Formation and characterization of alpha gel formed by fatty alcohol and amino acid surfactants containing alkyl chains with 12 carbons

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Introduction:

α-Gel, as a specific lamellar liquid crystal structure, presents unique parameters and attracts broad interest in recent years. According to theoretical analysis, the Krafft temperature of α-gel needs to be higher than the temperature at which the product is intended to be employed. This restricts the surfactants suitable for formation of α-gel should contain a hydrophobic chain with no less than 14 carbon atoms [1]. However, in personal care products, surfactants containing alkyl chains with less than 12 carbons are widely applied due to their properties. It is urgent to develop new methods of formation of α-gel. We recently reported the preparation and characterization of alpha gel formed by fatty alcohol and amino acid surfactants containing alkyl chains with 12 carbons [2]. A simple way to generate α-gel was developed using sodium lauroyl sarcosinate, and furtherly extended to other amino acid based surfactants. In this study, the impactors in the formation of α-gel were investigated and discussed.

Materials & Methods:

The mixture of a pre-calculated amount of fatty alcohol and chosen surfactant was heated to 85℃ under stirring. After all contents were totally melted, the mixture was kept at this temperature for 4 h. The mixture was slowly cooled to 25℃ by stirring at low speed. The α-gel structure was formed during the cooling process.

Cetyl alcohol, stearyl alcohol were involved as fatty alcohol. Sodium lauroyl sarcosinate was chosen as typical amino acid surfactant.

The lamellar structure of mixture was primarily observed under Polarized Optical Microscopy (POM), and furtherly analyzed by Diffraction Scanning Calorimetry (DSC) and Small angle X-ray scattering (SAXS) and wide angle X-ray scattering (WAXS) experiments.

Results & Discussion:

The gel samples composed of sodium lauroyl sarcosinate, stearyl alcohol, cetyl alcohol and water were prepared with method described and analyzed at 25℃.

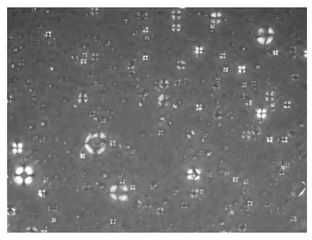

Figure 1. Optical texture of the α-gel sample composed of sodium lauroyl sarcosinate, fatty alcohol and water, through polarized optical microscopy (POM) at 25℃

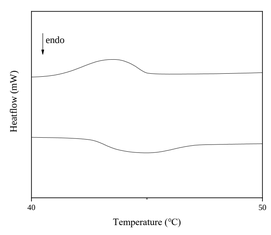

Figure 2. DSC thermograms of α-gel mixture, heated from 25℃ to 90℃ at 2℃/min, kept at 90℃ for 1 min, and then cooled to 25℃ at -2℃/min, under a draft of air of 50 mL/min.

•SAXS b) WAXS

Figure 3. X-ray diffraction pattern of α-gel mixture described above. The insets depict the change in intensity at scattering angle 2θ from 0.5° to 10° and 10° to 30°, respectively. The *d*-spacing value of lamellar structure displayed was calculated by the Bragg equation: nλ=2d sinθ.

Results & Discussion:

Figure 4 DSC curves and POM images of α-gel sample composed of sodium lauroyl sarcosinate, fatty alcohol and water, with different total solid content range from 17 wt. % to 46 wt. %. All samples were heated from 25℃ to 90℃ at 2℃/min, kept at 90℃ for 1 min, and then cooled to 25℃ at -2℃/min, under a draft of air of 50 mL/min.

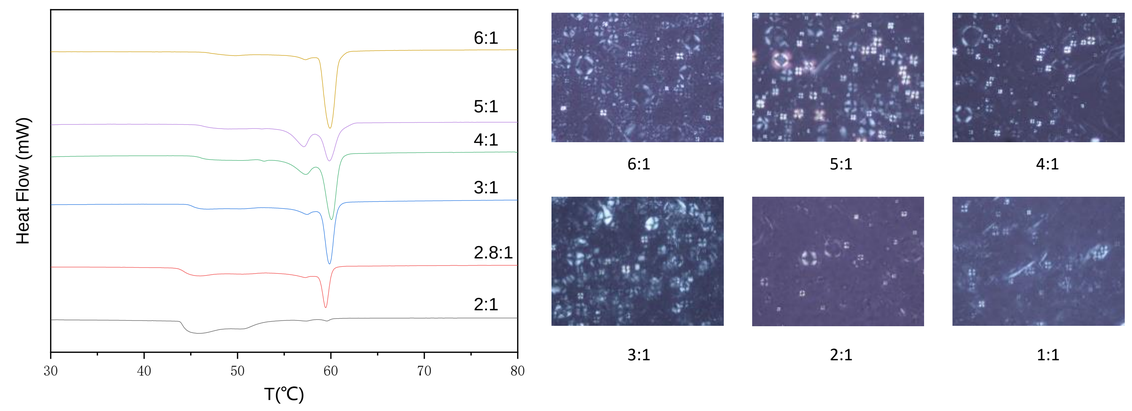

Figure 5 DSC curves and POM images of α-gel sample composed of sodium lauroyl sarcosinate, fatty alcohol and water, with fixed total solid content and various mole ratios of fatty alcohol to surfactant range from 6:1 to 2:1. All samples were heated from 25℃ to 90℃ at 2℃/min, kept at 90℃ for 1 min, and then cooled to 25℃ at -2℃/min, under a draft of air of 50 mL/min.

According to Figure 4, the peaks of phase transition temperatures between 40℃ to 45℃ became broad and moved downwards along with the increase of total solid content of samples. This phenomena was consistent with the trend presented along with the increase of quantity of fatty alcohol, see Figure 5. The peaks of the lamellar structure were continuously observed in the SAXS of samples consisting water concentration ranged from 60 wt. % to 95 wt.%, which was approximately coincidence with the observation results of DSC curves.

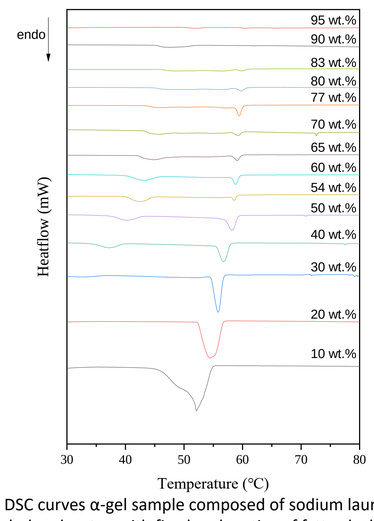

Figure 6 DSC curves α-gel sample composed of sodium lauroyl sarcosinate, fatty alcohol and water, with fixed mole ratios of fatty alcohol to surfactant and various water concentration range from 10 wt. % to 95 wt. %. All samples were heated from 25℃ to 90℃ at 2℃/min, kept at 90℃ for 1 min, and then cooled to 25℃ at -2℃/min, under a draft of air of 50 mL/min.

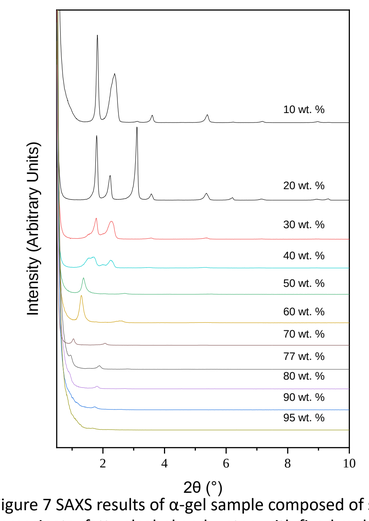

Figure 7 SAXS results of α-gel sample composed of sodium lauroyl sarcosinate, fatty alcohol and water, with fixed mole ratios of fatty alcohol to surfactant and various water concentration range from 10 wt. % to 95 wt. %.

Conclusions:

Based our previous research on the new simple way of formation of α-gel sample consisting fatty alcohol, surfactants containing hydrophobic chains with 12 carbon atoms, and water. This study furtherly investigated the impactors of the formation of lamellae structure. It was concluded that appropriate amount of water and total solid content were required for generation of the α-gel structure.

References:
[1] Wang, F. C.; Marangoni, A. G. (2015) Effect of intrinsic and extrinsic factors on the stability of the α-gel phase of a glyceryl monostearate – water system. RSC Advances, 5: 43121-43129.
[2] Ren, H., Tang, X., Chen, M. (2021) Preparation and characterization of alpha gel formed by fatty alcohol and amino acid surfactants. Journal of Surfactants and Detergents, DOI:10.1002/jsde.12539.