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Overview of Synthetic Methodologies for Development of Cationic Gemini Surfactants

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Abstract

In the present article we have summarized our research work related to synthesis and investigation of several new types of cationic gemini surfactants containing different headgroups (*i.e.* pyridinium, imidazolium, pyrrolidinium, piperidinium, morpholinium). We have used three different principal methodologies to develop several new types of gemini surfactants: (1) regioselective co-bromination protocol followed by quaternization (2) regioselective epoxy ring opening reactions followed by quaternization (3) Alkylation reactions followed by quaternization. These cationic surfactants have been investigated for their surface and physicochemical properties and the studies have established these surfactants to be superior compared to conventional/commercially available cationic surfactants.

Key-words: *Gemini surfactant, Synthesis, CMC, Surface properties, DNA interaction, Cytotoxicity*

1. Introduction

Cationic surfactants are important category of surfactant molecules, which are important constituent of several commercial formulations. Gemini cationic surfactants consisting of two positively charged hydrophilic headgroup and two hydrophobic tail often connected by a spacer are considered superior surfactants molecules due to their affinity to self-aggregate at much lower concentration in aqueous solution compared to the monomeric counterparts[1,2]. In recent years several new types of the cationic gemini surfactants have been developed and investigated for different application areas. These gemini surfactants have demonstrated ability to interact and condense DNA, form complexes with active drug molecules and enhanced ability to kill and retard the growth of pathogenic microorganisms, and hence are presently being investigated for several biomedical applications. These surfactants often self-aggregate for form micelles at very low concentration and demonstrate superior surfactant properties compared to conventional monomeric surfactants. Currently these surfactant molecules are being considered for several emerging application areas. They are able to act as soft template for synthesis of mesoporous/microporous and are being used to develop several new types of hollow inorganic materials. These surfactants are also able to stabilize several metal-based nanoparticles[3]. The versatile physicochemical properties and wide range of application ranging from biomedical to material science led to development of several new types of cationic gemini surfactants.

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2. Experimental methodology for synthesis of gemini surfactants

We in our research group have adopted three principal methodologies for the synthesis of new types of gemini surfactants.

2.1 Regioselective co-bromination protocol followed by quaternization

One of the principal methodology used for the synthesis of new type of gemini surfactants containing thioether spacer units is regioselective electrophilic co-bromination using *N*-bromosuccinimide (NBS) as organic reagent (**Fig. 1**a). NBS forms a cyclic bromonium ion with terminal alkenes at low temperature. Dithiols, which are strong nucleophiles, are able to selectively attack the less-hindered terminal carbon in a regioselective manner via anti-Markovnikov addition to form reactive intermediates, which can be quaternized with pyridine or *N*-methylimidazole to get new type of thioether spacer containing gemini surfactants[4-6].

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