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Investigation of self-assembly properties and the effect of tween series co-surfactants on the stability of nonionic branched-chain glycolipid hexosomes

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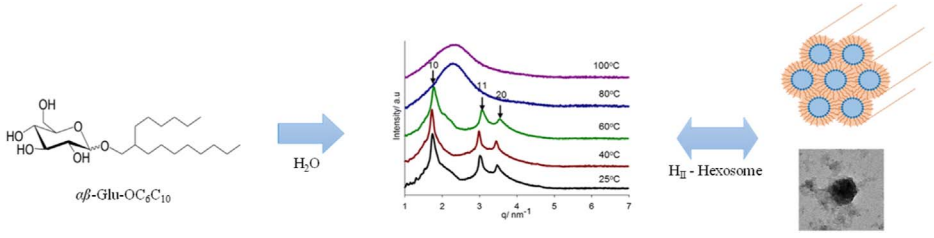
HIGHLIGHTS

- The technical grade of branched-chain glycolipid formed an inverse hexagonal dispersion (hexosome).
- The CAC reduced when nonionic co-surfactant added to the branched-chain glycolipid solution.
- Co-surfactant (Tween series) reduced the particle size and enhanced the stability of glycolipid hexosome.
- Branched-chain glycolipid could be used as alternative nonionic surfactant and drug carrier system for various application.

GRAPHICAL ABSTRACT



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ABSTRACT

Sugar-based surfactants have recently drawn much attention due to their nonionic and bio-friendly properties. These glycolipids are also popular because they can be found in nature or synthesized (e.g. alkyl polyglucosides) from cheap natural resources. In this research, the liquid crystalline and self-assembly properties of a novel branch alkylated glycolipid, namely 2-hexyldecyl-β(/α)-D-glucoside (αβ-Glu-$OC_{10}C_6$), were studied using differential scanning calorimetry (DSC), optical polarizing microscopy (OPM) and small-angle X-ray scattering (SAXS). The αβ-Glu-$OC_{10}C_6$ in anhydrous condition formed a columnar phase with focal conic texture, whereas in the binary aqueous system, αβ-Glu-$OC_{10}C_6$ formed inverse hexagonal dispersions known as hexosomes. The critical aggregation concentrations (CACs) were studied for the branched-chain glycolipid when this was mixed with nonionic co-surfactants (Tween series). The addition of co-surfactants to the glycolipid dispersions reduced the CAC value of αβ-Glu-$OC_{10}C_6$, thus making the system more stable. The formation of mixed surfactant hexosomes was further investigated in terms of their particle size and morphology by using a particle sizer and a transmission electron microscope (TEM), respectively. Furthermore, the particle size variations and particle migration were investigated using light backscattering measurements for 24 h. In the previous study, αβ-Glu-$OC_{10}C_6$ hexosomes produced were unstable because the balance between hydrophilic and lipophilic was not optimum to stabilize the formation of a stable double layer. Therefore, the addition of co-surfactant Tween series reduced the particle size and enhanced the stability of αβ-Glu-$OC_{10}C_6$. Thus, branched-chain glycolipid provided an alternative nonionic surfactant with interesting phase behaviour as a drug carrier system for various applications.

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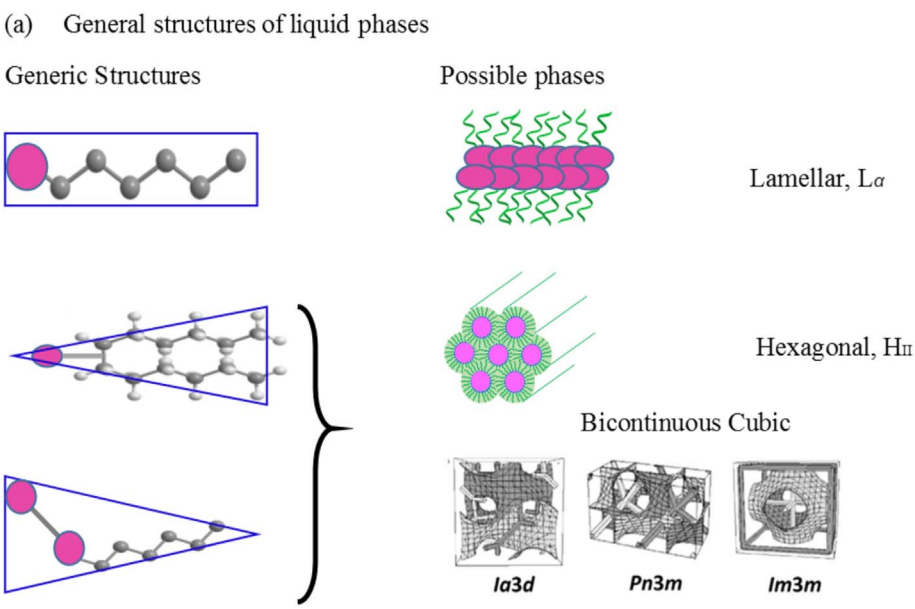

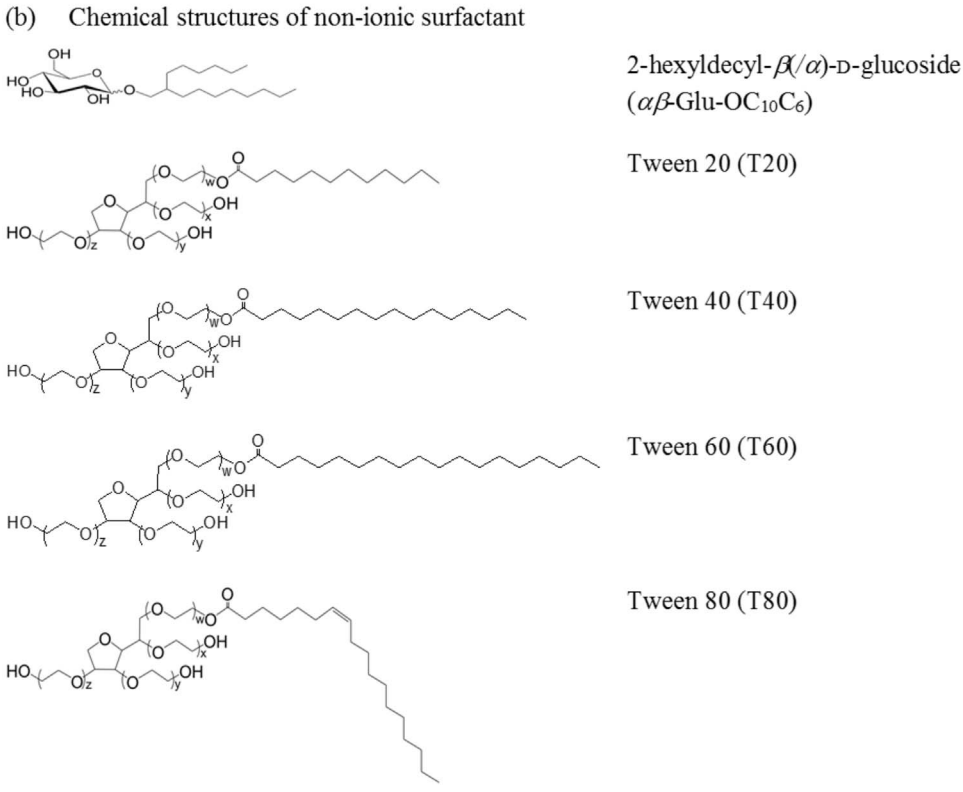

Fig. 1. (a) General structures of liquid phases: lamellar L_{α}, hexagonal H_{II}, and bicontinuous cubic *Ia3d*, *Pn3m* and *Im3m* (Reproduced from ref [62]. Copyright 2016 American Chemical Society) (b) Chemical structures of nonionic surfactants; αβ-Glu-$OC_{10}C_6$ and Tween series (co-surfactants), namely T20, T40, T60 and T80, with alkyl chain lengths of C12, C14, C18 and C18:1 respectively.

1. Introduction

Overwhelming trend towards using eco-friendly surfactants has made both synthetic and natural glycolipids a popular option in industry. Natural glycolipids are difficult to extract due to problems of purifying lipids. Consequently, synthetic glycolipids have become high in demand because of the interest in biomimicking research [1]. Therefore, research and the development of synthetic glycolipids are actively ongoing, supported by the structural improvement of glycolipids to match suitable functional applications. One of the structural improvements for mimicking natural glycolipids is the introduction of chain branching, which has been attempted by many groups [1–5]. In addition to being a nonionic surfactant, glycolipids may exhibit different liquid crystalline phases where they can form different mesophases depending on factors such as temperature and concentration [6]. They are described as amphitropic [7] because they can form liquid crystals in dry form as well as when in contact with solvents such as water and dimethyl sulfoxide (DMSO) [1,8–13].