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# Novel Synthesized Cationic Gemini Surfactants Bearing Amido Group and Their Application in Nanotechonoly

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## ABSTRACT

A nonionic modified cationic gemini surfactants (MEGS, PEGS, SEGS and OEGS) were synthesized via Chloroacetic acid was taken to react with ethylene glycol compound in the presence p-Toluene sulfonic acid as acid catalyst and dry benzene as a required solvent to form the diester compound. Secondly, A various fatty acids as myristic, palmitic, stearic and oleic acids were reacted with 3-(*N, N* Dimethylamino)-1-propylamine in the presence a dry benzene as a solvent to form the corresponding fatty acid amides (MA, PA, SA, OA). Finally, the quaternarization process was done by treatment of the prepared diester compound and the obtained fatty acid amides (MA, PA, SA, OA) in ethanol as a solvent to produce the corresponding cationic gemini surfactants (MEGS, PEGS, SEGS and OEGS). The chemical structures of the synthesized Gemini surfactants were elucidated by FTIR and $^{1}$HNMR spectroscopic tools. The evaluation of surface and thermodynamic properties was studied, leading to conclude the potential ability of the synthesized surfactants to be adsorbed in solutions which means the applicability in a wide range industrial field.

***Keywords:*** Surfactants, Gemini surfactants, Surface activity, Nanotechnology**,** Design.

## 1. Introduction

The word surfactant is consisting of the three words) Surface Active Agents (surfactants are materials that lower the surface & interfacial tensions between two liquids or between liquid and solid (Gezer, *et al.,* 2011 and Farn, 1992). The unusual characteristic properties of surfactants in solution especially at the interfaces owe it to the presence of distinct hydrophilic as well as hydrophobic domains in the same molecule (Moroi, 1992 and Schramm, 2000). Surfactants are compounds that gathered at the interface of fluids and change its property. They are mainly used to lower or increase one's solubility into another and this leads to the formation of a more stable fluid boundaries (Rapp, 2017). More precisely, any substance or material that perturbs the surface and interfacial tension is considered as a surfactant. Practically, surfactants can be used as wetting agents, emulsifiers, foaming agents, dispersants, and corrosion inhibitor (Gezer, *et al.,* 2011, Farn, 1992, Rapp, 2017, Abbott, 2015, Gwaltney-Brant, 2012 and Prieto-Blanco, *et al.,* 2007).

Surfactants molecules have Amphipathic structure. It composed of two major groups; head or hydrophobic group which is water loving group (water-soluble) can be neutral or charged, and tail or hydrophobic group usually hydrocarbon chain in aqueous solvent can be linear or branched. Hydrophilic group can be expressed in an acid anion and a hydrophobic group, such as an alkyl chain. Water loving molecules tend to congregate near the former and water repelling groups congregate near the latter (Gezer, *et al.,* 2011and Rapp, 2017).

Nanotechnology is the manipulation of matter on a near-molecule scale to produce new structures, materials and devices. The technology promises scientific advancement in many sectors such as medicine, consumer products, energy, materials and manufacturing (Cross, 1986) Nanotechnology is generally defined as engineered structures, devices, and systems. Nanomaterials are defined as those things that have a length scale between 1 and 100 nanometers (Michel, *et al.,* 2012). At this size, materials begin to exhibit unique properties that affect physical, and biological

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behavior. Researching, developing, and utilizing these properties is at the heart of new technology. Workers within nanotechnology-related industries have the potential to be exposed to uniquely engineered materials with novel sizes, shapes, and physical and chemical properties. Occupational health risks associated with manufacturing and using nanomaterials are not yet clearly understood. Minimal information is currently available on dominant exposure routes, potential exposure levels, and material toxicity of nanomaterials (Torres-Torres, *et al.,* 2015, Seung, *et al.,* 2003, Jean, and Albertus, 2011, Batista, *et al.,* 2015, Nix, and William, 2016, Chien-Chun, *et al.,* 2013, Dan, *et al.,* 2014, Ibrahim, *et al.,* 2019, Rabenberg, and Ferreira, 2008, Mirkin, 2021, Panikkanvalappil, *et al.,* 2011, and Andrea, and Michael, 2016.

## 2. Materials

Myristic, Oleic, Palmitic and Stearic acids were purchased from obtained from Algomhoria Chemical Co., Cairo, Egypt. 3-(*N, N* Dimethylamino)-1-propylamine (99%), chloroacetic Acid, polyethyleneglycol-400 and p-Toluene sulfonic acid were purchased from Sigma-Aldrich Chemicals Co. Methanol, dry benzene, diethyl ether, and sodium sulfate anhydrous were purchased from AL-Nasr Chemicals Company. All the required solvents and reagents were utilized as received without further purification.

## 3. Result and Discussion

### 3.1. Synthesis

As shown in Figure 1, the general synthesis procedure of the target cationic gemini surfactants consists of three steps. Initially, Chloroacetic acid was taken to react with ethylene glycol compound in the presence p-Toluene sulfonic acid as acid catalyst and dry benzene as a required solvent to form the diester compound. Secondly, A various fatty acids as myristic, palmitic, stearic and oleic acids were reacted with 3-(*N, N* Dimethylamino)-1-propylamine in the presence a dry benzene as a solvent to form the corresponding fatty acid amides (MA, PA, SA, OA). Finally, the quaternarization process was done by treatment of the prepared diester compound and the obtained fatty acid amides (MA, PA, SA, OA) in ethanol as a solvent to produce the corresponding cationic gemini surfactants (MEGS, PEGS, SEGS and OEGS) with yields equal to 77 and 81%, respectively. The structure of synthesized cationic gemini surfactants was investigated using various spectroscopic tools.

### 3.2. Spectroscopic analysis of the synthesized compounds.

**FT-IR spectrum of diester compound.**

The spectrum showed the appearance of ester group at 1735 $cm^{-1}$ (νC=O ester) (Figure 2).

***N*-(3-(dimethylamino) propyl)tetradecanamide (MA)**

The FT-IR spectra confirm the expected functional groups in the synthesized by showing bands at 3308 $cm^{-1}$ (νNH stretching), 2814-2763 $cm^{-1}$ (νCH aliphatic chain), 1640 $cm^{-1}$ (νC=O amide), 1556 $cm^{-1}$ (νNH bending), 1463$cm^{1}$ (ν$CH_2$ bending), 1329 $cm^{-1}$ (ν$CH_3$ bending), 1042 $cm^{1}$ (νC–N alkyl stretching).

$^{1}$H NMR spectra showed signals

at: δ = 0.85 ppm (t, 3H, $CH_3CH_2$), 1.17 ppm (m, 24H, $CH_3CH_2$), 1.48 ppm (m, 2H, $NHCOCH_2CH_2$), 2.04 ppm (m, 2H, $NHCH_2CH_2CH_2$), 2.19 ppm (t, 2H, $NHCOCH_2$), 2.71 ppm (s, 6H, $^{+}N(CH_3)_2$), 3.1 ppm (t, 2H, $NHCH_2CH_2CH_2$), 3.62 – 3.44 ppm(t, 2H, $NHCH_2CH_2CH_2$), 8.0 ppm (s, 1H, CONH), (Figure 3.)

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**N-(3-(dimethylamino)propyl)palmitamide (PA)**

The FT-IR spectra showed the expected functional groups in *N*-(3-(dimethylamino)propyl) palmitamide (PA)*;* bands at 3307 $cm^{-1}$ (νNH stretching), 2815-2763 $cm^{-1}$ (νCH aliphatic chain), 1640$cm^{-1}$ (νC=O amide), 1556 $cm^{-1}$ (νNH bending), 1463 $cm^{-1}$ (ν$CH_2$ bending), 1346 $cm^{-1}$ (ν$CH_3$ bending), 1042 $cm^{-1}$ (νC–N alkyl stretching).

$^{1}$H NMR spectra showed signals

at: δ = 0.85 ppm (t, 3H, $CH_3CH_2$), 1.2 ppm (m, 24H, $CH_3CH_2$), 1.49 ppm (m, 2H, $NHCOCH_2CH_2$), 2.05 ppm (m, 2H, $NHCH_2CH_2CH_2$), 2.19 ppm (t, 2H, $NHCOCH_2$), 2.7 ppm (s, 6H, $^{+}N(CH_3)_2$), 3.1 ppm (t, 2H, $NHCH_2CH_2CH_2$), 3.9 ppm (t, 2H, $NHCH_2CH_2CH_2$), 7.7 ppm (s, 1H, CONH) (Figure 3.4.).

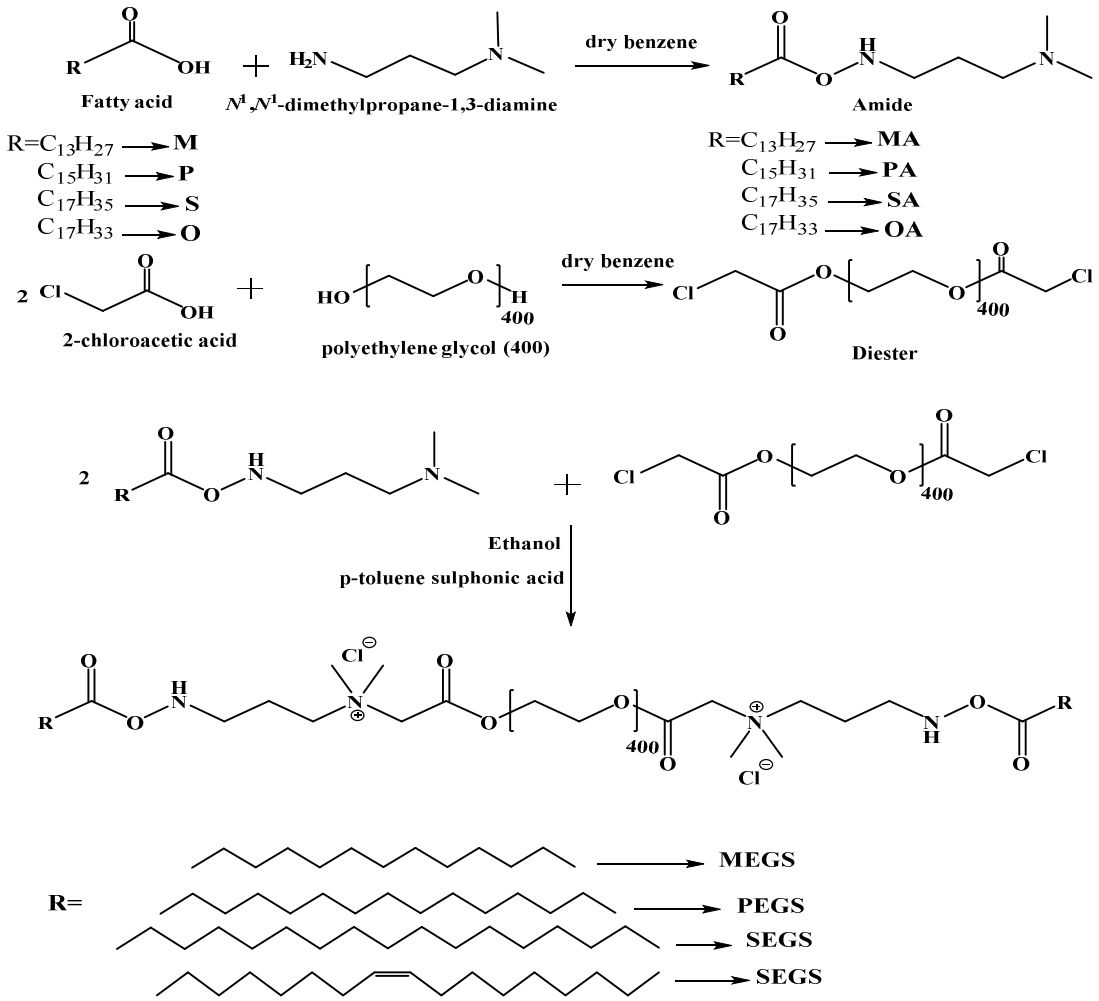


**Fig. 1:** Schematic procedure for synthesis the target cationic gemini surfactants **(MEGS, PEGS, SEGS and OEGS).**

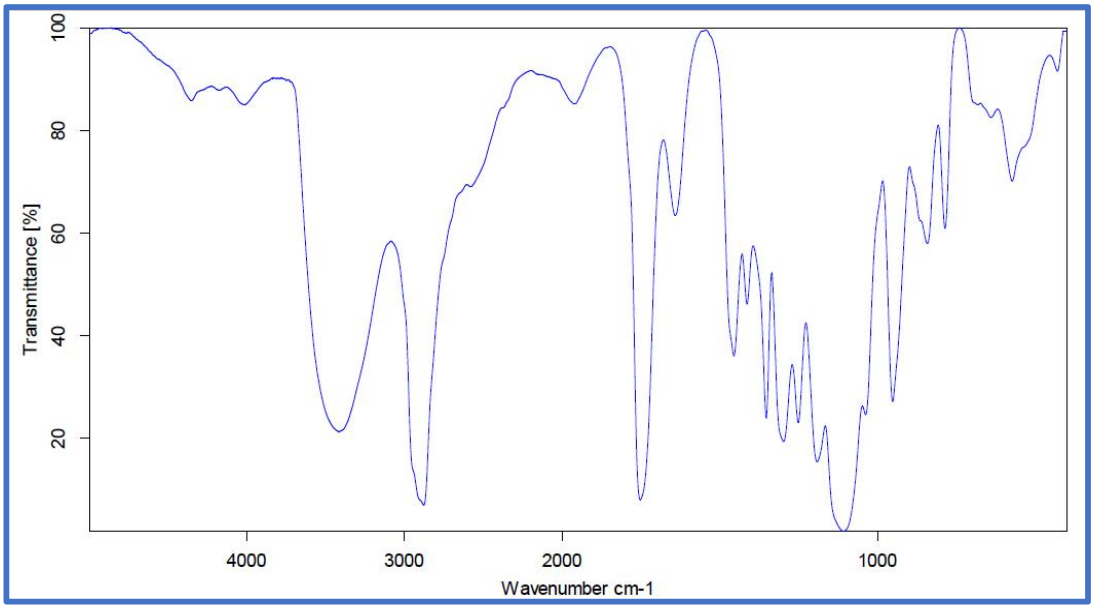


**Fig. 2:** IR spectrum of diester compound.

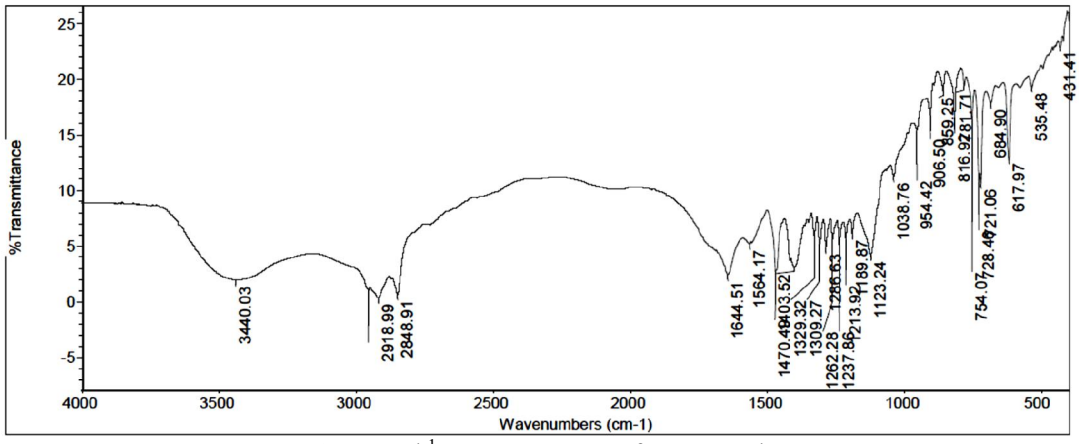


**Fig. 3:** IR and $^{1}$H NMR spectra of compound MA

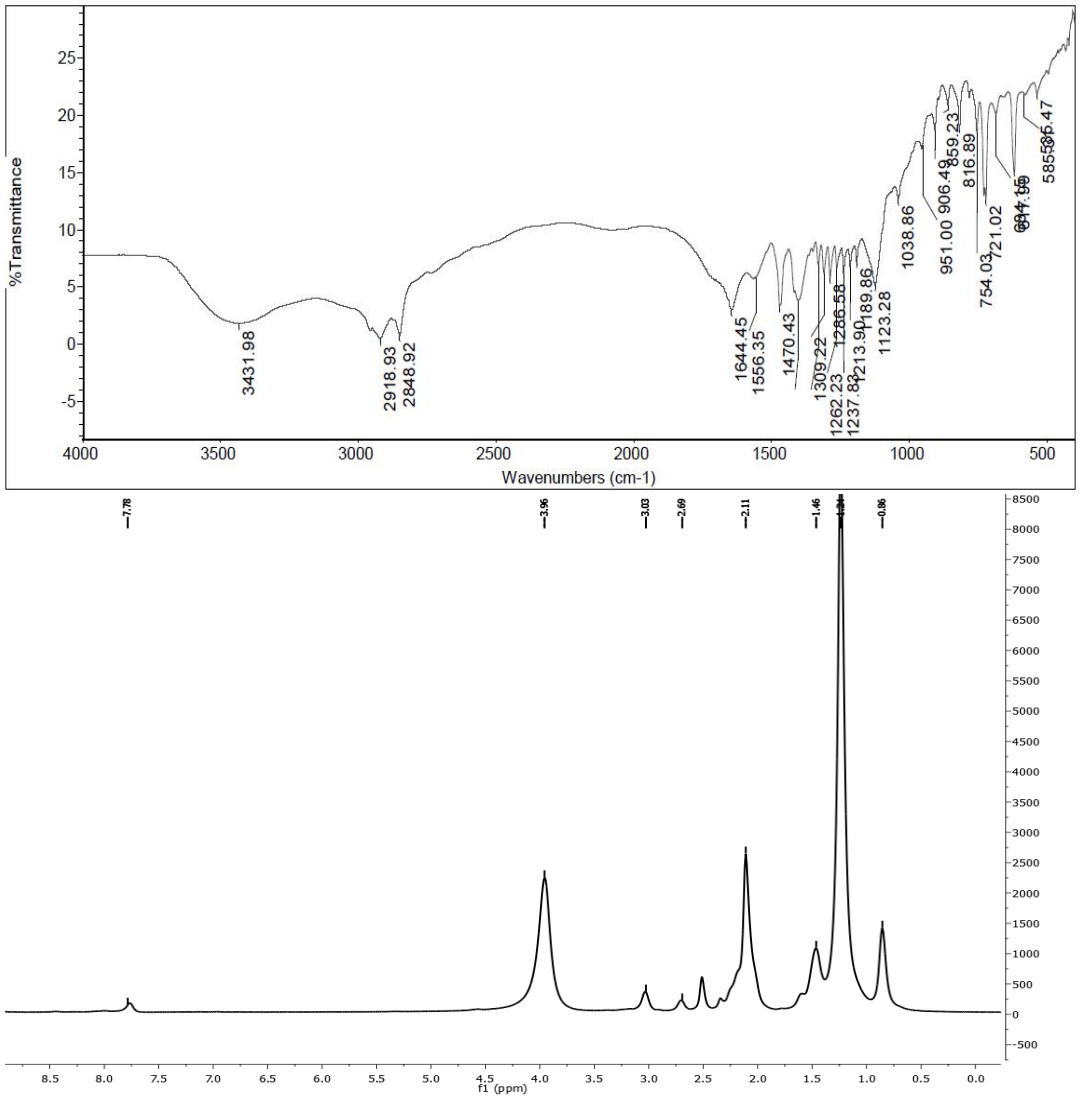


**Fig. 4:** IR and $^{1}$H NMR spectra of compound PA

**N-(3-(dimethylamino) propyl)stearamide (SA)**

The FT-IR spectrum confirm the expected functional groups by showing bands at 3316 $cm^{-1}$ (νNH stretching), 2850-2763 $cm^{-1}$ (νCH aliphatic chain), 1637 $cm^{-1}$ (νC=O amide), 1543 $cm^{-1}$ (νNH bending), 1469 $cm^{-1}$ (ν$CH_2$ bending), 1312 $cm^{-1}$(ν$CH_3$ bending), 1042 $cm^{-1}$ (νC–N alkyl stretching). $^1$H NMR spectrum showed signals

at: δ = 0.85 ppm (t, 3H, $CH_3CH_2$), 1.25 ppm (m, 56H, $CH_3CH_2$), 2.04 ppm (m, 2H, $NHCH_2CH_2CH_2$), 2.17 ppm (t, 2H, $NHCOCH_2$), 2.28 ppm (s, 6H, $^+N(CH_3)_2$), 3.05 ppm (t, 2H, $NHCH_2CH_2CH_2$), 3.7 ppm (t, 2H, $NHCH_2CH_2CH_2$), 7.75 ppm (s, 1H, CONH) (Figure 5.).

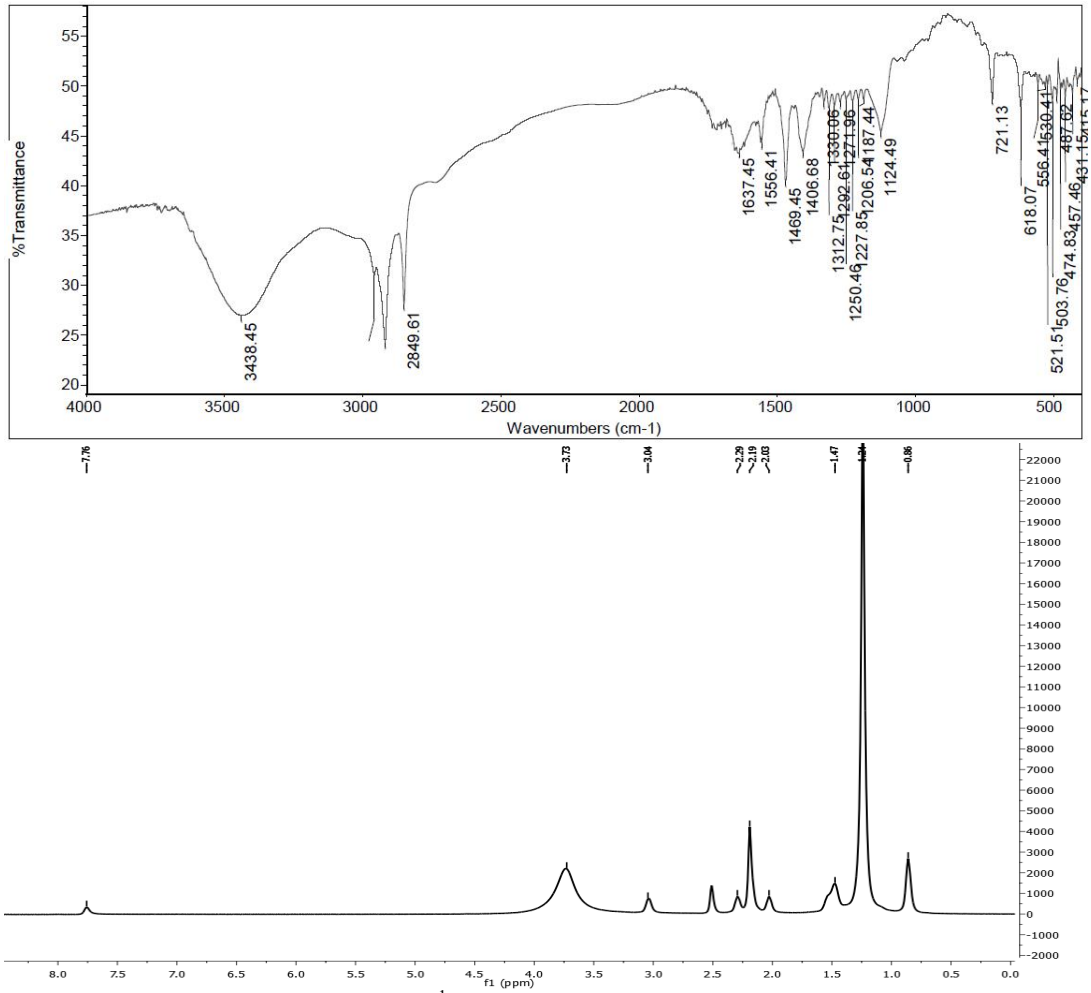


**Fig. 5:** IR and $^1$H NMR spectra of compound SA

**N-(3-(dimethylamino) propyl)oleamide (OA)**

The FT-IR spectra showed the expected functional groups in *N*-(3-(dimethylamino)propyl)oleamide (OA); at 3297 $cm^{-1}$ (νNH stretching), 3005 $cm^{-1}$ (νC=C stretching), 2854-2766 $cm^{-1}$ (νCH aliphatic chain), 1647 $cm^{-1}$ (νC=O amide), 1555 $cm^{-1}$ (νNH bending), 1464 $cm^{-1}$ (ν$CH_2$ bending), 1378 $cm^{-1}$ (ν$CH_3$ bending), 1041 $cm^{-1}$ (νC–N alkyl stretching) (Figure 6).

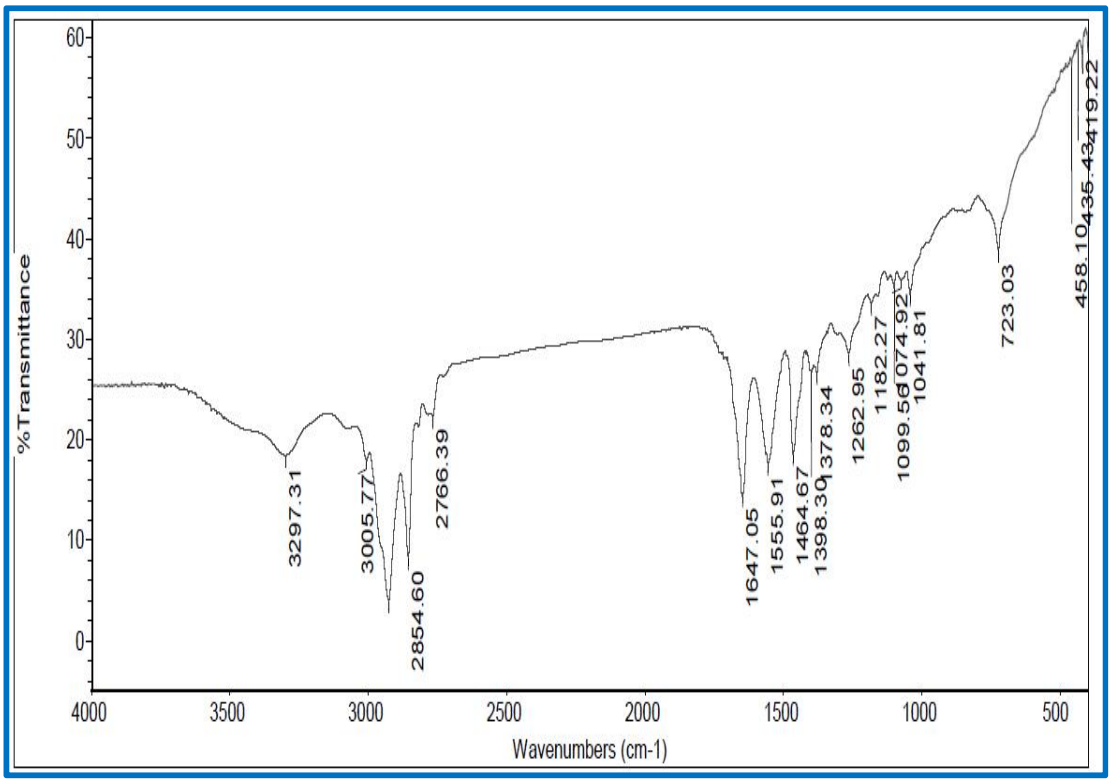


**Fig. 6:** IR spectrum of *N*-(3-(dimethylamino)propyl)oleamide (**OA**)

**N,N'-((ethane-1,2-diylbis(oxy))bis(2-oxoethane-2,1-diyl))bis (N,N-dimethyl-3- ((meristoyloxy) amino) propan-1-aminium) (MEGS).**

The FT-IR spectra showed bands at 3405 $cm^{-1}$ (νNH stretching), 2852 $cm^{-1}$ (νCH aliphatic chain), 1746 $cm^{-1}$ (νC=O ester), 1653 $cm^{-1}$ (νC=O amide), 1567 $cm^{-1}$ (νNH bending), 1467 $cm^{1}$ (ν$CH_2$ bending), 1352 $cm^{-1}$ (ν$CH_3$ bending), 1035 $cm^{1}$ (νC–N alkyl stretching), 592 $cm^{-1}$ (νC–CL stretching).

$^{1}$H NMR spectrum showed signals at: δ =0.83 ppm (t, 6H, $CH_3$), 1.07-1.2 ppm (m, 40H, $CH_3CH_2$), 1.46 ppm (m, 4H, $NHCOCH_2CH_2$ ) 2.07 ppm (m, 4H, $NHCH_2CH_2CH_2$ ), 2.5 ppm (t, 4H, $NHCOCH_2$), 3.1 ppm (t, 4H, $NHCH_2CH_2CH_2$), 3.4 ppm (s, 12H, $^{+}N(CH_3)_2$), 4.2 ppm (s, 4H, $^{+}NCH_2COO$), 4.39-4.62 ppm (t, $OCH_2CH_2O$), 8.02 ppm (s, 2H, CONH).

$^{13}$C NMR (101 MHz, DMSO) δ 188.44, 173.12, 70.23, 55.06, 49.03, 42.64, 40.49, 40.28, 40.07, 39.86, 39.65, 39.44, 39.23, 36.07, 35.84, 31.75, 29.50, 29.42, 29.28, 29.17, 25.69, 24.81, 22.54, 14.37. (Figure 7).

**N,N'-((ethane-1,2-diylbis(oxy)) bis (2-oxoethane-2,1-diyl))bis (N,N-dimethyl-3-((palmitoyloxy) amino)propan-1-aminium) (PEGS)**

The FT-IR spectrum showed bands at 3381 $cm^{-1}$ (νNH stretching), 2853 $cm^{-1}$ (νCH aliphatic chain), 1747 $cm^{-1}$ (νC=O ester), 1648 $cm^{-1}$ (νC=O amide), 1548 $cm^{-1}$ (νNH bending), 1466 $cm^{-1}$ (ν$CH_2$ bending), 1352 $cm^{-1}$ (ν$CH_3$ bending), 1034 $cm^{-1}$ (νC–N alkyl stretching), 721 $cm^{-1}$ (νC–CL stretching).

$^{1}$H NMR spectrum showed signals at: δ = 0.72 ppm (t, 6H, $CH_3$), 1.12 ppm (m, 48H, $CH_3CH_2$), 1.4 ppm (m, 4H, $NHCOCH_2CH_2$ ), 1.78 ppm (m, 4H, $NHCH_2CH_2$ $CH_2$ ), 2.01 ppm (t, 4H, $NHCOCH_2$), 3.03 ppm (t, 4H, $NHCH_2CH_2CH_2$), 3.37 ppm (s, 12H, $^{+}N(CH_3)_2$), 3.8 ppm (t, 4H, $NHCH_2$ $CH_2CH_2$), 4.14 ppm (s, 4H, $^{+}NCH_2COO$), 4.3-4.48 ppm (t, $OCH_2CH_2O$), 8.1 ppm (s, 2H, CONH) (Figure 8).

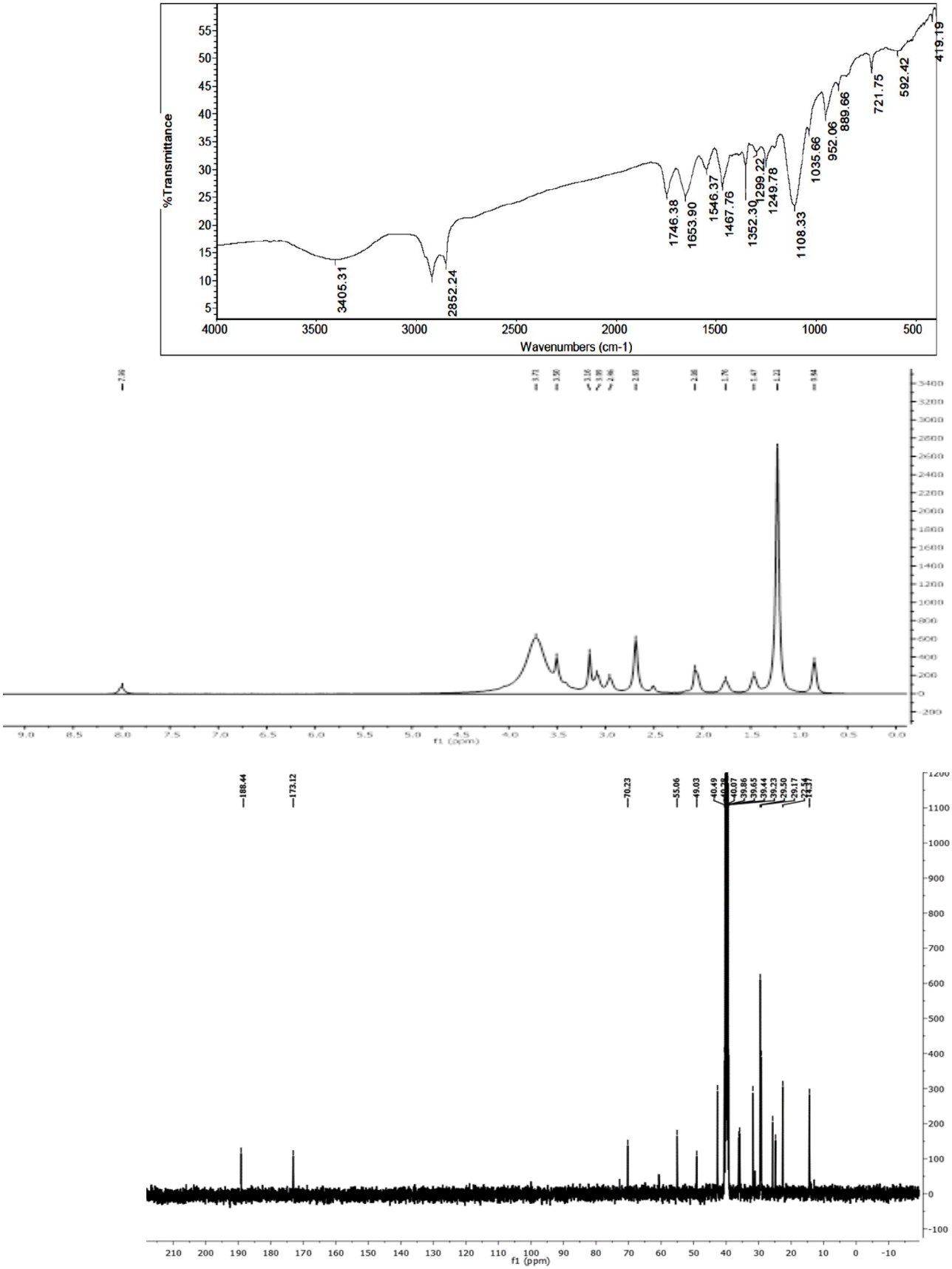


**Fig. 3.7:** IR, $^{1}H$ and $^{13}C$ NMR spectra of compound MEGS

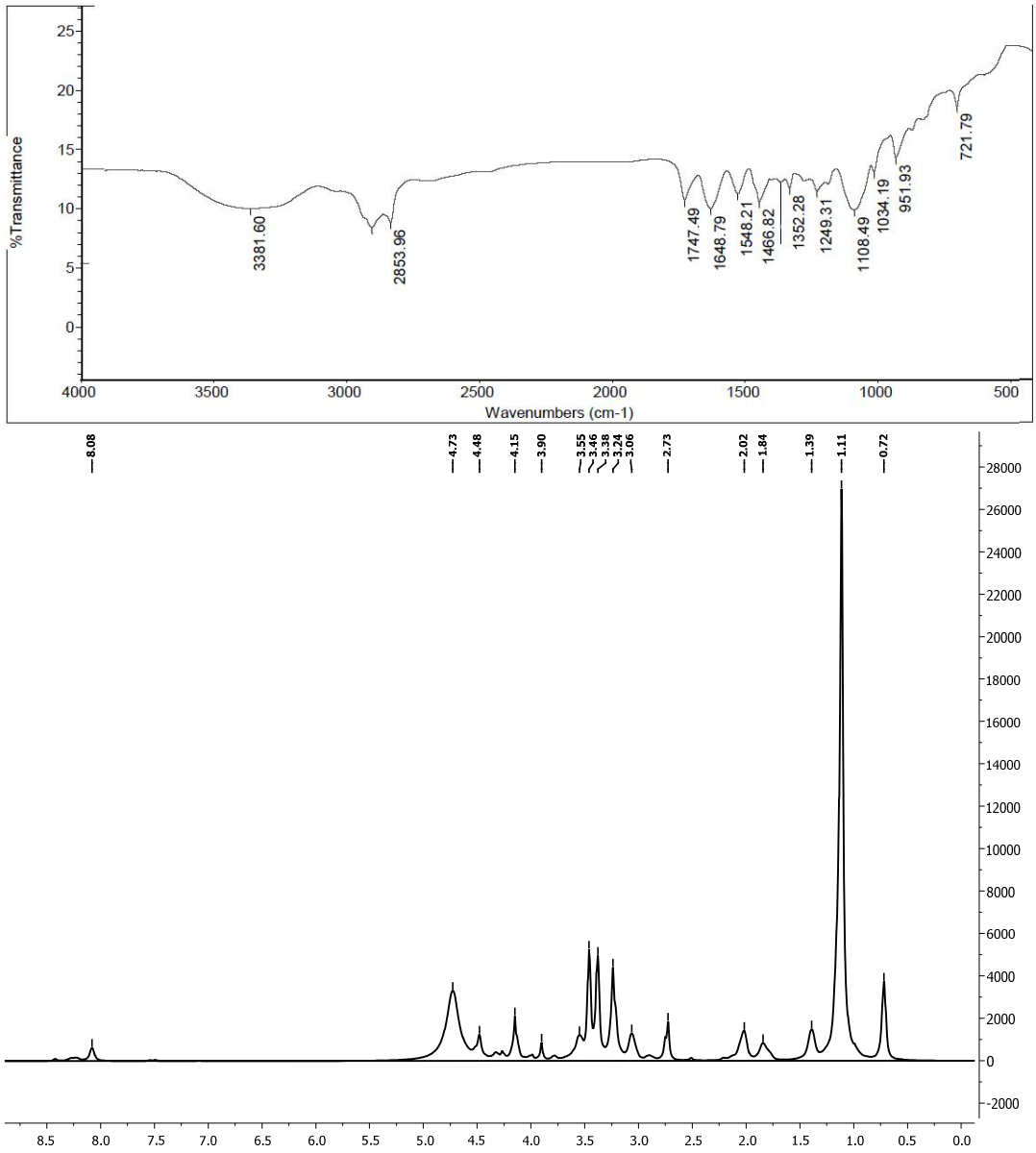


**Fig. 3.8:** IR and $^{1}H$ NMR spectra of compound PEGS

**N,N'-((ethane-1,2-diylbis(oxy))bis(2-oxoethane-2,1-diyl))bis(N,N-dimethyl-3-((stearoyloxy)amino) propan-1-aminium) (SEGS)**

The FT-IR spectrum showed bands at 3381 $cm^{-1}$ (νNH stretching), 2725 $cm^{-1}$ (νCH aliphatic chain), 1746$cm^{-1}$ (νC=O ester), 1652 $cm^{-1}$ (νC=O amide), 1549 $cm^{-1}$ (νNH bending), 1467 $cm^{-1}$ (νCH$_2$ bending), 1352 $cm^{-1}$(νCH$_3$ bending), 1034 $cm^{-1}$ (νC–N alkyl stretching), 585 $cm^{-1}$ (νC–CL stretching). 1041 $cm^{-1}$ (νC–N alkyl stretching).

$^{1}H$ NMR spectrum showed signals at: δ =0.8 ppm (t, 6H, CH$_3$), 1.2-1.8 ppm (m, 64H, CH$_3$CH$_2$), 2.1 ppm (m, 4H, NHCH$_2$CH$_2$CH$_2$ ), 2.5 ppm (t, 4H, NHCOCH$_2$), 3.1 ppm (t, 4H, NHCH$_2$CH$_2$CH$_2$), 3.4 ppm (s, 12H, $^{+}$N(CH$_3$)$_2$), 4.12 ppm (s, 4H, $^{+}$NCH$_2$COO), 4.57 ppm (t, OCH$_2$CH$_2$O), 8.03 ppm (s, 2H, CONH).

$^{13}C$ NMR (101 MHz, DMSO) δ 186.25, 173.10, 81.78, 55.34, 50.88, 49.05, 43.03, 40.50, 40.29, 40.08, 39.87, 39.66, 39.46, 39.25, 35.85, 31.74, 31.13, 29.48, 29.14, 25.69, 25.23, 22.54, 14.39. (Figure 9).

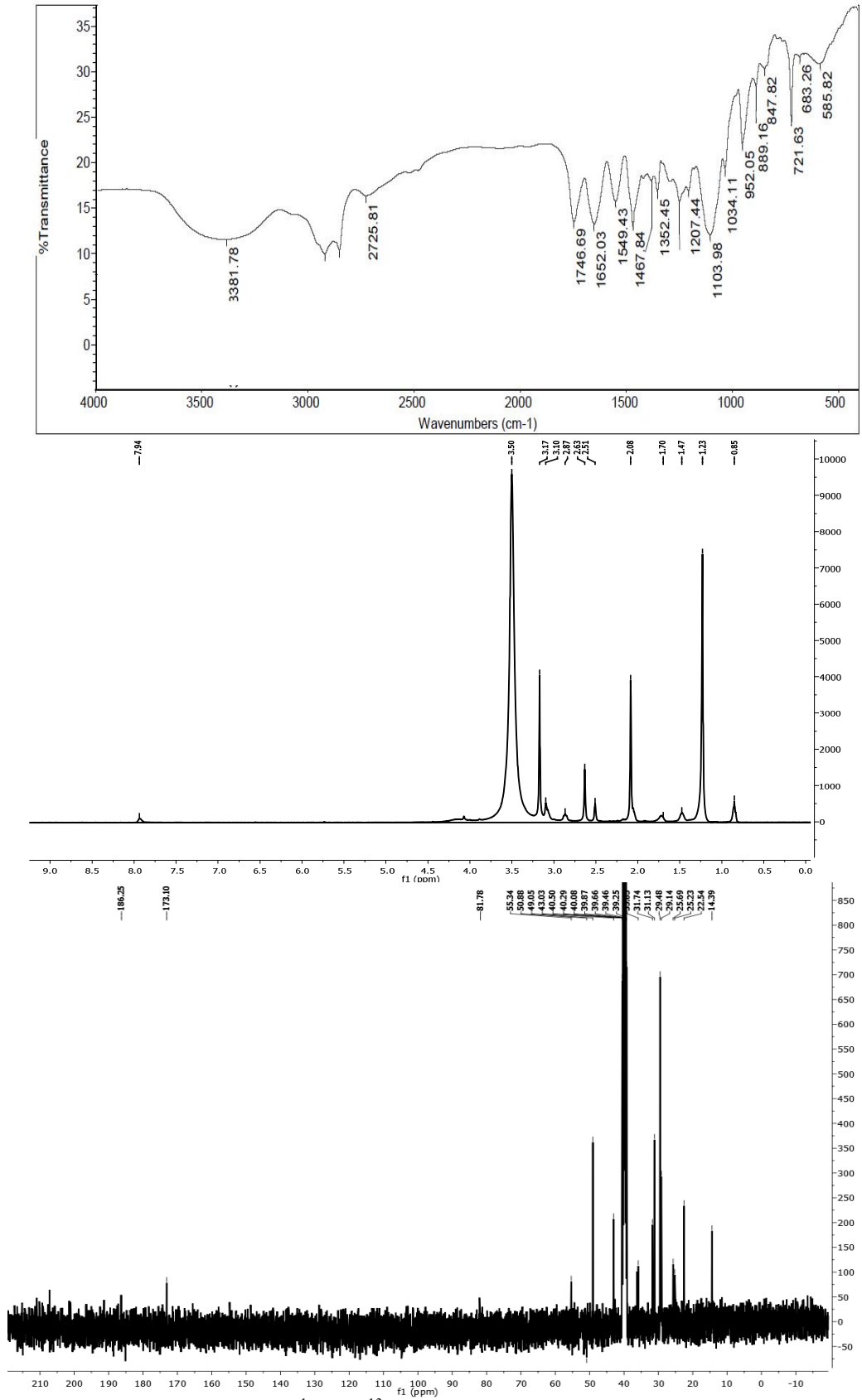


**Fig. 3.9:** IR, $^{1}H$ and $^{13}C$ NMR spectra of compound SEGS

**N,N'-((ethane-1,2-diylbis(oxy))bis (2-oxoethane-2,1-diyl)) bis(N,N-dimethyl-3-((oleroyloxy) amino) propan-1-aminium) (OEGS)**

The FT-IR spectrum showed bands at 3420 $cm^{-1}$ (νNH stretching), 3006 $cm^{-1}$ (νC=C stretching), 2854 $cm^{-1}$ (νCH aliphatic chain), 1745 $cm^{-1}$ (νCO ester), 1651 $cm^{-1}$ (νC=O amide), 1550 $cm^{-1}$ (νNH bending), 1466 $cm^{-1}$ (ν$CH_2$ bending), 1352 $cm^{-1}$ (ν$CH_3$ bending), 1034 $cm^{-1}$ (νC–N alkyl stretching), 600 $cm^{-1}$ (νC–CL stretching).

$^1$H NMR spectrum showed signals at: δ =0.8 ppm (t, 6H, $CH_3$), 1.07-1.2 ppm (m, 40H, $CH_3(CH_2)_n$), 1.46 ppm (m, 4H, $NHCOCH_2CH_2$ ) 1.9 ppm (m, 4H, $NHCH_2CH_2CH_2$ ), 2 ppm (t, 4H, $NHCOCH_2$), 2.11 ppm (m, 8H, $CH_2CHCHCH_2$), 3.09 ppm (t, 4H, $NHCH_2CH_2CH_2$), 3.3 ppm (s, 12H, $^+N(CH_3)_2$), 4.17 ppm (s, 4H, $^+NCH_2COO$), 4.3-4.46 ppm (t, $OCH_2CH_2O$), 5.19 ppm (t, 4H, $CH_2CHCHCH_2$), 8.07 ppm (s, 2H, CONH) (Figure 3.10).

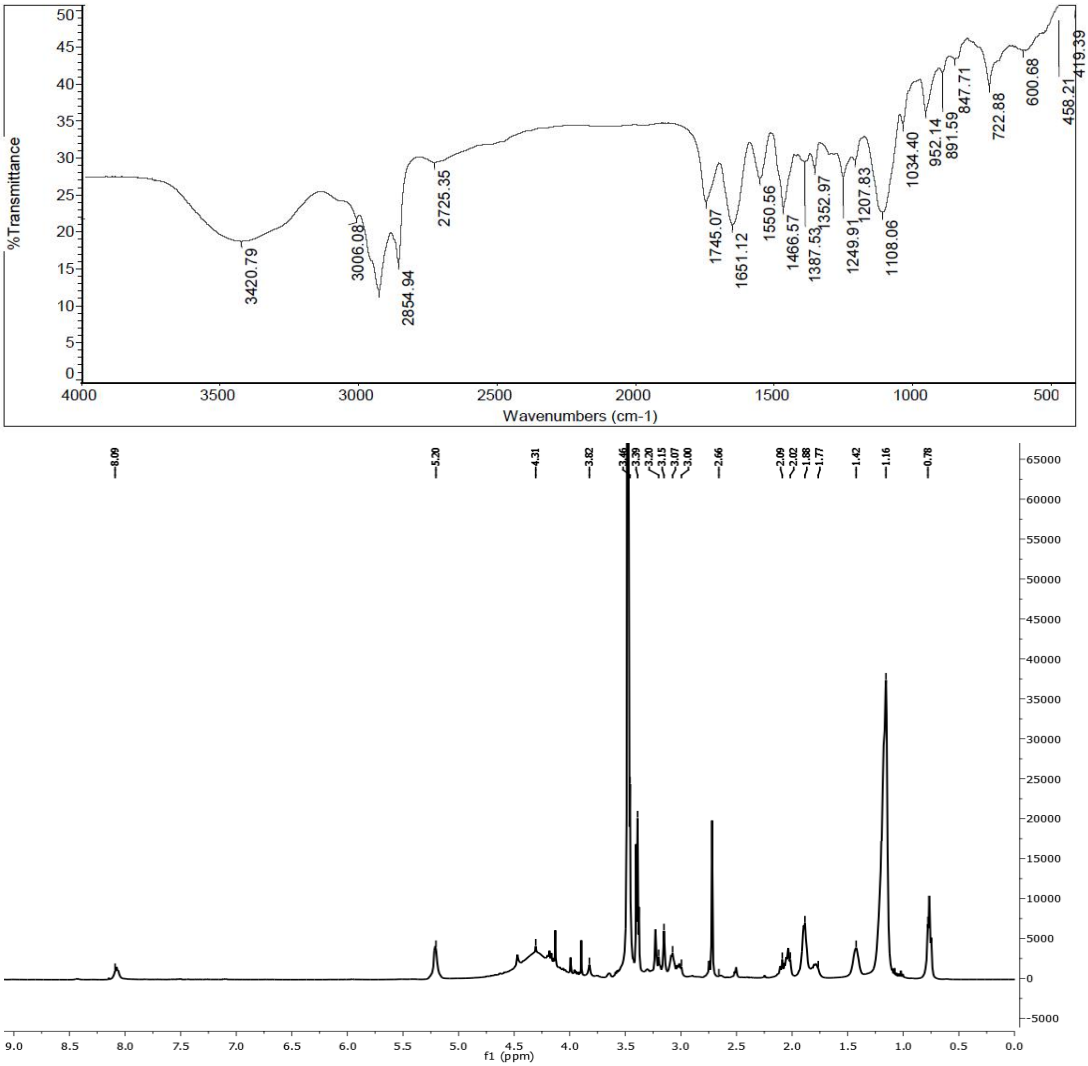


**Fig. 3.10:** IR and $^1$H NMR spectra of compound OEGS

### 3.3. Surface active properties

**Critical micelle concentration ($C_{cmc}$)**

The surface-active parameters of cationic gemini surfactants have been investigated by surface tension measurements at different temperatures. By plotting the surface tension (γ) versus – log C as shown in the Figure 11, the critical micelle concentration of the cationic surfactants was estimated. CMC value was determined at the intercept of the extrapolations of the linear parts of the plotted γ vs

– log C. Figure 11. shows a significant decline in surface tension compared to the log of the surfactant under investigation concentration at different temperatures. This is due to the accumulation of surfactant molecules at the air/liquid interface. Both of $C_{cmc}$ and $\gamma_{cmc}$ can be derived from Figure 11. Effectiveness ($\pi_{cmc}$) at $C_{cmc}$, is defned by the extent of surface tension reduction attained at the critical micelle concentration in Table 1, 2 and 3 revealed that the synthesized surfactants are considered to be a good surface-active agents. $\pi_{cmc}$ was calculated from the following equation.

$$\pi_{cmc} = \gamma_o - \gamma_{cmc} \quad \text{.....(1)}$$

The most effective surfactant is one that gives the greater lowering in surface tension for a critical micelle concentration (CMC). According to the results, Myristic cationic surfactant is the most effective surfactant.

**Surface excess ($\Gamma_{max}$) & minimum surface area ($A_{min}$)**

The effective measure of the surfactants adsorption at the air/solution interface ($\Gamma_{max}$), is calculated from the Gibbs's adsorption equation through plotting γ against ln C where the slope refers to d γ/d ln C

$$\Gamma_{max} = (-1/nRT)(d\gamma/d\ln C) \quad \text{.....(2)}$$

where γ denotes the surface tension, R is the gas constant, T is the absolute temperature, and C is the surfactant concentration. $A_{min}$ is obtained by using the following equation

$$A_{min} = 10^{14}/(N_A\Gamma_{max}) \quad \text{.....(3)}$$

where $N_A$ is the Avogadro number. Appropriate $\Gamma_{max}$ & $A_{min}$ values are shown in Table 1, 2 and 3. These results showed that the cationic surfactants molecules are tightly packed at the air – solution interface and a good surface agent and indicate that the values of surface excess ($\Gamma_{max}$) of the prepared cationic surfactants decreases with increasing minimum surface area $A_{min}$ of the surfactant molecule.

**Standard free energies of micellization and adsorption**

The standard free energy of micellization, a measure of the tendency of the synthesized cationic surfactants to form micelles, is calculated from the following equation

$$\Delta G_{mic} = -RT\ln C_{CMC} \quad \text{.....(4)}$$

From Table, it is evident that the values of the standard free energies of micellization are always negative, indicating that this process is spontaneous.

**Effect of temperatures**

From Figure 11, the γ value decrease with increasing temperature as in Table 1, 2 and 3 while $\pi_{cmc}$ and $A_{min}$ value increase with temperature. Analysis of data indicate that Myristic cationic surfactant is the most effective surfactant due to its hydrophobic fatty chain is less than that of Palmitic cationic surfactant and Oleic cationic surfactant. it was notable that $\pi_{cmc}$ and $A_{min}$ values of Oleic cationic surfactant are more than that of Palmitic cationic surfactant which can be explained as presence of л-bond.

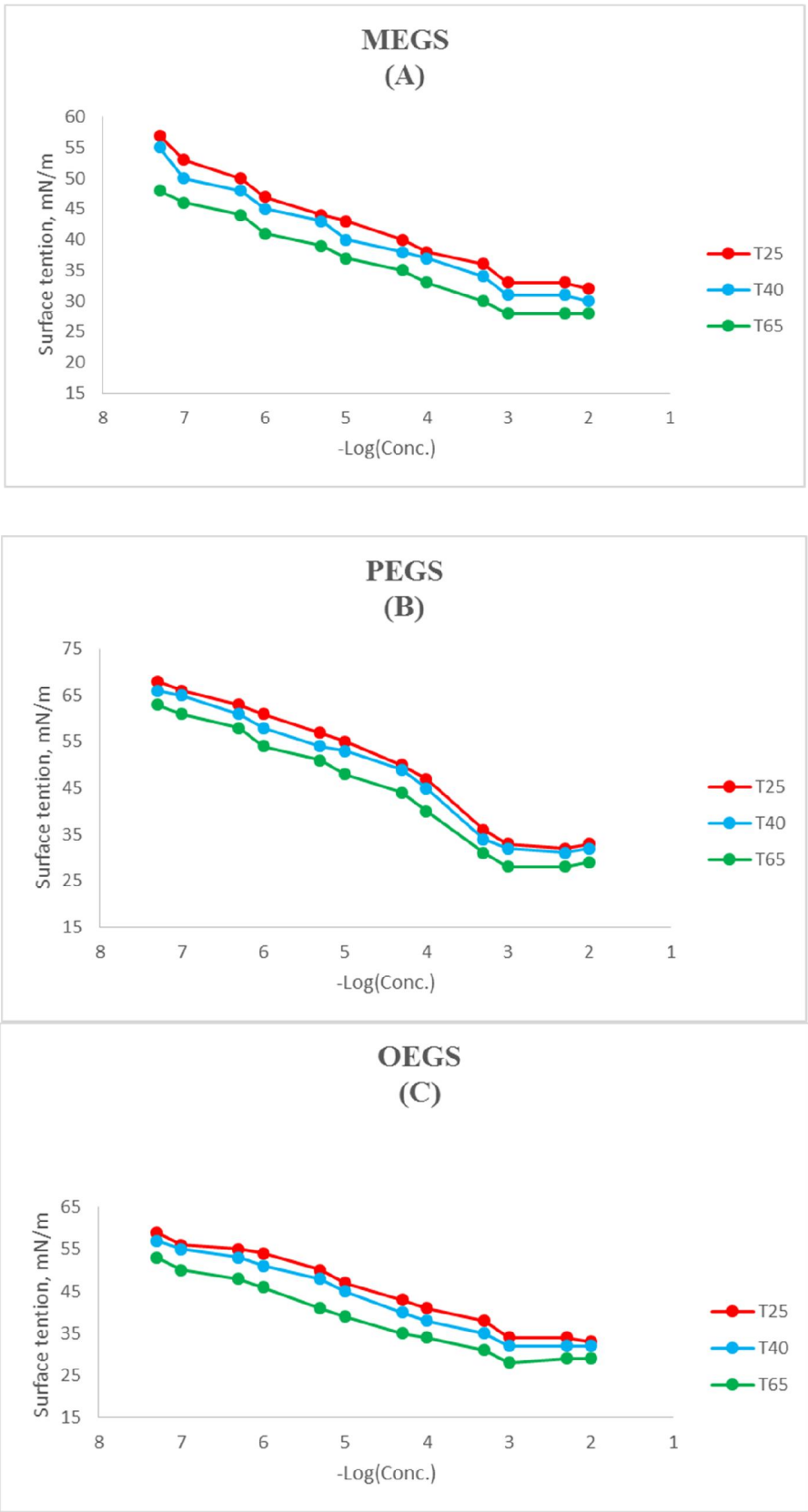


**Fig. 11:** Variation of surface tension against concentration of the synthesized cationic gemini surfactants (MEGS, PEGS and OEGS) at 25°C.

**Table 1:** Surface-active properties of the prepared cationic gemini surfactant (MEGS) from the surface tension at 25ºC

| Comp. | Temp. | γ | $\pi_{cmc}$ | Surface excess ($\Gamma_{max}$) | Minimum surface area ($A_{min}$) | $\Delta G_{mic}$ | CMC |
|---|---|---|---|---|---|---|---|
| MEGS | 25 | 33 | 39.86 | 0.000297366 | 5.58336E-07 | -47.324 | 0.00025 |
| | 40 | 31 | 41.86 | 0.000275694 | 6.02228E-07 | -49.706 | 0.00025 |
| | 55 | 28 | 44.86 | 0.000237889 | 6.97932E-07 | -52.088 | 0.00025 |

**Table 2:** Surface-active properties of the prepared cationic gemini surfactant (PEGS) from the surface tension at 25ºC

| Comp. | Temp. | γ | $\pi_{cmc}$ | Surface excess ($\Gamma_{max}$) | Minimum surface area ($A_{min}$) | $\Delta G_{mic}$ | CMC |
|---|---|---|---|---|---|---|---|
| PEGS | 25 | 36 | 36.86 | 0.000424299 | 3.91305E-07 | -51.279 | 0.000125 |
| | 40 | 34 | 38.86 | 0.000403965 | 4.11001E-07 | -53.860 | 0.000125 |
| | 55 | 31 | 41.86 | 0.000397851 | 4.17317E-07 | -56.441 | 0.000125 |

**Table 3:** Surface-active properties of the prepared cationic gemini surfactant (OEGS) from the surface tension at 25ºC

| Comp. | Temp. | γ | $\pi_{cmc}$ | Surface excess ($\Gamma_{max}$) | Minimum surface area ($A_{min}$) | $\Delta G_{mic}$ | CMC |
|---|---|---|---|---|---|---|---|
| OEGS | 25 | 34 | 38.86 | 0.000326249 | 5.08907E-07 | -47.324 | 0.00025 |
| | 40 | 32 | 40.86 | 0.000323949 | 5.12519E-07 | -49.706 | 0.00025 |
| | 55 | 29 | 43.86 | 0.000295224 | 5.62387E-07 | -52.088 | 0.00025 |

### 3.4. Transmission Electron Microscope (TEM)

Nanoparticle size was determined by using TEM model Model JEM 2100, JEOL, Japan, which was carried out in the Egyptian Petroleum Research Institute "EPRI". A convenient way to produce good TEM samples is to use copper grids. The copper grid was pre-covered with a very thin amorphous carbon film. To investigate the prepared $Cu_2O$NPs using TEM, small droplets of the liquid was placed on the carbon-coated grid. A photographic plate of the transmission electron microscopy was employed on the present work to investigate the microstructure of the prepared samples as shown in Figure 12.

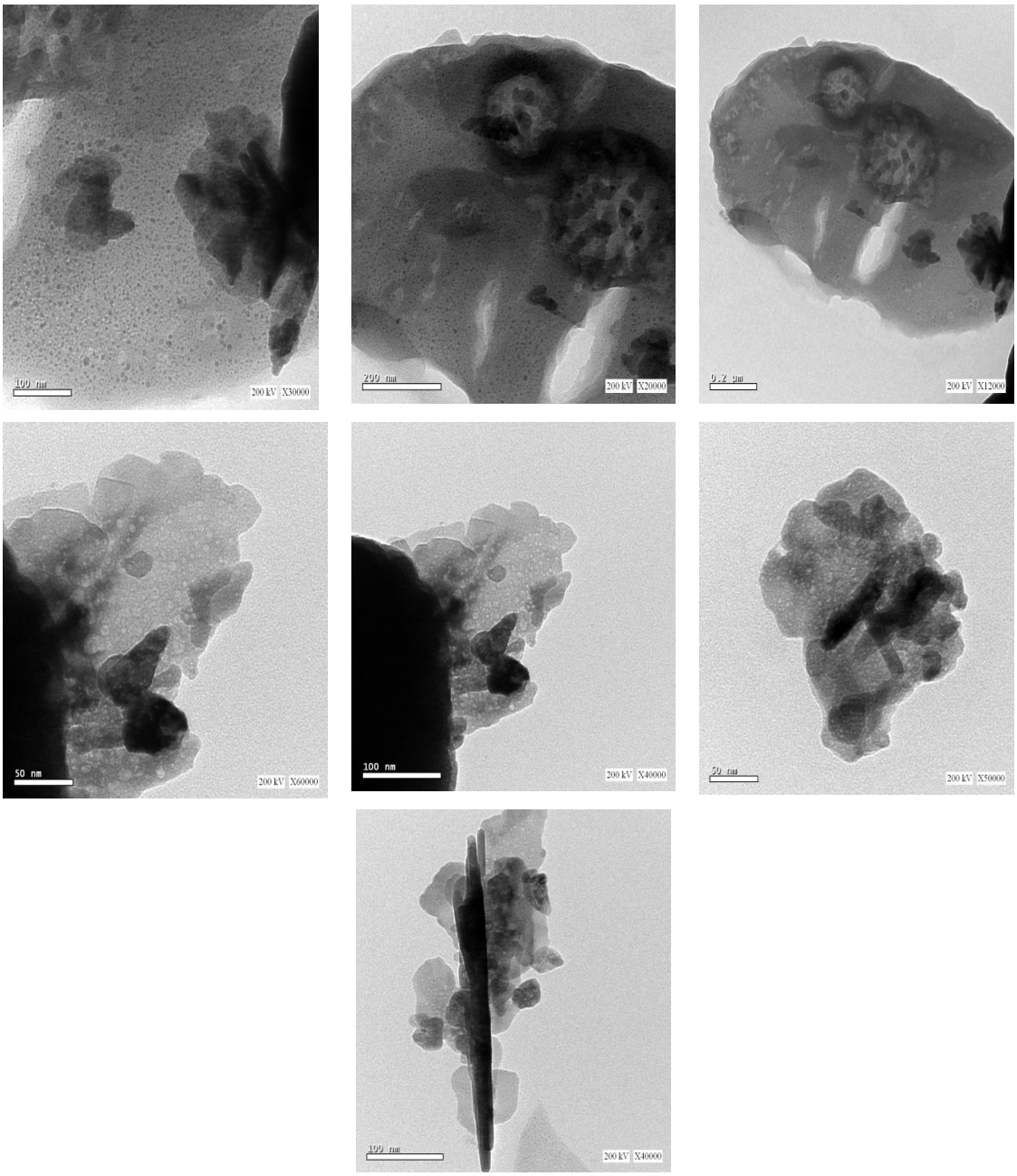


**Fig. 12:** Represents the Transmission Electron Microscopy (TEM) images of the obtained $Cu_2O$. TEM image of the $Cu_2O$ shows well dispersed roughly spherical particles. The mean sizes of $Cu_2O$ particles are about 34 nm and 60 nm for the surfactants SLES and Triton X-100, respectively

## 4. Conclusion

In the present work, a series of nonionic cationic gemini surfactants (MEGS, PEGS, SEGS and OEGS) were synthesized. Also, the chemical structures of the synthesized Gemini surfactants were elucidated by FTIR and $^1$HNMR spectroscopic tools. As well as he evaluation of surface and thermodynamic properties was studied, leading to conclude the potential ability of the synthesized surfactants to be adsorbed in solutions which means the applicability in a wide range industrial field as the nanotechnology application.

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