H_{35}\]

IR spectrum of (20c) shows, νNH at 3404, νC=O at 1703, 1656 and 1597, and the characteristic band of phthalazine nucleus at 1543 cm\(^{-1}\) due to ring vibration (cf. fig. 13).

Mass spectrum of (20c) shows molecular ion peak at M\(^+\) + 2 = 430, 7.25% and show ion peak at m/z = 161, 72.1 % corresponding of phthalazine nucleus. (cf. fig. 49, Chart 10).
Chart 10
5- Synthesis of pyrazole derivatives via the reaction of fatty acid hydrazide with ethyl benzoyl acetate and/or diethyl malonate.

Fatty acid hydrazide (13a-c) reacts with ethylbenzoylacetate and/or diethylmalonate to give 1-N-alkanoyl-3-ethoxy-5-phenyl-pyrazole (21a-c) and/or 1-N-alkanoyl-3,5-diethoxy-pyrazole (22a-c).

\[ \text{R-C-NH-NH}_2 + \text{Ph-C-CH}_2\text{C-OC}_2\text{H}_5 \rightarrow \text{R-C-N=NC=O} \]

(13a-c)

\[ \text{H}_2\text{C=C-CH}_2\text{C-OC}_2\text{H}_5 \rightarrow \text{R-C-N=NC=O} \]

(21a-c)

\[ \text{R}_1\text{CHO-C-CH}_2\text{C-OC}_2\text{H}_5 \rightarrow \text{R-C-N=NC=O} \]

(22a-c)

\( \text{R}_1, \text{a} = \text{C}_{13}\text{H}_{27}, \text{b} = \text{C}_{15}\text{H}_{31}, \text{c} = \text{C}_{17}\text{H}_{35} \)

IR spectrum (21a) exhibits, \( \nu\text{C}=\text{N} \) at 1593 and \( \nu\text{C}=\text{O} \) at 1703, \( \nu\text{CH} \) aliphatic in region (2920-2850) and \( \nu\text{CH} \) aromatic at 3020 and the characteristic band (22ii) of pyrazole ring at (1465) cm\(^{-1}\) (c.f. Fig.14).

\(^1\text{HNMR}\) spectrum of (22a) shows signals at \( \delta \ 0.85 \) (t, 3H, terminal \( \text{CH}_3 \)), \( \delta \ 1.3 \) (s, 24H, \( \text{CH}_2 \) of alkyl chain), \( \delta \ 2.1 \) (s, 2H, \( \text{CH} \) cyclic), \( \delta \ 7.3 \) (s, 5H, \( \text{ArH} \)) and \( \delta \ 2.3 \) (m, 3H, \( \text{CH}_2\text{CH}_3 \)) (c.f. fig.31).
6- Synthesis of thiazole derivatives via the reaction of fatty acid hydrazide (13a-c) with benzaldehyde.

The reaction of fatty acid hydrazide (13a-c) with benzaldehyde in acetic acid give N-alkanoyl-benzal hydrazone (23a-c) (Schiff base).

\[
\text{R-C-NH-NH}_2 + \text{PhCHO} \xrightarrow{\text{EtOH}} \text{R-C-NH-N=CH-Ph}
\]

(13a-c) \hspace{1cm} (23a-c)

\[ R, \ a = C_{13}H_{27}, \ b = C_{15}H_{31}, \ c = C_{17}H_{35} \]

IR spectrum of (23a) exhibits, vNH at 3228, strong band at 2360 for the linear structure of the compound vC=O of amide at 1662 and vC=N at 1598 cm\(^{-1}\) (cf. fig.15).

\(^1\)HNMR spectrum of (23c) shows signals at \(\delta\) 0.9 (t, 3H, terminal CH\(_3\)), \(\delta\) 1.3 (s, 32H, CH\(_2\) of alkyl chain), \(\delta\) 1.9 (s, 1H, N=CH), \(\delta\) 7.3-7.7 (m, 4H, ArH) and \(\delta\) 3.7 (s, 1H, NH proton) disappeared by addition of D\(_2\)O (cf. fig. 32).

When the Schiff base derivatives (23a-c) were treated with thioglycollic acid in dry benzene leads to the formation of 3-N-amidoalkyl-2-phenyl-1,3-thiazole-4-one (24a-c).

\[
\text{R-C-NH-N=CH-Ph} + \text{HSCH}_2\text{COOH} \xrightarrow{\text{EtOH}} \text{R-C-NH-}
\]

(23a-c) \hspace{1cm} (24a-c)

\[ R, \ a = C_{13}H_{27}, \ b = C_{15}H_{31}, \ c = C_{17}H_{35} \]
Results and Discussion

IR spectrum of (24c) which shows, vNH at 3204, vC=O at 1690, 1648, vCH of aromatic at 3099 and vCH of alkyl chain in region (2920-2850) cm\(^{-1}\) (cf. fig. 16).

\(^1\)HNMR spectrum of (24c) shows signals at \(\delta\) 0.9 (t, 3H, terminal CH\(_3\)), \(\delta\) 1.2 (s, 32H, CH\(_2\) of alkyl chain), \(\delta\) 1.7 (s, 2H, S-CH\(_2\)), \(\delta\) 2.6 (s, H, CH-Ph), \(\delta\) 7.3-7.9 (m, 5H, ArH), \(\delta\) 8.7 (s, 1H, NH proton) which disappeared by addition of D\(_2\)O (cf. fig. 33).

7-Synthesis of oxadiazole derivatives via the reaction of Schiff base derivative (23a-c) with ferric chloride.

When the Schiff base adducts (23a-c) were treated by ferric chloride in acetic acid lead to formation of 2-alkyl-5-phenyl-1,3,4-oxadiazole (25a-c).

\[
\begin{align*}
\text{R-C-NH-N=CH-Ph} & \quad \text{FeCl}_3 \quad \text{Ac}_2\text{O} \\
\rightarrow \quad & \quad \text{R-} \quad \text{N} \quad \text{N} \quad \text{Ph}
\end{align*}
\]

(23a-c) \quad (25a-c)

\(R\), \(a = C_{13}H_{27}\), \(b = C_{15}H_{31}\), \(c = C_{17}H_{35}\)

IR spectrum of (25c) exhibits, vC= N at 1599 and 1549, vC-O-C at 1100, vCH aliphatic at 2920-2850, vCH aromatic at 3047 and the characteristic band of heterocyclic ring in region (1040-1030) cm\(^{-1}\) (cf. fig. 17).

\(^1\)HNMR spectrum of (25b) shows signals at \(\delta\) 0.9 (t, 3H, terminal CH\(_3\)), \(\delta\) 1.2 (s, 28H, CH\(_2\) of alkyl chain), \(\delta\) 7.3 (s, 5H, ArH) (cf. fig. 34).
Preparation of nonionic surfactants from the synthesized heterocyclic compounds.

Nonionic surfactants are prepared by the addition of different moles of propylene oxide (n = 3, 5 and 7) to the synthesized heterocyclic derivatives to yield polypropenoxylation products.

The structures of the synthesized nonionic surfactants were confirmed via IR and $^1$H NMR spectra.

IR spectrum of (20a) after the addition of propylene oxide showed, two broad bands at 1100 and 950 cm$^{-1}$ corresponding for vC-O-C ether linkage of poly propenoxy chain, beside the original bands of the compound.

$^1$HNMR spectrum of (23a) after the addition, showed the protons of propenoxy group are assigned as broad multiple signals in the region (3.2-3.7), beside the other protons of the compound.

Surface active properties of nonionic surfactants.

The surface active and related properties, including surface and interfacial tension, cloud point, foaming power, wetting time, and emulsification properties were investigated to evaluate the possible application of these products in the different industrial fields.

1- Surface and interfacial tension:

In comparing surfactants or emulsifiers by surface or interfacial tension measurements, two factors, efficiency and effectiveness need to be considered. Ross$^{221}$ suggests that a good measure of efficiency is the amount of a surfactant required to reduce the tension by 20-dyne/cm and the minimum tension obtainable with the surfactant measured its
effectiveness. The values of surface and interfacial tension of the synthesized products increased by increasing the number of propenoxy group as found by \(^{(50)}\) per molecule of products as shown in (Table 6).

2- **Cloud point:**

All the synthesized products have high cloud points, which gave the good performance in hot water. Generally, the cloud point increases with increasing the number of propenoxy group per hydrophobic molecule as found by \(^{(51)}\) as show in (Table 6).

3- **Wetting time:**

All the products show decreasing in wetting time, where good wetting time are recorded with a low propylene oxide content as found by \(^{(102)}\) as shown in (Table 6).

4- **Foaming power:**

In general, the nonionic surfactants form unstable foam. It was reported that the foaming height of the prepared surfactants increases with increasing of propylene oxide unit per molecule of surfactant as found by \(^{(57)}\) as shown in (Table 6).

5- **Emulsifying properties:**

Emulsion stability was measured using standard procedures. From the data recorded in (Table 6) the emulsifying properties increase with decreasing number of propylene oxide units and increase with increasing of alkyl chain as found by \(^{(82)}\).

6- **Critical Micelle Concentration (CMC):**

The (CMC) values of aqueous solutions of the synthesized surfactants were determined from the concentration dependence of
surface tension values at 25 °C. The critical micelle concentration (CMC) was determined and listed in (Table 7). The value of (CMC) increases with increasing the number of propenoxy groups and it decreases with increasing the alkyl chain length as found by (132).

**Biodegradability.**

Biodegradation die-away test in ordinary river water gave satisfactory results (Table 7), where, the biodegradation was expressed by measurement of the surface tension with time (day). The rate of degradation of these compounds depends on the size of molecule; bulky molecule diffuses through the cell membrane and its degradation is more difficult, this means that these compounds with lower moles of propylene oxide are more degradable than that which contains higher moles of propylene oxide as found by (31). In general, the products have high rate of degradation ranging about 95% degradation during around 5 days.

**Biological activity.**

The surfactant products were screened for antibacterial activity against Bacillus cercus, Bacillus circulans and antifungal activity against Aspergillus clavatus and pencillium notatum. All the tested compounds showed antimicrobial activity against tested microorganisms, the results of the antimicrobial activity are shown in (Table 8).
Table (5): Physical properties of prepared compounds before addition of propylene oxide.

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.Wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>13a</td>
<td>C_{10}H_{36}N_{2}O</td>
<td>242</td>
<td>Benz.</td>
<td>75</td>
<td>White</td>
<td>69.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.76</td>
</tr>
<tr>
<td>13b</td>
<td>C_{10}H_{36}N_{2}O</td>
<td>270</td>
<td>Tol.</td>
<td>72</td>
<td>White</td>
<td>71.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.31</td>
</tr>
<tr>
<td>13c</td>
<td>C_{10}H_{36}N_{2}O</td>
<td>298</td>
<td>Benz.</td>
<td>70</td>
<td>White yellow</td>
<td>72.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.63</td>
</tr>
<tr>
<td>14a</td>
<td>C_{24}H_{46}N_{2}O_{2}</td>
<td>382</td>
<td>EtOH</td>
<td>65</td>
<td>yellow</td>
<td>75.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.58</td>
</tr>
<tr>
<td>14b</td>
<td>C_{26}H_{46}N_{2}O_{2}</td>
<td>410</td>
<td>MeOH</td>
<td>63</td>
<td>Pale yellow</td>
<td>76.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.18</td>
</tr>
<tr>
<td>14c</td>
<td>C_{28}H_{46}N_{2}O_{2}</td>
<td>438</td>
<td>EtOH</td>
<td>68</td>
<td>Red yellow</td>
<td>76.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.9</td>
</tr>
<tr>
<td>15a</td>
<td>C_{24}H_{46}N_{2}O_{2}</td>
<td>384</td>
<td>Tol.</td>
<td>57</td>
<td>Yellow</td>
<td>75.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.12</td>
</tr>
<tr>
<td>15b</td>
<td>C_{26}H_{46}N_{2}O_{2}</td>
<td>412</td>
<td>Benz.</td>
<td>60</td>
<td>Pale yellow</td>
<td>75.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.87</td>
</tr>
<tr>
<td>15c</td>
<td>C_{28}H_{46}N_{2}O_{2}</td>
<td>440</td>
<td>MeOH</td>
<td>65</td>
<td>Brown</td>
<td>76.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.54</td>
</tr>
<tr>
<td>16a</td>
<td>C_{18}H_{38}N_{2}O_{3}</td>
<td>322</td>
<td>Tol.</td>
<td>73</td>
<td>Yellow</td>
<td>67.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.13</td>
</tr>
<tr>
<td>16b</td>
<td>C_{20}H_{38}N_{2}O_{3}</td>
<td>350</td>
<td>Benz.</td>
<td>68</td>
<td>Red yellow</td>
<td>68.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.67</td>
</tr>
<tr>
<td>16c</td>
<td>C_{22}H_{38}N_{2}O_{3}</td>
<td>378</td>
<td>AcOH</td>
<td>70</td>
<td>Red yellow</td>
<td>69.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.97</td>
</tr>
<tr>
<td>17a</td>
<td>C_{18}H_{38}N_{2}O_{3}</td>
<td>324</td>
<td>EtOH</td>
<td>62</td>
<td>Yellow</td>
<td>66.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66.83</td>
</tr>
<tr>
<td>17b</td>
<td>C_{20}H_{38}N_{2}O_{3}</td>
<td>352</td>
<td>AcOH</td>
<td>65</td>
<td>Pale yellow</td>
<td>68.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.3</td>
</tr>
<tr>
<td>17c</td>
<td>C_{22}H_{40}N_{2}O_{3}</td>
<td>380</td>
<td>AcOH</td>
<td>68</td>
<td>Red yellow</td>
<td>69.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.71</td>
</tr>
</tbody>
</table>
Table (5): Cont.

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>H</td>
</tr>
<tr>
<td>18a</td>
<td>C_{12}H_{28}N_{5}OS</td>
<td>284</td>
<td>EtOH</td>
<td>58</td>
<td>White yellow</td>
<td>63.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18b</td>
<td>C_{17}H_{33}N_{5}OS</td>
<td>312</td>
<td>MeOH</td>
<td>55</td>
<td>yellow</td>
<td>65.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18c</td>
<td>C_{19}H_{35}N_{5}OS</td>
<td>340</td>
<td>EtOH</td>
<td>53</td>
<td>Pale yellow</td>
<td>67.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19a</td>
<td>C_{1d}H_{30}N_{2}O_{2}</td>
<td>282</td>
<td>Tol.</td>
<td>55</td>
<td>yellow</td>
<td>68.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19b</td>
<td>C_{16}H_{34}N_{2}O_{2}</td>
<td>310</td>
<td>Benz.</td>
<td>53</td>
<td>Red yellow</td>
<td>69.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19c</td>
<td>C_{20}H_{38}N_{2}O_{2}</td>
<td>338</td>
<td>EtOH</td>
<td>56</td>
<td>Pale yellow</td>
<td>71.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20a</td>
<td>C_{22}H_{32}N_{2}O_{3}</td>
<td>372</td>
<td>EtOH</td>
<td>67</td>
<td>yellow</td>
<td>70.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20b</td>
<td>C_{24}H_{36}N_{2}O_{3}</td>
<td>400</td>
<td>AcOH</td>
<td>65</td>
<td>yellow</td>
<td>72.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20c</td>
<td>C_{26}H_{40}N_{2}O_{3}</td>
<td>428</td>
<td>AcOH</td>
<td>62</td>
<td>Red yellow</td>
<td>72.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21a</td>
<td>C_{28}H_{34}N_{2}O_{2}</td>
<td>398</td>
<td>EtOH</td>
<td>58</td>
<td>White yellow</td>
<td>75.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21b</td>
<td>C_{23}H_{22}N_{2}O_{2}</td>
<td>426</td>
<td>Benz.</td>
<td>62</td>
<td>yellow</td>
<td>76.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21c</td>
<td>C_{29}H_{44}N_{2}O_{2}</td>
<td>454</td>
<td>Benz.</td>
<td>60</td>
<td>Pale yellow</td>
<td>76.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22a</td>
<td>C_{21}H_{38}N_{2}O_{3}</td>
<td>366</td>
<td>MeOH</td>
<td>62</td>
<td>White yellow</td>
<td>68.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22b</td>
<td>C_{23}H_{40}N_{2}O_{3}</td>
<td>394</td>
<td>EtOH</td>
<td>65</td>
<td>Yellow</td>
<td>70.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22c</td>
<td>C_{23}H_{46}N_{2}O_{3}</td>
<td>422</td>
<td>EtOH</td>
<td>63</td>
<td>Pale yellow</td>
<td>71.09</td>
</tr>
<tr>
<td>No.</td>
<td>M.F.</td>
<td>M.wt</td>
<td>Solvent</td>
<td>Yield %</td>
<td>Color</td>
<td>Analysis data calc./Found %</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>------</td>
<td>---------</td>
<td>---------</td>
<td>--------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$C$</td>
</tr>
<tr>
<td>23a</td>
<td>$C_{21}H_{34}N_2O$</td>
<td>330</td>
<td>Benz.</td>
<td>62</td>
<td>Brown</td>
<td>76.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.52</td>
</tr>
<tr>
<td>23b</td>
<td>$C_{23}H_{38}N_2O$</td>
<td>358</td>
<td>Tol.</td>
<td>65</td>
<td>Brown</td>
<td>77.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77.17</td>
</tr>
<tr>
<td>23c</td>
<td>$C_{25}H_{42}N_2O$</td>
<td>386</td>
<td>EtOH</td>
<td>68</td>
<td>Red brown</td>
<td>77.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77.83</td>
</tr>
<tr>
<td>24a</td>
<td>$C_{25}H_{38}N_2O_2S$</td>
<td>404</td>
<td>Benz.</td>
<td>67</td>
<td>yellow</td>
<td>68.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.48</td>
</tr>
<tr>
<td>24b</td>
<td>$C_{22}H_{40}N_2O_2S$</td>
<td>432</td>
<td>Benz.</td>
<td>63</td>
<td>yellow</td>
<td>69.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.68</td>
</tr>
<tr>
<td>24c</td>
<td>$C_{27}H_{44}N_2O_2S$</td>
<td>460</td>
<td>Tol.</td>
<td>65</td>
<td>Pale yellow</td>
<td>70.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.62</td>
</tr>
<tr>
<td>25a</td>
<td>$C_{21}H_{32}N_2O$</td>
<td>328</td>
<td>Benz.</td>
<td>65</td>
<td>brown</td>
<td>76.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.99</td>
</tr>
<tr>
<td>25b</td>
<td>$C_{21}H_{36}N_2O$</td>
<td>356</td>
<td>EtOH</td>
<td>62</td>
<td>Red brown</td>
<td>77.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77.73</td>
</tr>
<tr>
<td>25c</td>
<td>$C_{25}H_{40}N_2O$</td>
<td>384</td>
<td>AcOH</td>
<td>60</td>
<td>brown</td>
<td>78.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78.30</td>
</tr>
</tbody>
</table>
Table (6): Surface properties of nonionic surfactants.

<table>
<thead>
<tr>
<th>Comp.</th>
<th>n</th>
<th>Surface Tension (dyne/cm) 0.1 %</th>
<th>Interfacial Tension (dyne/cm) 0.1 %</th>
<th>Cloud Point °C</th>
<th>Wetting time (sec) 0.1%</th>
<th>Emulsion stability (min.)</th>
<th>Foam height (mm) 1% cmc $10^{-3}$</th>
<th>mmole/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>13a</td>
<td>3</td>
<td>30</td>
<td>9.5</td>
<td>79</td>
<td>35</td>
<td>127</td>
<td>118</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>32</td>
<td>10.5</td>
<td>95</td>
<td>26</td>
<td>111</td>
<td>126</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>11.0</td>
<td>&gt;100</td>
<td>20</td>
<td>95</td>
<td>134</td>
<td>3.9</td>
</tr>
<tr>
<td>13b</td>
<td>3</td>
<td>31</td>
<td>10.0</td>
<td>70</td>
<td>37</td>
<td>128</td>
<td>126</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>11.0</td>
<td>90</td>
<td>30</td>
<td>112</td>
<td>135</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>36</td>
<td>11.5</td>
<td>95</td>
<td>22</td>
<td>96</td>
<td>150</td>
<td>3.8</td>
</tr>
<tr>
<td>13c</td>
<td>3</td>
<td>32</td>
<td>10.5</td>
<td>68</td>
<td>40</td>
<td>130</td>
<td>133</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>12.0</td>
<td>87</td>
<td>33</td>
<td>115</td>
<td>140</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>13.5</td>
<td>93</td>
<td>25</td>
<td>98</td>
<td>155</td>
<td>3.6</td>
</tr>
<tr>
<td>16a</td>
<td>3</td>
<td>29</td>
<td>7.5</td>
<td>67</td>
<td>43</td>
<td>117</td>
<td>100</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>31</td>
<td>9.5</td>
<td>77</td>
<td>34</td>
<td>87</td>
<td>125</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>33</td>
<td>10.5</td>
<td>91</td>
<td>27</td>
<td>74</td>
<td>150</td>
<td>4.3</td>
</tr>
<tr>
<td>16b</td>
<td>3</td>
<td>30</td>
<td>8.5</td>
<td>63</td>
<td>46</td>
<td>120</td>
<td>105</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>32</td>
<td>10.5</td>
<td>72</td>
<td>39</td>
<td>90</td>
<td>128</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>35</td>
<td>12.0</td>
<td>88</td>
<td>30</td>
<td>77</td>
<td>146</td>
<td>4.1</td>
</tr>
<tr>
<td>16c</td>
<td>3</td>
<td>31</td>
<td>9.5</td>
<td>59</td>
<td>48</td>
<td>125</td>
<td>115</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>34</td>
<td>11.0</td>
<td>66</td>
<td>43</td>
<td>92</td>
<td>147</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>12.5</td>
<td>76</td>
<td>32</td>
<td>79</td>
<td>152</td>
<td>3.9</td>
</tr>
<tr>
<td>17a</td>
<td>3</td>
<td>29</td>
<td>9.0</td>
<td>69</td>
<td>46</td>
<td>118</td>
<td>113</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>31</td>
<td>10.5</td>
<td>74</td>
<td>36</td>
<td>86</td>
<td>127</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>11.0</td>
<td>84</td>
<td>27</td>
<td>74</td>
<td>142</td>
<td>4.1</td>
</tr>
<tr>
<td>17b</td>
<td>3</td>
<td>31</td>
<td>9.0</td>
<td>64</td>
<td>48</td>
<td>120</td>
<td>115</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>34</td>
<td>11.0</td>
<td>79</td>
<td>39</td>
<td>180</td>
<td>130</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>11.5</td>
<td>88</td>
<td>30</td>
<td>76</td>
<td>146</td>
<td>3.9</td>
</tr>
<tr>
<td>17c</td>
<td>3</td>
<td>33</td>
<td>9.5</td>
<td>61</td>
<td>52</td>
<td>123</td>
<td>119</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>36</td>
<td>11.5</td>
<td>76</td>
<td>42</td>
<td>90</td>
<td>133</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>12.0</td>
<td>91</td>
<td>32</td>
<td>70</td>
<td>154</td>
<td>3.8</td>
</tr>
<tr>
<td>18a</td>
<td>3</td>
<td>33</td>
<td>8.5</td>
<td>65</td>
<td>41</td>
<td>117</td>
<td>120</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>9.5</td>
<td>74</td>
<td>33</td>
<td>96</td>
<td>125</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>10.0</td>
<td>86</td>
<td>28</td>
<td>82</td>
<td>128</td>
<td>5.1</td>
</tr>
<tr>
<td>18b</td>
<td>3</td>
<td>34</td>
<td>9.0</td>
<td>62</td>
<td>44</td>
<td>118</td>
<td>120</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>37</td>
<td>10.5</td>
<td>70</td>
<td>36</td>
<td>97</td>
<td>127</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>11.0</td>
<td>92</td>
<td>30</td>
<td>83</td>
<td>130</td>
<td>4.9</td>
</tr>
<tr>
<td>18c</td>
<td>3</td>
<td>36</td>
<td>9.5</td>
<td>57</td>
<td>48</td>
<td>120</td>
<td>125</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>39</td>
<td>11.0</td>
<td>66</td>
<td>39</td>
<td>99</td>
<td>130</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>41</td>
<td>12.5</td>
<td>85</td>
<td>32</td>
<td>85</td>
<td>140</td>
<td>4.7</td>
</tr>
</tbody>
</table>
### Table (6): Cont.

<table>
<thead>
<tr>
<th>Comp.</th>
<th>n</th>
<th>Surface Tension (dyne/cm) 0.1%</th>
<th>Interfacial Tension (dyne/cm) 0.1%</th>
<th>Cloud Point °C 1%</th>
<th>Wetting time (sec) 0.1%</th>
<th>Emulsion stability (min.)</th>
<th>Foam height (mm) 1%</th>
<th>cmc x 10^-3 mole/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>19a</td>
<td>3</td>
<td>31</td>
<td>7.5</td>
<td>73</td>
<td>40</td>
<td>105</td>
<td>90</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>9.0</td>
<td>85</td>
<td>32</td>
<td>81</td>
<td>115</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>36</td>
<td>10.0</td>
<td>96</td>
<td>22</td>
<td>59</td>
<td>130</td>
<td>4.6</td>
</tr>
<tr>
<td>19b</td>
<td>3</td>
<td>32</td>
<td>8.0</td>
<td>69</td>
<td>43</td>
<td>108</td>
<td>92</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>10.0</td>
<td>82</td>
<td>34</td>
<td>84</td>
<td>117</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>11.0</td>
<td>92</td>
<td>26</td>
<td>62</td>
<td>132</td>
<td>4.4</td>
</tr>
<tr>
<td>19c</td>
<td>3</td>
<td>34</td>
<td>8.5</td>
<td>66</td>
<td>47</td>
<td>110</td>
<td>95</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>37</td>
<td>10.5</td>
<td>79</td>
<td>36</td>
<td>86</td>
<td>120</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>39</td>
<td>11.5</td>
<td>89</td>
<td>28</td>
<td>65</td>
<td>140</td>
<td>4.2</td>
</tr>
<tr>
<td>20a</td>
<td>3</td>
<td>30</td>
<td>7.0</td>
<td>71</td>
<td>45</td>
<td>125</td>
<td>115</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>32</td>
<td>7.5</td>
<td>83</td>
<td>30</td>
<td>88</td>
<td>128</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>9.0</td>
<td>97</td>
<td>22</td>
<td>76</td>
<td>150</td>
<td>4.2</td>
</tr>
<tr>
<td>20b</td>
<td>3</td>
<td>31</td>
<td>7.5</td>
<td>65</td>
<td>47</td>
<td>127</td>
<td>121</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>8.0</td>
<td>80</td>
<td>33</td>
<td>91</td>
<td>134</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>35</td>
<td>9.5</td>
<td>93</td>
<td>25</td>
<td>78</td>
<td>155</td>
<td>3.9</td>
</tr>
<tr>
<td>20c</td>
<td>3</td>
<td>32</td>
<td>8.0</td>
<td>63</td>
<td>49</td>
<td>130</td>
<td>126</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>9.5</td>
<td>78</td>
<td>35</td>
<td>94</td>
<td>143</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>37</td>
<td>11.5</td>
<td>91</td>
<td>27</td>
<td>81</td>
<td>160</td>
<td>3.8</td>
</tr>
<tr>
<td>23a</td>
<td>3</td>
<td>28</td>
<td>8.5</td>
<td>69</td>
<td>47</td>
<td>83</td>
<td>105</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>31</td>
<td>9.5</td>
<td>74</td>
<td>33</td>
<td>73</td>
<td>119</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>11.0</td>
<td>87</td>
<td>23</td>
<td>64</td>
<td>134</td>
<td>4.3</td>
</tr>
<tr>
<td>23b</td>
<td>3</td>
<td>30</td>
<td>8.5</td>
<td>63</td>
<td>49</td>
<td>78</td>
<td>110</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>33</td>
<td>10.5</td>
<td>70</td>
<td>36</td>
<td>85</td>
<td>126</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>36</td>
<td>12.0</td>
<td>83</td>
<td>25</td>
<td>75</td>
<td>141</td>
<td>4.0</td>
</tr>
<tr>
<td>23c</td>
<td>3</td>
<td>31</td>
<td>8.5</td>
<td>58</td>
<td>52</td>
<td>89</td>
<td>116</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>35</td>
<td>11.0</td>
<td>64</td>
<td>38</td>
<td>76</td>
<td>130</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>12.5</td>
<td>80</td>
<td>27</td>
<td>68</td>
<td>153</td>
<td>3.8</td>
</tr>
<tr>
<td>24a</td>
<td>3</td>
<td>31</td>
<td>9.0</td>
<td>72</td>
<td>38</td>
<td>81</td>
<td>112</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>32</td>
<td>10.0</td>
<td>81</td>
<td>32</td>
<td>68</td>
<td>125</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>34</td>
<td>12.0</td>
<td>92</td>
<td>23</td>
<td>57</td>
<td>140</td>
<td>4.6</td>
</tr>
<tr>
<td>24b</td>
<td>3</td>
<td>32</td>
<td>9.5</td>
<td>67</td>
<td>41</td>
<td>82</td>
<td>115</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>34</td>
<td>10.5</td>
<td>76</td>
<td>35</td>
<td>70</td>
<td>127</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>36</td>
<td>11.5</td>
<td>86</td>
<td>27</td>
<td>60</td>
<td>150</td>
<td>4.3</td>
</tr>
<tr>
<td>24c</td>
<td>3</td>
<td>34</td>
<td>10.0</td>
<td>61</td>
<td>43</td>
<td>85</td>
<td>120</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>36</td>
<td>11.5</td>
<td>69</td>
<td>37</td>
<td>72</td>
<td>130</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>38</td>
<td>12.5</td>
<td>84</td>
<td>30</td>
<td>63</td>
<td>155</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Table (7): Biodegradability of the Prepared Surfactants.

<table>
<thead>
<tr>
<th>No.</th>
<th>n</th>
<th>1st day</th>
<th>2nd day</th>
<th>3rd day</th>
<th>4th day</th>
<th>5th day</th>
<th>6th day</th>
<th>7th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>13a</td>
<td>3</td>
<td>54</td>
<td>67</td>
<td>77</td>
<td>86</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>60</td>
<td>69</td>
<td>81</td>
<td>92</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>58</td>
<td>64</td>
<td>73</td>
<td>88</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>13b</td>
<td>3</td>
<td>52</td>
<td>65</td>
<td>75</td>
<td>84</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>58</td>
<td>66</td>
<td>78</td>
<td>90</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>54</td>
<td>61</td>
<td>70</td>
<td>85</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>13c</td>
<td>3</td>
<td>50</td>
<td>64</td>
<td>73</td>
<td>82</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>46</td>
<td>57</td>
<td>64</td>
<td>76</td>
<td>87</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>52</td>
<td>59</td>
<td>68</td>
<td>79</td>
<td>87</td>
<td>94</td>
</tr>
<tr>
<td>16a</td>
<td>3</td>
<td>57</td>
<td>65</td>
<td>79</td>
<td>88</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>54</td>
<td>62</td>
<td>70</td>
<td>84</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>51</td>
<td>57</td>
<td>70</td>
<td>75</td>
<td>89</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>16b</td>
<td>3</td>
<td>55</td>
<td>64</td>
<td>77</td>
<td>86</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>59</td>
<td>72</td>
<td>81</td>
<td>89</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>55</td>
<td>66</td>
<td>75</td>
<td>83</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td>16c</td>
<td>3</td>
<td>54</td>
<td>63</td>
<td>76</td>
<td>84</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>58</td>
<td>69</td>
<td>78</td>
<td>87</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>46</td>
<td>53</td>
<td>63</td>
<td>72</td>
<td>80</td>
<td>88</td>
<td>96</td>
</tr>
<tr>
<td>17a</td>
<td>3</td>
<td>51</td>
<td>61</td>
<td>70</td>
<td>82</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>50</td>
<td>59</td>
<td>68</td>
<td>79</td>
<td>88</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>57</td>
<td>64</td>
<td>75</td>
<td>85</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>17b</td>
<td>3</td>
<td>49</td>
<td>59</td>
<td>68</td>
<td>79</td>
<td>90</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>57</td>
<td>65</td>
<td>75</td>
<td>83</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>53</td>
<td>61</td>
<td>71</td>
<td>80</td>
<td>89</td>
<td>95</td>
</tr>
<tr>
<td>17c</td>
<td>3</td>
<td>48</td>
<td>57</td>
<td>66</td>
<td>78</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>46</td>
<td>54</td>
<td>62</td>
<td>73</td>
<td>82</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>51</td>
<td>58</td>
<td>68</td>
<td>78</td>
<td>89</td>
<td>-</td>
</tr>
<tr>
<td>18a</td>
<td>3</td>
<td>53</td>
<td>63</td>
<td>72</td>
<td>82</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>59</td>
<td>68</td>
<td>78</td>
<td>89</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>48</td>
<td>55</td>
<td>64</td>
<td>76</td>
<td>83</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>18b</td>
<td>3</td>
<td>51</td>
<td>61</td>
<td>69</td>
<td>80</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48</td>
<td>57</td>
<td>65</td>
<td>75</td>
<td>85</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>52</td>
<td>62</td>
<td>72</td>
<td>79</td>
<td>89</td>
<td>97</td>
</tr>
<tr>
<td>18c</td>
<td>3</td>
<td>49</td>
<td>58</td>
<td>67</td>
<td>78</td>
<td>87</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>46</td>
<td>54</td>
<td>62</td>
<td>73</td>
<td>82</td>
<td>89</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>79</td>
<td>58</td>
<td>68</td>
<td>77</td>
<td>87</td>
<td>96</td>
</tr>
</tbody>
</table>
Table (7): Cont.

<table>
<thead>
<tr>
<th>No.</th>
<th>n</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; day</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; day</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; day</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>6&lt;sup&gt;th&lt;/sup&gt; day</th>
<th>7&lt;sup&gt;th&lt;/sup&gt; day</th>
</tr>
</thead>
<tbody>
<tr>
<td>19a</td>
<td>3</td>
<td>53</td>
<td>63</td>
<td>72</td>
<td>80</td>
<td>88</td>
<td>96</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>61</td>
<td>69</td>
<td>78</td>
<td>87</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>78</td>
<td>65</td>
<td>7</td>
<td>84</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>19b</td>
<td>3</td>
<td>51</td>
<td>61</td>
<td>70</td>
<td>77</td>
<td>86</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>58</td>
<td>76</td>
<td>75</td>
<td>84</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>55</td>
<td>62</td>
<td>71</td>
<td>80</td>
<td>89</td>
<td>97</td>
</tr>
<tr>
<td>19c</td>
<td>3</td>
<td>50</td>
<td>56</td>
<td>68</td>
<td>75</td>
<td>84</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>56</td>
<td>64</td>
<td>72</td>
<td>81</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>44</td>
<td>53</td>
<td>59</td>
<td>68</td>
<td>77</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>20a</td>
<td>3</td>
<td>55</td>
<td>67</td>
<td>78</td>
<td>88</td>
<td>95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>53</td>
<td>63</td>
<td>75</td>
<td>87</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>51</td>
<td>58</td>
<td>79</td>
<td>81</td>
<td>89</td>
<td>97</td>
<td>-</td>
</tr>
<tr>
<td>20b</td>
<td>3</td>
<td>53</td>
<td>65</td>
<td>76</td>
<td>86</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>61</td>
<td>73</td>
<td>85</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>49</td>
<td>55</td>
<td>67</td>
<td>77</td>
<td>85</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td>20c</td>
<td>3</td>
<td>53</td>
<td>64</td>
<td>75</td>
<td>86</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>58</td>
<td>70</td>
<td>82</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>46</td>
<td>53</td>
<td>64</td>
<td>75</td>
<td>83</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>23a</td>
<td>3</td>
<td>52</td>
<td>59</td>
<td>67</td>
<td>77</td>
<td>87</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>57</td>
<td>63</td>
<td>74</td>
<td>85</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>55</td>
<td>60</td>
<td>72</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>23b</td>
<td>3</td>
<td>49</td>
<td>57</td>
<td>64</td>
<td>75</td>
<td>84</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>47</td>
<td>54</td>
<td>61</td>
<td>72</td>
<td>81</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>52</td>
<td>58</td>
<td>69</td>
<td>75</td>
<td>89</td>
<td>95</td>
</tr>
<tr>
<td>23c</td>
<td>3</td>
<td>47</td>
<td>55</td>
<td>62</td>
<td>74</td>
<td>83</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>45</td>
<td>51</td>
<td>58</td>
<td>69</td>
<td>78</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>43</td>
<td>48</td>
<td>55</td>
<td>65</td>
<td>72</td>
<td>86</td>
<td>93</td>
</tr>
<tr>
<td>24a</td>
<td>3</td>
<td>55</td>
<td>65</td>
<td>78</td>
<td>85</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>53</td>
<td>63</td>
<td>75</td>
<td>82</td>
<td>87</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>50</td>
<td>57</td>
<td>71</td>
<td>78</td>
<td>84</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td>24b</td>
<td>3</td>
<td>53</td>
<td>63</td>
<td>75</td>
<td>82</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>51</td>
<td>59</td>
<td>72</td>
<td>79</td>
<td>85</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>55</td>
<td>67</td>
<td>75</td>
<td>81</td>
<td>88</td>
<td>95</td>
</tr>
<tr>
<td>24c</td>
<td>3</td>
<td>52</td>
<td>61</td>
<td>72</td>
<td>80</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49</td>
<td>57</td>
<td>68</td>
<td>76</td>
<td>83</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>45</td>
<td>52</td>
<td>65</td>
<td>72</td>
<td>79</td>
<td>90</td>
<td>-</td>
</tr>
</tbody>
</table>
Table (8): Antimicrobial activity of nonionic surfactants

<table>
<thead>
<tr>
<th>Compd.</th>
<th>Bacteria</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>\textit{Bacillus cercus} &amp; \textit{Bacillus circulans} &amp; \textit{Aspergillus's clavatus} &amp; \textit{Penicillium notatum}</td>
<td></td>
</tr>
<tr>
<td>13a</td>
<td>-        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>13b</td>
<td>+        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>13c</td>
<td>+        &amp; +</td>
<td>++</td>
</tr>
<tr>
<td>14a</td>
<td>-        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>14b</td>
<td>-        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>14c</td>
<td>-        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>15a</td>
<td>-        &amp; -</td>
<td>-</td>
</tr>
<tr>
<td>15b</td>
<td>-        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>15c</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>16a</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>16b</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>16c</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>17a</td>
<td>+        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>17b</td>
<td>-        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>17c</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>18a</td>
<td>-        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>18b</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>18c</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
<tr>
<td>19a</td>
<td>+        &amp; -</td>
<td>-</td>
</tr>
<tr>
<td>19b</td>
<td>+        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>19c</td>
<td>-        &amp; -</td>
<td>++</td>
</tr>
<tr>
<td>20a</td>
<td>+        &amp; +</td>
<td>-</td>
</tr>
<tr>
<td>20b</td>
<td>+        &amp; +</td>
<td>-</td>
</tr>
<tr>
<td>20c</td>
<td>+        &amp; +</td>
<td>-</td>
</tr>
<tr>
<td>21a</td>
<td>-        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>21b</td>
<td>-        &amp; -</td>
<td>+</td>
</tr>
<tr>
<td>21c</td>
<td>+        &amp; +</td>
<td>+</td>
</tr>
</tbody>
</table>
Table (8): Cont.

<table>
<thead>
<tr>
<th>Compd.</th>
<th>Bacteria</th>
<th></th>
<th>Fungi</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacillus circulus</td>
<td>Bacillus circulans</td>
<td>Aspergillus's clavatus</td>
<td>Penicillum notatum</td>
</tr>
<tr>
<td>22a</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>22b</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>22c</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>23a</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>23b</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>23c</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>24a</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>24b</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>24c</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>25a</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>25b</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>25c</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
</tbody>
</table>

(+++) Very strong inhibition, (++) strong inhibition, (+) moderate inhibition.
PART (3)

Anionic surfactants containing heterocyclic moiety from α-sulphonated fatty acid isothiocyanate

Among anionic surfactants containing an aromatic structure element are alkyl benzene sulphonate accompanied by alkyl-naphthalene sulfonates (222-225). In these compounds, hydrophilic sulfonic group is separated from long chain alkyl hydrophobe by single six member benzene or naphthalene rings. The structure analogues to the above ones may be surfactants containing five member heteroaromatic groups. It has been well established that various triazoles, oxazoles, benzoxazoles and thiazoles are of biological interest (203-205). This encourage us to synthesis a novel groups of anionic surfactants containing those nucleus from sodium salts of α-sulphonated long chain fatty acids (myristic, palmitic and stearic) isothiocyanate by reaction with different nucleophiles as phenyl hydrazine, glycine, anthranilic, o-aminophenol and thioglycollic acid, hopping to possess good surface properties and expected to have biological activities.

Synthesis of α-sulphonated fatty acid isothiocyanate.

The isothiocyanates of sodium salt of α-sulphonated fatty acids (myristic, palmitic and stearic) (27a-c) were prepared from its sodium salt of α-sulphonate fatty acid chloride (26a-c) (which prepared from the corresponding fatty acid with chlorosulphonic acid in carbon tetrachloride and then reacted with thionyl chloride) (20), through its reaction with ammonium thiocyanate in dry acetone as following:
Results and Discussion

\[ \text{R-CH-C-Cl} \xrightarrow{\text{acetone}} \text{R-CH-C-SN} \xrightarrow{\text{SO}_3\text{Na}} \text{rearrangement} \xrightarrow{\text{SO}_3\text{Na}} \text{R-CH-C-N=C=S} \]

\[
\text{(26a-c)} \quad R, \ a = C_{12}H_{25}, \ b = C_{14}H_{29}, \ c = C_{16}H_{33}
\]

The isothiocyanates (27a-c) were prepared in situ during the reaction to prevent its decomposition.

Synthesis of anionic surfactants containing heterocyclic compounds from \( \alpha \)-sulphonated fatty acid isothiocyanate.

1.-Synthesis of 1,2,4-triazoline-5-thione derivatives via the reaction of isothiocyanate (27a-c) with phenyl hydrazine.

When the solution of sodium salt of \( \alpha \)-sulphonated of fatty acid isothiocyanate (27a-c) in acetone was treated with phenyl hydrazine, it gave intermediate, which undergoes cyclization followed by dehydration to give 3 (\( \alpha \)-sulphonated alkyl)-2-phenyl-1,2,4-triazolinyl-5-thione (28a-c).

\[ \text{R-CH-C-N=C=S} + \text{PhNHNNH}_2 \xrightarrow{\text{cyclicization}} \text{R-CH-C-NH-C-NH-NH-Ph} \]

\[
\text{(27a-c)} \quad R, \ a = C_{12}H_{25}, \ b = C_{14}H_{29}, \ c = C_{16}H_{33}
\]
IR spectrum of (28c) shows, vNH at 3229, vC=N at 1600, vC=S at 1375, vSO₂ at 1180, 689 and vCH² of alkyl chain in region (2920-2850) cm⁻¹.

¹H NMR spectrum of (28c), the protons are assigned as follow δ 0.9 (t, 3H, terminal CH₃), δ 1.3 (s, 32H, CH₂ of alkyl chain), δ 2.3 (s, 1H, CH-SO₃Na), δ 7.4-8.2 (m, 5H, ArH) and δ 8.7 (s, 1H, NH). (cf. fig. 35).

2-Synthesis of 1,3-oxazolidine-5-one derivatives via the reaction of isothiocyanate (27a-c) with glycine.

Glycine reacts with sodium salt of α-sulphonated of fatty acid isothiocyanate (27a-c) in the presence of pyridine as a base to produce thiourea derivatives which cyclized to 2-(sodium salt of α-sulphonated amidoalkyl)-2-thiol-1,3-oxazolidine-5-one (29a-c).

IR spectrum of (29b) shows the following bands, vNH² at 3205 and 3319, vSH at 2061, vC=O² at 1647 and 1704, vSO₂ at 1178 and 672 cm⁻¹ (cf. fig.18).
3- Synthesis of quinazoline-2-thione -4-one derivatives via the reaction of isothiocyanate (27a-c) with anthranilic acid, followed cyclization.

Addition of anthranilic acid to sodium salt of α-sulphonated fatty acid isothiocyanate (27a-c) leads to the formation of thiourea derivatives (30a-c).

\[
\begin{align*}
R-\text{CH}_2-C-N=C=S & \quad \text{H}_2\text{N} & \quad \text{COOH} \\
\text{SO}_3\text{Na} & & \text{pyridine} & & \text{SO}_3\text{Na} & \quad \text{COOH} \\
(27a-c) & & & & (30a-c)
\end{align*}
\]

\( R, a = \text{C}_{12}\text{H}_{25}, \quad b = \text{C}_{14}\text{H}_{29}, \quad c = \text{C}_{16}\text{H}_{33} \)

IR spectrum of (30a) exhibits, \( \nu_{\text{OH}} \) at 3396, \( \nu_{\text{NH}} \) at 3121 and 3195, \( \nu_{\text{C}=\text{O}} \) of amido at 1650, \( \nu_{\text{C}=\text{O}} \) of acid at 1702, \( \nu_{\text{C}=\text{S}} \) at 1379 and \( \nu_{\text{SO}_2} \) at 1077 and 679 cm\(^{-1}\). Also there is a strong band at 2359 cm\(^{-1}\) for linear structure of the compound.

\(^1\)HNMR spectrum of (30c) shows the signals at \( \delta \) 0.9 (t, 3H, terminal CH\(_3\)), \( \delta \) 1.2-1.4 (m, 32H, CH\(_2\) of alkyl chain), \( \delta \) 3.9 (m, 2H, NH protons), \( \delta \) 9.3 (s, 1H, OH), \( \delta \) 7.3 (s, 4H, ArH) and \( \delta \) 2.1 (t, 1H, CHSO\(_3\)Na) (cf. fig.36).

Treating of thiourea derivatives (30a-c) with acetic anhydride yielded 1-N (sodium salt of α-sulphonated alkanoyl) 1,3-quinazoline-2-thione -4-one (31a-c).

\[
\begin{align*}
R-\text{CH}_2-C-N=C-N & \quad \text{COOH} & \quad \text{Ac}_2\text{O} & \quad \text{R-CH}_2-C-N \quad \text{COOH} \\
\text{SO}_3\text{Na} & & & \text{SO}_3\text{Na} & \quad \text{SO}_3\text{Na} \\
(30a-c) & & & (31a-c)
\end{align*}
\]

\( R, a = \text{C}_{12}\text{H}_{25}, \quad b = \text{C}_{14}\text{H}_{29}, \quad c = \text{C}_{16}\text{H}_{33} \)
\(^1\)HNMR spectrum of (32c) shows signals, δ 0.9 (t, 3H, CH₃-C-C), δ (1.2-1.6) (m, 32H, CH₂ of alkyl chain), δ (6.6-7.2) (m, 4H, ArH), δ (7.7-8.5) (a broad s, 1H, NH), δ 2.4 (t, 1H, CHSO₃Na). (cf. fig. 38).

Cyclization of thiocarbamate derivatives (32a-c) by fusion leads to evolution of H₂S gas and formation of 2-(sodium salt of α-sulphonated amidoalkyl)-1,3-benzoxazole (33a-c).

\[
\begin{align*}
R-\text{CH-C-NH-C-O} & \overset{\text{fusion}}{\rightarrow} R-\text{CH-C-NH-SH} \\
\text{SO₃Na} & \rightarrow \text{SO₃Na} \\
(32a-c) & \rightarrow (33a-c)
\end{align*}
\]

R, a = C₁₂H₂₅, b = C₁₄H₂₉, c = C₁₆H₃₃
IR spectrum of (33c) shows the following bands, νNH at 3228, νC=O at 1704, νC=N at 1599, νSO₂ at 1071, 1107 and νCH₂ aliphatic chain in region (2980-2850) cm⁻¹ (cf. fig.21).

¹HNMR spectrum of (33c) shows signals at δ 0.8 (t, 3H, CH₃-C-C), δ 1.2-1.4 (m, 32H, CH₂ alkyl chain), δ 2.1 (t, 1H, CHSO₃Na), δ 7.2-7.9 (m, 4H, ArH) and 3.6 (s, 1H, NH) which disappeared by addition of D₂O (cf. fig. 39).

5- Synthesis of 1,3-thiazolidine derivatives via the reaction of isothiocyanate (27a-c) with thioglycollic acid, followed by cyclization.

Thioglycollic acid reacts with sodium salt of α-sulphonated of fatty acid isothiocyanate (27a-c) to produce the adducts (34a-c).

\[
\begin{align*}
\text{R-CH-C-N=C=S} & \quad \text{HSCH₂COOH} \quad \text{---} \quad \text{R-CH-C-NH-C-S-CH₂COOH} \\
\text{SO₃Na} & \quad \text{SO₃Na} \\
\text{(27a-c)} & \quad \text{(34a-c)}
\end{align*}
\]

\[
R, a = C₁₂H₂₅, \quad b = C₁₄H₂₉, \quad c = C₁₆H₃₃
\]

IR spectrum of (34c) exhibits, νNH at 3183, νOH at 3450, νC=O of amid at 1654, νC=O of acid at 1710, νC=S at 1377 and νSO₂ at 1180 and 1268 cm⁻¹ (cf. fig. 22).

When the products (34a-c) were cyclized by acetic anhydride leads to the formation of 3-N (α-sulphonated alkanoyl)-1,3-thiazolidine-2-thione-4-one (35a-c).
Results and Discussion

\[
\text{R-CH-C-NH-C-S-CH}_2\text{COOH} \xrightarrow{\text{Ac}_2\text{O}} \text{R-CH-C-N}=\text{C-S}}\text{SO}_3\text{Na}\]

(34a-c)

\[
\text{R, a = C}_{12}\text{H}_{25}, \ b = \text{C}_{14}\text{H}_{29}, \ c = \text{C}_{16}\text{H}_{33}\]

IR spectrum of (35c) exhibits, a broad band for \(\nu\text{C}=\text{O}^{\text{a}}\) centered at 1690, \(\nu\text{SO}_2\), at 969 and \(\nu\text{CH}^{\text{a}}\) of alkyl chain in region (2920-2850) cm\(^{-1}\).

6-Synthesis of thiourea derivatives via the reaction of isothiocyanate (27a-c) with aniline.

Sodium salt of \(\alpha\)-sulphonated fatty acid isothiocyanate (27a-c) reacts with aniline to give thiourea derivatives (36a-c) as follow:

\[
\text{R-CH-C-N}=\text{C-S}}\text{SO}_3\text{Na} + \text{NH}_2 \rightarrow \text{R-CH-C-N}=\text{C-NH-N}}\text{SO}_3\text{Na}
\]

(36a-c)

R, a = C\(_{12}\)H\(_{25}\), b = C\(_{14}\)H\(_{29}\), c = C\(_{16}\)H\(_{33}\)

IR spectrum of (36a) exhibits, two bands at 3146 and 3205 for two \(\nu\text{NH}^{\text{a}}\), band at 1652 for \(\nu\text{C}=\text{O}\), at 1346 for \(\nu\text{C}=\text{S}\) and at 1137 and 1221 cm\(^{-1}\) for \(\nu\text{SO}_2\) (cf. fig. 23).
Surface active properties of anionic surfactants

Anionic surfactants are very widely distributed throughout science, technology, and everyday life. Examples which at once come to mind are the washing, wetting out of textile materials, the preparation of dispersions and emulsion, the application of agricultural and a wide variety of special uses, the number of which is continually increasing.

The surface active and related properties of the synthesized compounds including, surface and interfacial tension, Kraft point, wetting time, foaming and emulsification properties are given in (Table 10). Biodegradability and antimicrobial effects were examined and tested in (Table 11,12) respectively.

1- Surface and interfacial tension.

The synthesized anionic surfactants with heterocyclic moiety derivatives showed lower values for surface tension and interfacial tension. The results are recorded in (Table 10). It was found that, the lower values of surface and interfacial tension that may be due to the electrostatic repulsion between the ionized molecule as found by \(^{22}\) and these values are decreases with the decreasing in alkyl chain length as found by \(^{217}\).

2- Kraft point.

Kraft point of the prepared anionic surfactants was measured as the temperature where 1% dispersion becomes clear on gradual heating. All the synthesized surfactants are freely soluble in water at 1 wt % concentration and at any temperature. The synthesized anionic surfactants with heterocyclic moiety derivatives showed lower values for Kraft point, this fact may fail due to the presence of retarding groups in the same
molecule as found by [226]. In general, Kraft points measurements proved that the higher the molecular weight the higher the Kraft point.

3- Wetting time:

All the synthesized surfactants are good wetting agent, where wetting time increased as the alkyl chain length increase as found by [217]. The products were thus very effective as wetting agents in distilled water. So, they can find a wide application to play an important role as wetting agents in textile industry (Table 10).

4- Foaming height:

It is reported that the efficiency of surfactants as a foamer increases with increasing alkyl chain length as found by [218], where the prepared anionic surfactants with heterocyclic moiety recorded higher values of foaming height as found by [237] as recorded in (Table 10).

5- Emulsion stability:

The products of anionic surfactants are good emulsifying agents as may be seen in (Table 10) the emulsion stability increased with the molecular weight of the fatty acid moiety in the product as found by [218].

6- Ca\(^{++}\) Stability:

The calcium stability values show that the prepared surfactants can be used in hard water. The calcium stability decreased with an increase in the molecular weight of the hydrophobic part of the surfactant under the conditions of a constant temperature. Concerning the results in (Table 10).
7- Stability towards hydrolysis:

The results listed in (Table 10), revealed that, the prepared anionic surfactants are moderately stable in basic medium and the stability increases by increasing the alkyl chain length as found by \(^{(227)}\). Also, anionic surfactant containing heterocyclic moieties recorded high values toward alkaline hydrolysis as found by \(^{(226)}\).

Biodegradability.

The results showed that, the rate of degradation was decreased with increasing the molecular weight or alkyl chain length. This indicated that, the more bulky the molecule was the lower biodegradability of the surfactant as shown in (Table 11).

Biological activity.

The anionic surfactants containing heterocyclic moiety afforded a double function as surface active agents and antimicrobial activities. So, all the prepared surfactants were tested for their bactericidal activities against Eschericia Coli and Bacillus Cereus and their fungicidal activities against Aspergillus Flavus and Penicillium notatum. (Table 12), revealed that the presence of heterocyclic moiety in the prepared anionic surfactant molecule revealed an increase in the biological activity as found by \(^{(226)}\).
Table (9): Physical properties of prepared compounds

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./ Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>28a</td>
<td>C_{21}H_{32}N_{5}O_{3}S_{2}Na</td>
<td>461</td>
<td>Benz.</td>
<td>60</td>
<td>yellow</td>
<td>54.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.82</td>
</tr>
<tr>
<td>28b</td>
<td>C_{25}H_{36}N_{5}O_{3}S_{2}Na</td>
<td>489</td>
<td>Tol.</td>
<td>63</td>
<td>Pale</td>
<td>56.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>56.65</td>
</tr>
<tr>
<td>28c</td>
<td>C_{25}H_{40}N_{5}O_{3}S_{2}Na</td>
<td>517</td>
<td>Benz.</td>
<td>58</td>
<td>Red</td>
<td>58.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>58.61</td>
</tr>
<tr>
<td>29a</td>
<td>C_{17}H_{31}N_{2}O_{3}S_{2}Na</td>
<td>446</td>
<td>EtOH</td>
<td>55</td>
<td>White</td>
<td>45.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>45.93</td>
</tr>
<tr>
<td>29b</td>
<td>C_{19}H_{33}N_{2}O_{3}S_{2}Na</td>
<td>474</td>
<td>MeOH</td>
<td>57</td>
<td>yellow</td>
<td>48.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.44</td>
</tr>
<tr>
<td>29c</td>
<td>C_{21}H_{36}N_{2}O_{3}S_{2}Na</td>
<td>502</td>
<td>Benz.</td>
<td>53</td>
<td>Pale</td>
<td>50.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>50.43</td>
</tr>
<tr>
<td>30a</td>
<td>C_{22}H_{31}N_{2}O_{3}S_{2}Na</td>
<td>508</td>
<td>AcOH</td>
<td>73</td>
<td>yellow</td>
<td>51.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>52.12</td>
</tr>
<tr>
<td>30b</td>
<td>C_{24}H_{37}N_{2}O_{3}S_{2}Na</td>
<td>536</td>
<td>EtOH</td>
<td>70</td>
<td>Pale</td>
<td>53.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>53.95</td>
</tr>
<tr>
<td>30c</td>
<td>C_{26}H_{41}N_{2}O_{3}S_{2}Na</td>
<td>564</td>
<td>AcOH</td>
<td>75</td>
<td>Pale</td>
<td>55.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>55.55</td>
</tr>
<tr>
<td>31a</td>
<td>C_{22}H_{31}N_{2}O_{3}S_{2}Na</td>
<td>490</td>
<td>EtOH</td>
<td>60</td>
<td>Pale</td>
<td>53.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>53.93</td>
</tr>
<tr>
<td>31b</td>
<td>C_{24}H_{37}N_{2}O_{3}S_{2}Na</td>
<td>518</td>
<td>MeOH</td>
<td>63</td>
<td>Red</td>
<td>55.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>55.83</td>
</tr>
<tr>
<td>31c</td>
<td>C_{26}H_{39}N_{2}O_{3}S_{2}Na</td>
<td>546</td>
<td>AcOH</td>
<td>66</td>
<td>Red</td>
<td>57.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yellow</td>
<td>57.42</td>
</tr>
<tr>
<td>32a</td>
<td>C_{21}H_{31}N_{2}O_{3}S_{2}Na</td>
<td>480</td>
<td>Tol.</td>
<td>75</td>
<td>Brown</td>
<td>52.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>52.75</td>
</tr>
<tr>
<td>32b</td>
<td>C_{22}H_{37}N_{2}O_{3}S_{2}Na</td>
<td>508</td>
<td>Benz.</td>
<td>72</td>
<td>Brown</td>
<td>54.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.52</td>
</tr>
<tr>
<td>32c</td>
<td>C_{25}H_{41}N_{2}O_{3}S_{2}Na</td>
<td>536</td>
<td>Tol.</td>
<td>70</td>
<td>Red</td>
<td>55.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>brown</td>
<td>65.22</td>
</tr>
</tbody>
</table>
Table (9): Cont.

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./ Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>H</td>
</tr>
<tr>
<td>33a</td>
<td>C₂₁H₃₁N₂O₂SNa</td>
<td>446</td>
<td>Tol.</td>
<td>65</td>
<td>Brown</td>
<td>56.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56.83</td>
<td>7.22</td>
</tr>
<tr>
<td>33b</td>
<td>C₂₃H₃₄N₂O₃SNa</td>
<td>474</td>
<td>Benz.</td>
<td>62</td>
<td>Brown</td>
<td>58.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>58.42</td>
<td>7.54</td>
</tr>
<tr>
<td>33c</td>
<td>C₂₅H₃₆N₂O₄SNa</td>
<td>502</td>
<td>Benz.</td>
<td>60</td>
<td>Red brown</td>
<td>59.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.92</td>
<td>7.92</td>
</tr>
<tr>
<td>34a</td>
<td>C₁₇H₃₆NO₆S₃Na</td>
<td>463</td>
<td>MeOH</td>
<td>65</td>
<td>Yellow</td>
<td>44.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>44.22</td>
<td>6.65</td>
</tr>
<tr>
<td>34b</td>
<td>C₁₉H₃₈NO₆S₃Na</td>
<td>491</td>
<td>MeOH</td>
<td>63</td>
<td>Pale yellow</td>
<td>46.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46.55</td>
<td>7.22</td>
</tr>
<tr>
<td>34c</td>
<td>C₂₁H₄₀NO₆S₃Na</td>
<td>519</td>
<td>EtOH</td>
<td>68</td>
<td>Pale yellow</td>
<td>48.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.83</td>
<td>7.52</td>
</tr>
<tr>
<td>35a</td>
<td>C₁₇H₄₂NO₅S₃Na</td>
<td>445</td>
<td>EtOH</td>
<td>58</td>
<td>Pale yellow</td>
<td>45.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45.99</td>
<td>6.42</td>
</tr>
<tr>
<td>35b</td>
<td>C₁₉H₄₄NO₅S₃Na</td>
<td>473</td>
<td>MeOH</td>
<td>62</td>
<td>Pale yellow</td>
<td>48.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.35</td>
<td>6.85</td>
</tr>
<tr>
<td>35c</td>
<td>C₂₁H₄₆NO₅S₃Na</td>
<td>501</td>
<td>EtOH</td>
<td>66</td>
<td>Red yellow</td>
<td>50.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50.72</td>
<td>7.32</td>
</tr>
<tr>
<td>36a</td>
<td>C₂₁H₃₆N₂O₅S₂Na</td>
<td>464</td>
<td>Benz.</td>
<td>70</td>
<td>Yellow</td>
<td>54.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.45</td>
<td>7.25</td>
</tr>
<tr>
<td>36b</td>
<td>C₂₃H₄₈N₂O₅S₂Na</td>
<td>492</td>
<td>Tol.</td>
<td>73</td>
<td>Pale yellow</td>
<td>56.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56.22</td>
<td>7.73</td>
</tr>
<tr>
<td>36c</td>
<td>C₂₅H₄₄N₂O₅S₂Na</td>
<td>520</td>
<td>Tol.</td>
<td>75</td>
<td>Pale yellow</td>
<td>57.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57.82</td>
<td>7.95</td>
</tr>
</tbody>
</table>
Table (10): Surface properties of these compounds.

<table>
<thead>
<tr>
<th>No.</th>
<th>Surface Tension (dyne/cm) 0.1%</th>
<th>Interfacial Tension (dyne/cm) 0.1%</th>
<th>Kraft Point °C 1%</th>
<th>Wetting time (sec.) 0.1%</th>
<th>Emulsion stability (min.)</th>
<th>Foam height (mm) 0.1%</th>
<th>Ca$$^{++}$$ (ppm)</th>
<th>Stability to hydrolysis Min : Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>28a</td>
<td>30</td>
<td>7.5</td>
<td>17</td>
<td>65</td>
<td>54</td>
<td>200</td>
<td>450</td>
<td>38 : 15</td>
</tr>
<tr>
<td>28b</td>
<td>32</td>
<td>8.0</td>
<td>20</td>
<td>90</td>
<td>61</td>
<td>220</td>
<td>380</td>
<td>39 : 20</td>
</tr>
<tr>
<td>28c</td>
<td>34</td>
<td>8.5</td>
<td>25</td>
<td>123</td>
<td>65</td>
<td>225</td>
<td>350</td>
<td>39 : 55</td>
</tr>
<tr>
<td>29a</td>
<td>33</td>
<td>8.2</td>
<td>16</td>
<td>90</td>
<td>42</td>
<td>155</td>
<td>1460</td>
<td>44 : 25</td>
</tr>
<tr>
<td>29b</td>
<td>35</td>
<td>8.7</td>
<td>19</td>
<td>115</td>
<td>47</td>
<td>170</td>
<td>1350</td>
<td>45 : 12</td>
</tr>
<tr>
<td>29c</td>
<td>37</td>
<td>9.0</td>
<td>23</td>
<td>132</td>
<td>55</td>
<td>190</td>
<td>1200</td>
<td>45 : 55</td>
</tr>
<tr>
<td>30a</td>
<td>34</td>
<td>9.5</td>
<td>18</td>
<td>80</td>
<td>57</td>
<td>180</td>
<td>1240</td>
<td>37 : 16</td>
</tr>
<tr>
<td>30b</td>
<td>37</td>
<td>10.3</td>
<td>22</td>
<td>110</td>
<td>63</td>
<td>200</td>
<td>1150</td>
<td>38 : 31</td>
</tr>
<tr>
<td>30c</td>
<td>39</td>
<td>11.0</td>
<td>29</td>
<td>135</td>
<td>68</td>
<td>220</td>
<td>900</td>
<td>38 : 58</td>
</tr>
<tr>
<td>31a</td>
<td>33</td>
<td>11.4</td>
<td>16</td>
<td>100</td>
<td>51</td>
<td>185</td>
<td>1230</td>
<td>37 : 10</td>
</tr>
<tr>
<td>31b</td>
<td>35</td>
<td>12.0</td>
<td>21</td>
<td>115</td>
<td>56</td>
<td>200</td>
<td>1260</td>
<td>37 : 44</td>
</tr>
<tr>
<td>31c</td>
<td>37</td>
<td>12.5</td>
<td>27</td>
<td>126</td>
<td>60</td>
<td>230</td>
<td>850</td>
<td>38 : 03</td>
</tr>
<tr>
<td>32a</td>
<td>31</td>
<td>6.7</td>
<td>22</td>
<td>85</td>
<td>63</td>
<td>170</td>
<td>560</td>
<td>43 : 30</td>
</tr>
<tr>
<td>32b</td>
<td>33</td>
<td>7.0</td>
<td>25</td>
<td>100</td>
<td>67</td>
<td>190</td>
<td>500</td>
<td>44 : 10</td>
</tr>
<tr>
<td>32c</td>
<td>35</td>
<td>7.5</td>
<td>31</td>
<td>120</td>
<td>71</td>
<td>205</td>
<td>450</td>
<td>45 : 05</td>
</tr>
<tr>
<td>33a</td>
<td>32</td>
<td>8.7</td>
<td>17</td>
<td>90</td>
<td>61</td>
<td>180</td>
<td>1530</td>
<td>42 : 14</td>
</tr>
<tr>
<td>33b</td>
<td>34</td>
<td>9.2</td>
<td>22</td>
<td>105</td>
<td>66</td>
<td>200</td>
<td>1420</td>
<td>43 : 08</td>
</tr>
<tr>
<td>33c</td>
<td>36</td>
<td>10.0</td>
<td>26</td>
<td>115</td>
<td>72</td>
<td>215</td>
<td>1300</td>
<td>44 : 16</td>
</tr>
<tr>
<td>34a</td>
<td>30</td>
<td>8.5</td>
<td>22</td>
<td>95</td>
<td>57</td>
<td>210</td>
<td>1260</td>
<td>44 : 27</td>
</tr>
<tr>
<td>34b</td>
<td>32</td>
<td>9.0</td>
<td>25</td>
<td>120</td>
<td>59</td>
<td>220</td>
<td>1150</td>
<td>45 : 20</td>
</tr>
<tr>
<td>34c</td>
<td>34</td>
<td>9.5</td>
<td>28</td>
<td>134</td>
<td>64</td>
<td>235</td>
<td>950</td>
<td>46 : 3</td>
</tr>
<tr>
<td>35a</td>
<td>33</td>
<td>7.0</td>
<td>13</td>
<td>105</td>
<td>63</td>
<td>190</td>
<td>1360</td>
<td>43 : 15</td>
</tr>
<tr>
<td>35b</td>
<td>36</td>
<td>7.5</td>
<td>19</td>
<td>115</td>
<td>67</td>
<td>200</td>
<td>1240</td>
<td>43 : 59</td>
</tr>
<tr>
<td>35c</td>
<td>38</td>
<td>8.0</td>
<td>22</td>
<td>127</td>
<td>72</td>
<td>205</td>
<td>1120</td>
<td>44 : 43</td>
</tr>
<tr>
<td>36a</td>
<td>28</td>
<td>8.6</td>
<td>18</td>
<td>95</td>
<td>49</td>
<td>180</td>
<td>1420</td>
<td>39 : 18</td>
</tr>
<tr>
<td>36b</td>
<td>30</td>
<td>9.0</td>
<td>22</td>
<td>108</td>
<td>55</td>
<td>200</td>
<td>1360</td>
<td>40 : 02</td>
</tr>
<tr>
<td>36c</td>
<td>32</td>
<td>9.4</td>
<td>25</td>
<td>120</td>
<td>59</td>
<td>210</td>
<td>1300</td>
<td>40 : 48</td>
</tr>
</tbody>
</table>
Table (11): Biodegradability of the Prepared Surfactants.

<table>
<thead>
<tr>
<th>No.</th>
<th>1st day</th>
<th>2nd day</th>
<th>3rd day</th>
<th>4th day</th>
<th>5th day</th>
<th>6th day</th>
<th>7th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>28a</td>
<td>44</td>
<td>52</td>
<td>60</td>
<td>71</td>
<td>81</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28b</td>
<td>41</td>
<td>49</td>
<td>45</td>
<td>65</td>
<td>77</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>28c</td>
<td>38</td>
<td>45</td>
<td>51</td>
<td>62</td>
<td>70</td>
<td>84</td>
<td>-</td>
</tr>
<tr>
<td>29a</td>
<td>45</td>
<td>55</td>
<td>62</td>
<td>69</td>
<td>78</td>
<td>88</td>
<td>97</td>
</tr>
<tr>
<td>29b</td>
<td>41</td>
<td>50</td>
<td>58</td>
<td>66</td>
<td>75</td>
<td>85</td>
<td>-</td>
</tr>
<tr>
<td>29c</td>
<td>37</td>
<td>45</td>
<td>54</td>
<td>63</td>
<td>71</td>
<td>83</td>
<td>91</td>
</tr>
<tr>
<td>30a</td>
<td>41</td>
<td>51</td>
<td>64</td>
<td>75</td>
<td>90</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30b</td>
<td>38</td>
<td>46</td>
<td>58</td>
<td>72</td>
<td>87</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>30c</td>
<td>35</td>
<td>42</td>
<td>53</td>
<td>67</td>
<td>82</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td>31a</td>
<td>43</td>
<td>50</td>
<td>63</td>
<td>75</td>
<td>92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>31b</td>
<td>39</td>
<td>47</td>
<td>58</td>
<td>71</td>
<td>88</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>31c</td>
<td>37</td>
<td>44</td>
<td>54</td>
<td>68</td>
<td>75</td>
<td>89</td>
<td>94</td>
</tr>
<tr>
<td>32a</td>
<td>40</td>
<td>49</td>
<td>58</td>
<td>69</td>
<td>82</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>32b</td>
<td>37</td>
<td>46</td>
<td>55</td>
<td>64</td>
<td>79</td>
<td>88</td>
<td>97</td>
</tr>
<tr>
<td>32c</td>
<td>35</td>
<td>42</td>
<td>51</td>
<td>60</td>
<td>74</td>
<td>86</td>
<td>94</td>
</tr>
<tr>
<td>33a</td>
<td>47</td>
<td>55</td>
<td>66</td>
<td>77</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>33b</td>
<td>43</td>
<td>53</td>
<td>62</td>
<td>72</td>
<td>86</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>33c</td>
<td>39</td>
<td>50</td>
<td>58</td>
<td>68</td>
<td>83</td>
<td>89</td>
<td>95</td>
</tr>
<tr>
<td>34a</td>
<td>45</td>
<td>56</td>
<td>67</td>
<td>78</td>
<td>90</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>34b</td>
<td>42</td>
<td>52</td>
<td>64</td>
<td>75</td>
<td>87</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>34c</td>
<td>39</td>
<td>47</td>
<td>59</td>
<td>69</td>
<td>79</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>35a</td>
<td>49</td>
<td>58</td>
<td>69</td>
<td>80</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>35b</td>
<td>45</td>
<td>54</td>
<td>65</td>
<td>77</td>
<td>89</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>35c</td>
<td>41</td>
<td>51</td>
<td>61</td>
<td>73</td>
<td>84</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td>36a</td>
<td>44</td>
<td>53</td>
<td>64</td>
<td>76</td>
<td>89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>36b</td>
<td>41</td>
<td>50</td>
<td>60</td>
<td>71</td>
<td>86</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>36c</td>
<td>38</td>
<td>46</td>
<td>55</td>
<td>66</td>
<td>79</td>
<td>89</td>
<td>97</td>
</tr>
</tbody>
</table>
Table (12): Antimicrobial activity of the synthesized anionic surfactants.

<table>
<thead>
<tr>
<th>Compd</th>
<th>Bacteria</th>
<th>Fungi</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Bacillus cereus</em></td>
<td><em>Bacillus coli</em></td>
<td><em>Aspergillus's flavus</em></td>
</tr>
<tr>
<td>28a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28b</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>28c</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>29a</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>29b</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>29c</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>30a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30b</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30c</td>
<td>+++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>31a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>31b</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>31c</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>32a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32b</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>32c</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>33a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>33b</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>33c</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>34a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>34b</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>34c</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>35a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>35b</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>35c</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>36a</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>36b</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>36c</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

 (++++) Very strong inhibition, (++) strong inhibition, (+) moderate inhibition.
PART (4)

Amphoteric surfactants containing heterocyclic moiety

From the previously synthesized compounds which containing heterocyclic moiety and having a tertiary nitrogen atom, we planned to prepare a further type of surface active agents by treating a tertiary nitrogen atom with hydrogen peroxide or sodium chloroacetate to produce a novel groups of amphoteric surfactants having a double functions antimicrobial and surface active properties, where the amine oxides have excellent foam-stabilizing. They have been used in shampoos and high-duty liquid detergents where they provide detergency, emolliency, and foam-boosting activity \(^{228,229}\). They also perform well in heavy detergent formulations providing good colon detergency. The use of amine oxides in fabric softener formulation has also been reported \(^{230}\).

Synthesis of amine oxide derivatives.

The amine oxides were prepared \(^{104}\) by oxidation of a tertiary amine with aqueous hydrogen peroxide. So, 3-alkyl-2-phenyl-1,2,4-triazoliny1-5-thione (4a-c) were treated with H\(_2\)O\(_2\) to produce 3-alkyl-2-phenyl-2-oxid-1,2,4-triazoline-5-thione (37a-c).

\[
\begin{align*}
\text{R} & \quad \text{N} \quad \text{NH} \\
\text{Ph} & \quad \text{N} \quad \text{S} \\
\end{align*}
\]

(4a-c)

\[
\begin{align*}
\text{R} & \quad \text{N} \quad \text{NH} \\
\text{Ph} & \quad \text{N} \quad \text{S} & \quad \text{O} \\
\end{align*}
\]

(37a-c)

R, a = C\(_{15}\)H\(_{27}\), b = C\(_{15}\)H\(_{31}\), c = C\(_{17}\)H\(_{35}\)
Also, 3-alkanoyl-1,3-thiazolidine-2-thione-4-one (11a-c) was used to produce 3-oxide-3-alkanoyl-1,3-thiazohidine-2-thione-4-one (38a-c) by oxidation with H$_2$O$_2$:

\[
\begin{array}{c}
\text{R-C-N} \\
\text{O} \\
\text{S} \\
\text{S} \\
\text{O} \\
\end{array} + \text{H}_2\text{O}_2 \rightarrow \begin{array}{c}
\text{R-C-N} \\
\text{O} \\
\text{S} \\
\text{S} \\
\text{O} \\
\end{array}
\]

\((11a-c) \quad (38a-c)\)

\(R, \quad a = C_{13}H_{27}, \quad b = C_{15}H_{31}, \quad c = C_{17}H_{35}\)

Also, 1-N-alkanoyl-3-ethoxy-5-phenyl-1,2-pyrazole (21a-c) were used to give 1-N-alkanoyl-N-oxide-3-ethoxy-5-phenyl-1,2-pyrazole (39a-c) by oxidation with H$_2$O$_2$ as:

\[
\begin{array}{c}
\text{O} \\
\text{R-C-N} \\
\text{Ph} \\
\text{OC}_2\text{H}_5 \\
\end{array} + \text{H}_2\text{O}_2 \rightarrow \begin{array}{c}
\text{O} \\
\text{R-C-N} \\
\text{Ph} \\
\text{OC}_2\text{H}_5 \\
\end{array}
\]

\((21a-c) \quad (39a-c)\)

\(R, \quad a = C_{13}H_{27}, \quad b = C_{15}H_{31}, \quad c = C_{17}H_{35}\)

Finally, 3-N-amidoalkyl-2-phenyl-1,3-thiazole-4-one (24a-c) were used to prepare 3-N-amidoalkyl-3-N-oxide-2-phenyl-1,3-thiazole-4-one (40a-c) by treating with H$_2$O$_2$ as:

\[
\begin{array}{c}
\text{O} \\
\text{R-C-NH} \\
\text{Ph} \\
\text{S} \\
\text{O} \\
\end{array} + \text{H}_2\text{O}_2 \rightarrow \begin{array}{c}
\text{O} \\
\text{R-C-NH} \\
\text{Ph} \\
\text{O} \\
\text{S} \\
\end{array}
\]

\((24a-c) \quad (40a-c)\)

\(R, \quad a = C_{13}H_{27}, \quad b = C_{15}H_{31}, \quad c = C_{17}H_{35}\)
**Results and Discussion**

All synthesized compounds were confirmed by:

IR spectrum of (38a) shows band at 1360 cm\(^{-1}\) for vN-O, beside the original bands of the compound.

Mass spectrum of (38b) shows a molecular ion peak at M\(^+\) + 1 = 387, 3.02\% and base peak at m/z = 57, 100\%. (cf. fig 49, chart 11).

![Chart 11](chart11.png)
Surface active properties of amphoteric surfactants

The surface active and related properties of the synthesized compounds including, surface and interfacial tension, Kraft point, wetting time, foaming and emulsification properties are given in (Table 14). Biodegradability and biological activity also determined and the results are listed in table (15,16) respectively.

1- Surface and interfacial tension:

In general, surface and interfacial tensions increased with increasing alkyl chain length, where amine oxide surfactants with heterocyclic moiety recorded higher value as found by\(^{(132)}\) of surface and interfacial tension as shown in Table (14).

2- Kraft point:

The Kraft points, of individual chain are listed in (table 14). The results indicated that the values of Kraft point increase by increasing the number of hydrophilic group's. All the synthesized amphoteric surfactants are soluble in water and the higher molecular weight is the higher Kraft points measurements as shown in Table (14).

3- Wetting time:

Also, wetting time increased as the alkyl chain length increased. The products were thus very effective as wetting agents in distilled water. So, they confined a wide application to play an important role as wetting agents in textile industry.

4- Foaming height:

Foaming height was reported that the efficiency of surfactants as a foamier increase with increasing alkyl chain length as found by\(^{(132)}\). In
general, the prepared amphoteric surfactants from amine oxide recorded higher foam height as shown in Table (14).

5- Emulsion stability:

The prepared amphoteric surfactants afforded higher emulsification stability as found by \(^{(102)}\), these results, might lead to the application of the surfactant of choice in pesticide and cosmetic formulation.

6- Stability towards hydrolysis:

Concerning to the stability towards acid and base hydrolysis, all the prepared surfactants have higher stability in acidic than in basic medium. The results listed in (Table 14), revealed that, the stability increases by increasing the alkyl chain length. Also, the prepared surfactant containing heterocyclic moieties recorded high values toward stability to hydrolysis as found by \(^{(227)}\).

Biodegradation.

The results showed that, the biodegradability decreased with increasing molecular weight or alkyl chain length as shown in Table (15). Also amphoteric surfactants containing heterocyclic moiety afforded a lower biodegradability due to the easy degradation for the heterocyclic moiety as found by \(^{(132)}\).

Biological activities

All the prepared surfactants were tested for their bactericidal activities against Bacillus subtilis and Bacillus cereus and their fungicidal activities against Aspergillus flavus and Pencillium notatum. Table (16) gives the presence of heterocyclic moiety in the prepared surfactant molecule revealed an increase in the biological activity and a decrease in biodegradability.
### Table (13): Physical properties of prepared compounds

<table>
<thead>
<tr>
<th>No.</th>
<th>M.F.</th>
<th>M.wt</th>
<th>Solvent</th>
<th>Yield %</th>
<th>Color</th>
<th>Analysis data calc./ Found %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>37a</td>
<td>C_{21}H_{31}N_{6}OS</td>
<td>375</td>
<td>Tol.</td>
<td>30</td>
<td>White</td>
<td>67.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.51</td>
</tr>
<tr>
<td>37b</td>
<td>C_{23}H_{27}N_{5}OS</td>
<td>403</td>
<td>Tol.</td>
<td>35</td>
<td>White yellow</td>
<td>68.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.69</td>
</tr>
<tr>
<td>37c</td>
<td>C_{24}H_{41}N_{6}OS</td>
<td>431</td>
<td>Benz.</td>
<td>32</td>
<td>White yellow</td>
<td>69.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.84</td>
</tr>
<tr>
<td>38a</td>
<td>C_{19}H_{28}NO_{3}S_{2}</td>
<td>359</td>
<td>EtOH</td>
<td>30</td>
<td>Yellow</td>
<td>56.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56.99</td>
</tr>
<tr>
<td>38b</td>
<td>C_{18}H_{33}NO_{3}S_{2}</td>
<td>387</td>
<td>EtOH</td>
<td>32</td>
<td>Yellow</td>
<td>58.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59.23</td>
</tr>
<tr>
<td>38c</td>
<td>C_{21}H_{37}NO_{3}S_{2}</td>
<td>415</td>
<td>AcOH</td>
<td>35</td>
<td>Pale yellow</td>
<td>60.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.91</td>
</tr>
<tr>
<td>39a</td>
<td>C_{23}H_{36}N_{2}O_{3}S</td>
<td>420</td>
<td>MeOH</td>
<td>30</td>
<td>White yellow</td>
<td>65.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65.93</td>
</tr>
<tr>
<td>39b</td>
<td>C_{23}H_{40}N_{2}O_{3}S</td>
<td>448</td>
<td>EtOH</td>
<td>35</td>
<td>Yellow</td>
<td>66.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.31</td>
</tr>
<tr>
<td>39c</td>
<td>C_{27}H_{44}N_{2}O_{3}S</td>
<td>476</td>
<td>EtOH</td>
<td>37</td>
<td>Yellow</td>
<td>68.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.32</td>
</tr>
<tr>
<td>40a</td>
<td>C_{25}H_{40}N_{2}O_{3}</td>
<td>416</td>
<td>Benz.</td>
<td>30</td>
<td>White</td>
<td>72.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.36</td>
</tr>
<tr>
<td>40b</td>
<td>C_{27}H_{44}N_{2}O_{3}</td>
<td>444</td>
<td>Tol.</td>
<td>32</td>
<td>White</td>
<td>72.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78.27</td>
</tr>
<tr>
<td>40c</td>
<td>C_{29}H_{48}N_{2}O_{3}</td>
<td>472</td>
<td>Tol.</td>
<td>35</td>
<td>White yellow</td>
<td>37.72</td>
</tr>
</tbody>
</table>
Table (14): Surface properties of these compounds.

<table>
<thead>
<tr>
<th>No.</th>
<th>Surface Tension (dyne/cm) 0.1</th>
<th>Interfacial Tension (dyne/cm) 0.1</th>
<th>Kraft Point °C 1%</th>
<th>Wetting time (sec.) 0.1%</th>
<th>Emulsion stability (min.) 1%</th>
<th>Foam height (mm) 1%</th>
<th>Stability to hydrolysis Min : Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>37a</td>
<td>38</td>
<td>6.2</td>
<td>21</td>
<td>86</td>
<td>55</td>
<td>113</td>
<td>31 : 15</td>
</tr>
<tr>
<td>37b</td>
<td>40</td>
<td>6.7</td>
<td>25</td>
<td>95</td>
<td>59</td>
<td>136</td>
<td>32 : 33</td>
</tr>
<tr>
<td>37c</td>
<td>41</td>
<td>8.7</td>
<td>29</td>
<td>106</td>
<td>64</td>
<td>145</td>
<td>34 : 16</td>
</tr>
<tr>
<td>38a</td>
<td>35</td>
<td>5.7</td>
<td>18</td>
<td>96</td>
<td>51</td>
<td>116</td>
<td>35 : 20</td>
</tr>
<tr>
<td>38b</td>
<td>37</td>
<td>7.0</td>
<td>26</td>
<td>101</td>
<td>55</td>
<td>135</td>
<td>36 : 08</td>
</tr>
<tr>
<td>38c</td>
<td>39</td>
<td>11.3</td>
<td>34</td>
<td>112</td>
<td>60</td>
<td>165</td>
<td>37 : 36</td>
</tr>
<tr>
<td>39a</td>
<td>33</td>
<td>7.5</td>
<td>25</td>
<td>108</td>
<td>71</td>
<td>70</td>
<td>42 : 43</td>
</tr>
<tr>
<td>39b</td>
<td>35</td>
<td>8.0</td>
<td>32</td>
<td>112</td>
<td>75</td>
<td>87</td>
<td>44 : 02</td>
</tr>
<tr>
<td>39c</td>
<td>37</td>
<td>10.5</td>
<td>37</td>
<td>120</td>
<td>82</td>
<td>112</td>
<td>45 : 13</td>
</tr>
<tr>
<td>40a</td>
<td>33</td>
<td>10.0</td>
<td>23</td>
<td>116</td>
<td>63</td>
<td>95</td>
<td>39 : 46</td>
</tr>
<tr>
<td>40b</td>
<td>34</td>
<td>11.5</td>
<td>30</td>
<td>122</td>
<td>68</td>
<td>108</td>
<td>40 : 54</td>
</tr>
<tr>
<td>40c</td>
<td>36</td>
<td>12.5</td>
<td>35</td>
<td>130</td>
<td>74</td>
<td>117</td>
<td>41 : 32</td>
</tr>
</tbody>
</table>