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Amidoamine double tailed cationic surfactant based on dimethylaminopropylamine: Synthesis, characterization and evaluation as biocide

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ABSTRACT

Three amidoamine cationic surfactants with double tailed were prepared and their chemical structures was confirmed using spectroscopic analysis like FTIR and ^{1}H NMR. The surface parameters of the amidoamine surfactants were determined from surface tension and conductance measurements. The double tailed amidoamine surfactant shown low critical micelle concentration than conventional surfactants with their dependence on chain length and temperatures. Thermodynamic parameters clarified the tendency of surfactants to adsorb at interface than to form micelle and both of the two processes depend on the alkyl chain and temperature. The prepared surfactants were evaluated against microorganism showing that they have good biological activity against both Gram positive and negative bacteria but they have no effect on fungi.

1. Introduction

Surfactants are amphiphile compounds (bifunctional molecules) that contain polar or ionic head group (cationic, anionic, nonionic or zwitterionic) attached to a large hydrophobic part. Typically, the hydrophobic part is an alkyl group with at least eight –CH_2– units. The surfactants are characterized by its ability to self-associate to form association colloids called micelles, the concentration at which it formed called critical micelle concentration. Micelles have interfacial regions containing ionic or polar head groups [1]. They have widespread importance and industrial applications such as detergents, paints, coatings, inks, adhesives, demulsification [2], textile processing, drilling mud, petrochemical recovery, corrosion inhibitors and biocides in petroleum industry [3–4]. Quaternary ammonium compounds have scores of uses because of their affinity for negatively charged surfaces and adsorption of these molecules depends mainly on certain physicochemical properties such as the presence of heteroatoms including oxygen, sulfur, nitrogen and phosphorus atoms and multiple bonds in the molecule through which they are adsorbed on the metal surface [5–8]. Due to the ability of surfactant to adsorb on the interfaces and to form micelle, it is used in nanotechnology in controlling the size and shapes of the nanoparticle [9]. The similarity in chemical structure of quaternary ammonium compounds and cellular constituents eases their destructive action toward microorganisms especially anaerobic bacteria called sulfate reducing bacteria (S.R.B) in souring systems. These bacteria are mainly sulfate reducers and their growth frequently causes severe corrosion problems in oil well pipes which lead to the economic losses as well as environmental health and safety hazards caused by the activity of stabilized mixed culture containing sulfate reducing bacteria (SMC-SRB) [10,11]. The presence of an amidoamine functional group in a surfactant helps in enhancing its biodegradability and in reducing its aquatic toxicity. Intermediates produced in the degradation process of amidoamine were found to be biodegradable and less toxic [12]. Therefore, this work aimed to prepare the amidoamine cationic surfactants with double tailed from dimethylaminopropylamine (DMAPA). As known derivatives based on DMAPA can be used in fuels as cloud point reducers, dispersants, and stabilizers for prevention of deposits or icing, reduction of octane number requirements and corrosion inhibitors for lubricants [13–14]. Due to the self-immunity of microorganism toward the conventional biocides, the use of cationic surfactant was greatly demanded [15–18]. In the present work, we introduced amide group in the cationic surfactant in order to increase the biodegradability and decrease their aquatic toxicity. The surface and thermodynamic properties like, critical micelle concentration (CMC), effectiveness (π_{cmc}), efficiency (Pc_{20}), maximum surface excess (Γ_{max}), minimum surface area (A_{min}), free energy of micellization (ΔG^{o}_{mic}) and free energy of adsorption (ΔG^{o}_{ads}) were determined beside the biocidal activity against fungi and bacteria.

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2. Experimental

2.1. Materials

All the chemicals used in the synthesis process of amidoamine surfactants were of analytical grades and used without more purification; dimethylaminopropylamine (DMAPA) 98%, decyl bromide 99%, dodecyl bromide 98%, hexadecyl bromide 98% and tetradecanoic acid 99% were purchased from Sigma-Aldrich Chemicals Co. The solvents (ethyl alcohol absolute and diethylether) are high grade and purchased from El-gomhoria Chemical Co.

2.2. Instruments

The chemical structure of the new prepared amidoamine cationic surfactants was characterized by; FTIR Spectra using ATI Mattsonm Infinity Series™,Bench top 961 controlled by Win First™ V2.01 Software (Egyptian Petroleum Institute) and ^{1}H NMR by Spect Varian, GEMINI 200(^{1}H 200 MHz) in DMSO-d_6 (National Research Institute). The surface tension for all prepared surfactants was measured using Tensiometer-K6 Processor (KrÜss Company, Germany) using the ring method.

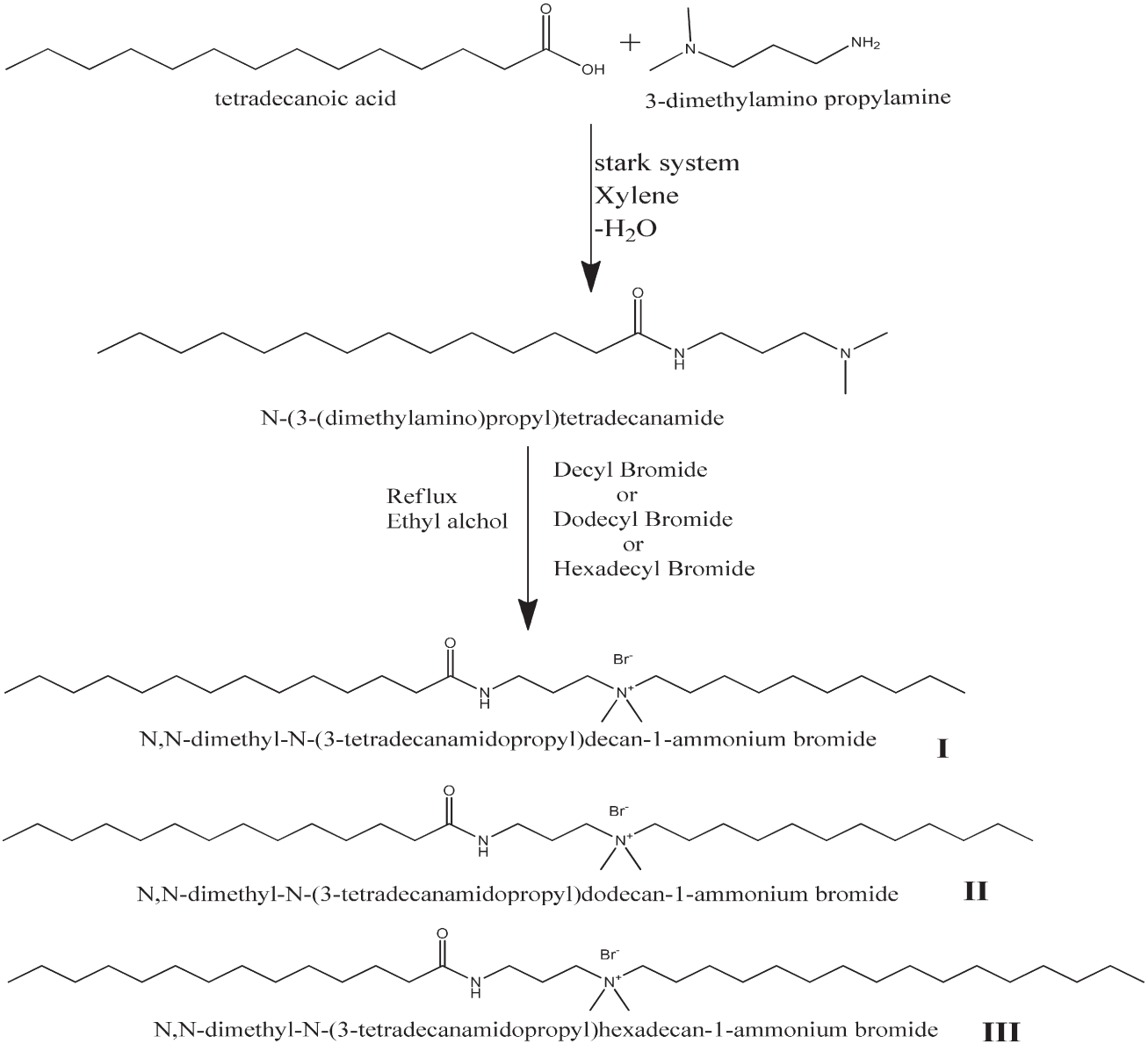
2.3. Synthesis of amidoamine cationic surfactants

2.3.1. Synthesis of N-(3-(dimethylamino) propyl)tetradecanamide derivatives

1,3-dimethylamino-1-propyl amine (DMAPA) (0.1 mol.) was dissolved in 120 mL xylene then 0.1 mol. of tetradecanoic acid was added with 0.01% p-toluene sulphonic acid as a catalyst. The reaction mixture subject to reflux at 138 °C until complete removal of reaction water (0.1 mol., 1.8 mL) using Dean–Stark apparatus. The solvent was evaporated under vacuum rotary evaporator. Petroleum ether was used to get rid of the used catalyst [19].

2.3.2. Synthesis of N,N-dimethyl-N-(3-tetradecanamidopropyl)alkan-1-aminium bromide derivatives

The prepared N-(3-(dimethylamino) propyl)tetradecanamide (0.1 mol.) from the previous step was refluxed with fatty alkyl bromide (decyl bromide, dodecyl bromide and hexadecyl bromide) (0.1 mol.) in



Scheme 1. General procedures for synthesis of double tailed cationic surfactants.