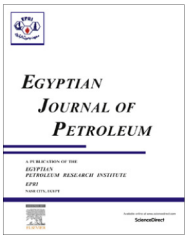
Egyptian Journal of Petroleum (2016) 25, 153–159

Egyptian Petroleum Research Institute

Egyptian Journal of Petroleum

www.elsevier.com/locate/egyjp
www.sciencedirect.com



FULL LENGTH ARTICLE

Surface and antibacterial activity of synthesized nonionic surfactant assembled on metal nanoparticles

E.M.S. Azzam *, **M.F. Zaki**

Applied Surfactants Laboratory, Petrochemicals Department, Egyptian Petroleum Research Institute, 11727 Nasr City, Cairo, Egypt

Received 2 January 2015; revised 29 March 2015; accepted 6 April 2015
Available online 2 January 2016

KEYWORDS

Nonionic surfactant;
Nanoparticles;
Surface and antibacterial activity

Abstract Herein, we synthesized a nonionic surfactant namely, tetradecanoate mercapto acetate polyethylene glycol. We investigate the assembling of the synthesized surfactant on different types of prepared nanoparticles using ultraviolet (UV) and transmission electron microscope (TEM). The surface properties of the synthesized surfactant and its nanostructure were studied. The effect of the prepared nanoparticles on the antibacterial activity of the synthesized surfactant toward sulfated reducing bacteria (SRB) was described in this work. The results show the enhancement of the antibacterial activity of the synthesized surfactant with nanoparticles more than without nanoparticles.

1. Introduction

Surfactants have been widely used in diverse products, such as motor oils, pharmaceuticals, detergents, and flotation agents [1,2]. In particular, surfactants can be used as bactericidal agents due to their amphiphilic nature and tendency to interact with biological membranes [3,4]. It has been proposed that surfactants can insert into membranes as interstitial components, leading to various functional consequences, including changes in bilayer organization, non-bilayer phase formation, and even solubilization [4]. In recent years, the applications of surfactants have extended to the field of nanotechnology, where they are used as powerful tools for the preparation and modification of NPs [5–7]. The coexistence of nanoparticles and surfactants can cause joint effects on biological systems and the environment, and previous studies have shown that mixtures of nanoparticles and surfactants exhibit two different joint effects on organisms: (1) surfactants can attach to the surface of nanoparticles, which alters the surface charge of the nanoparticles and thereby their dispersibility and toxicity [8,9] and (2) surfactants adsorbed on the surface of nanoparticles can inhibit the interaction between nanoparticles and bacteria through steric hindrance and charge repulsion and thus reduce the toxicities of nanoparticles [10]. Colloidal nanoparticles when adsorbed at the air–liquid or liquid–liquid interfaces can change the interfacial tension and also can stabilize the emulsions [11–13]. The combination of nanoparticles and surfactants at the interface is an important topic of research especially in their application to improve the stability of

* Corresponding author. Tel.: +20 1117710207.
E-mail address: eazzamep@yahoo.com (E.M.S. Azzam).
Peer review under responsibility of Egyptian Petroleum Research Institute.

http://dx.doi.org/10.1016/j.ejpe.2015.04.005

emulsions and foams [14–19]. Thus studies of interactions between nanoparticles and surfactants are very important, since, using interfacial tension data may be useful to get some information about the interface. The sulfate reducing bacteria (SRB) form a specialized group of microbes that use sulfate as terminal electron acceptor for their respiration and generate H_2S as a terminal product. The ubiquity of these bacteria leads to a variety of impressive industrial, economic and ecological effects because of their proneness to generate large quantities of H_2S. Many corrosions of industrial equipment have been ascribed to microbiologically influence corrosion (MIC) [20–22]. SRB is the main reason to cause the MIC by accelerating the corrosion rate, inducing stress corrosion and pitting corrosion [23–25]. In this work we describe the effect of the prepared nanoparticles (Ag, Cu, and Zn) on the surface activity of the synthesized nonionic surfactant (C14). We investigate the inhibition of sulfate reducing bacteria (SRB) using the synthesized nonionic surfactant. In addition, we study the performance of different types of prepared nanoparticles on the antibacterial activity of the synthesized nonionic surfactant.

2. Materials and experimental techniques

2.1. Materials

Chemicals used in this work were supplied as shown in Table 1.

2.1.1. Synthesis of the nonionic surfactant (C14)

The surfactant used in this work was synthesized as follows:

2.1.1.1. Synthesis of polyethylene glycol mono palmitate. Polyethylene glycol (400) (0.1 mol) and palmitic acid (0.1 mol) were esterified in the presence of xylene as solvent and 0.01 p-toluene sulfonic as a catalyst and the mixture was refluxed until the azeotropic amount of water (1.8 mal.) was removed. After removal of the solvent under vacuum using a rotary evaporator, the catalyst was then removed from the reaction product by extracting them using petroleum ether. Subsequent purification was done by means of vacuum distillation to remove the excess and unreacted and residual material [26].

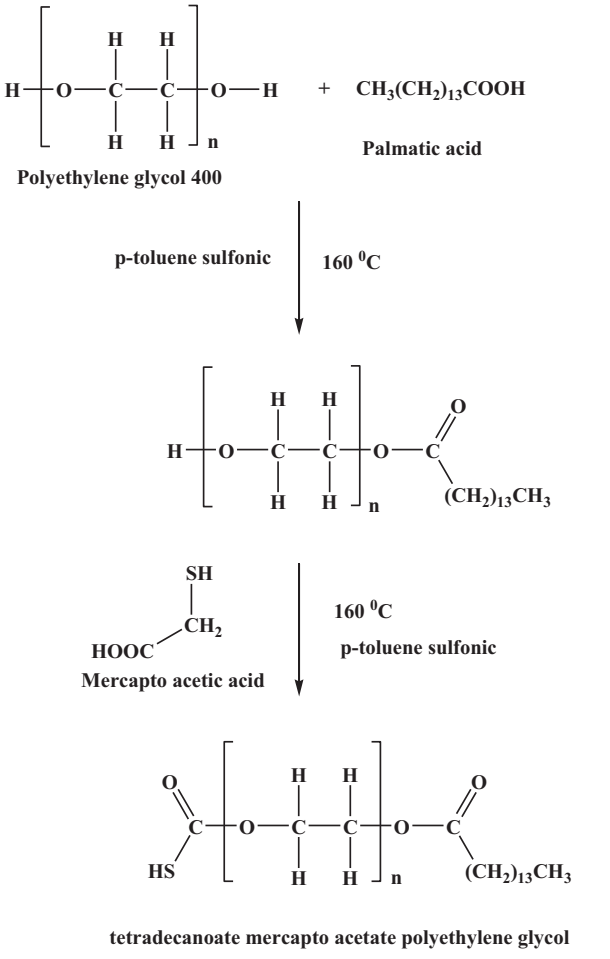
2.1.1.2. Synthesis of tetradecanoate mercapto acetate polyethylene glycol (C14). Mercapto acetic acid (0.1 mol) and polyethylene glycol monopalmitate (0.1 mol) were esterified in the presence of xylene as solvent and 0.01 p-toluene sulfonic as a catalyst and the mixture was refluxed until the azeotropic amount of water (1.8 mal.) was removed. After removal of the solvent under vacuum using a rotary evaporator, the catalyst was then removed from the reaction product by extracting it using petroleum ether. Subsequent purification was done by means of vacuum distillation to remove the excess and unreacted and residual material to give the synthesized surfactant (C14) [27] (see Scheme 1).

Table 1 Specification of the used chemicals.

Chemicals	Purity	Source
Zinc chloride anhydrous	AR	Aldrich
Silver nitrate	AR	Aldrich
Sodium borohydride	AR	Aldrich
Nickel chloride	AR	Aldrich
Cupper chloride	AR	Aldrich
Polyethylene glycol	AR	Aldrich
Palmitic acid	AR	Aldrich
p-toluene sulfonic	AR	Aldrich
Xylene	Lab. chemicals	Aldrich
Ethanol	Lab. chemicals	Aldrich
Mercapto acetic acid	AR	Aldrich

2.1.2. Preparation of colloidal zinc oxide nanoparticles coated with the nonionic thiol surfactant

Colloidal ZnO nanoparticles were prepared by the reduction of zinc chloride anhydrous in the presence of mercapto nonionic surfactant as a stabilizer and capping agent using sodium borohydride as a reducing agent [28]. The synthesized nonionic surfactant (0.02 mol) was dissolved in 100 ml ethanol and then, an ethanol solution (30 ml) of zinc chloride anhydrous (0.17 g, 0.03 mol) was added drop wise under intense stirring. The resulting mixture was stirred for 15 min and a freshly prepared aqueous solution (50 ml) of sodium borohydride (0.11 g, 0.06 mol) was added drop wise. The solution becomes milky white showing the formation of colloidal ZnO nanoparticles assembled on the synthesized mercapto nonionic surfactant



Scheme 1 Schematic illustration of the synthesis of the nonionic surfactant.