Small-angle X-ray scattering analysis of interfacial membranes in O/W emulsions prepared using polyether-modified silicone

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Oil-in-water (O/W) emulsions are oil droplets dispersed in water and are widely used in cosmetics and industrial formulations. However, they are inherently unstable and undergo destabilization processes such as creaming, flocculation, coalescence, and Ostwald ripening. Polyether-modified silicones (PEMS) are widely used as emulsifiers in cosmetic formulations because of their excellent sensory properties. Previous research has reported that stable O/W emulsions can be prepared through the adsorption of PEMS vesicles at the oil–water interface [1]. However, the detailed structure and physicochemical properties of the interfacial membranes formed by PEMS have not been fully understood. In this study, O/W emulsions were prepared using PEMS through different preparation methods, and the effects of the preparation process on the structure and physicochemical properties of the interfacial membranes were investigated using small-angle X-ray scattering (SAXS).
Polyoxyethylene (12) dimethylpolysiloxane (PEMS) and glyceryl tri-isooctanoate (TIOG) were used as a surfactant and oil, respectively. O/W emulsions were prepared by the following three preparation processes: (A) emulsification by agitating oil together with an aqueous vesicle dispersion of PEMS, (B) emulsification of an oil solution of PEMS by adding water, and (C) emulsification by adding oil and water to a lamellar liquid crystalline phase of PEMS. The emulsion droplets were observed by optical microscopy. The interfacial membrane structure of the emulsions was characterized by SAXS and generalized indirect Fourier transformation (GIFT) analysis of the obtained data.
Optical microscopic observation showed the emulsions prepared by processes A and C exhibited less droplet growth than those prepared by process B, indicating higher stability against coalescence. Since coalescence is closely related to the structure of the emulsion interface, it was suggested that the interfacial structures of the emulsions varied depending on the preparation process.
Bragg peaks corresponding to the lamellar structure were observed in the SAXS profiles of the emulsions prepared through processes A and C, whereas no such peaks were observed in the process B system. Furthermore, freeze-fracture transmission electron microscopy (FF-TEM) revealed that thick interfacial membranes were formed at the interface of the emulsions in processes A and C. In contrast, process B emulsions had no thick interfacial membranes. These results indicate that the structure of the interfacial membrane depends on the preparation process, and that the lamellar structure formed at the interface contributes to the suppression of coalescence.

References:

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