Original Technical Paper
J. Jpn. Soc. Colour Mater., **94** 〔9〕, 245–251 (2021)

Potential of High-Powered Bath-Type Ultrasonicator for Manufacturing of Emulsifier-Free Emulsions

Kazuo TAKEI*,**, Nozomi TAKAHASHI*** and Toshio SAKAI**,***,****,†

* *Tokyo Food Co., Ltd., 1687-1 Kamioshima, Tsukuba, Ibaraki 300-4351, Japan*
** *Graduate School of Medicine, Science and Technology, Shinshu University, 4-17-1 Wakasato, Nagano, Nagano 380-8553, Japan*
*** *Graduate School of Science and Technology, Shinshu University, 4-17-1 Wakasato, Nagano, Nagano 380-8553, Japan*
**** *Department of Materials Chemistry, Faculty of Engineering, Shinshu University, 4-17-1 Wakasato, Nagano, Nagano 380-8553, Japan*
†*Corresponding Author, E-mail: tsakai@shinshu-u.ac.jp*

(Received June 21, 2021; Accepted August 19, 2021)

Abstract

We report here on the manufacturing methods for emulsifier-free (EF-) oil-in-water (O/W) emulsions, in which oil and water were mechanically mixed in the absence of any emulsifiers such as surfactants. A commercially available bath-type ultrasonic cleaner (Bath-US; 42 kHz, 26 W) did not disperse dodecane (DD) completely in water even by the treatment for 15 min, and the average diameter of DD droplets in the EF-dodecane-in-water (DD/W) emulsions prepared was several micrometers. Using a commercially available horn-type ultrasonic homogenizer (Horn-US; 19.5 kHz, 600 W), the EF-DD/W emulsions were prepared by treatment for ~1 min, and the average diameter of DD droplets in EF-DD/W emulsions prepared was ~1 μm. Preparation of EF-DD/W emulsions using a high-powered bath-type ultrasonicator (HPBath-US; 28 kHz, 300 W) that we developed required the treatment period for ~1 min. The DD droplets in EF-DD/W emulsions prepared with HPBath-US became several hundred nanometers in diameter by treatment for ~10 min. The preparation of EF-DD/W emulsions with a commercially available rotor-stator homogenizer (RS-HG; 15,000 rpm, 800 W) required the treatment period for ~1 min, and DD droplets in DD/W emulsions prepared were several micrometers in diameter. Colloidal stability of EF-DD/W emulsions prepared with Horn-US and HPBath-US was higher than that of EF-DD/W emulsions prepared with Bath-US and RS-HG. These studies indicate that HPBath-US has advantages for the manufacturing of EF-O/W emulsions. Furthermore, the continuous manufacturing of EF-DD/W emulsions was achieved by attaching the flow chamber with HPBath-US.

Key-words*: Manufacturing method, Emulsifier-free oil-in-water emulsion, High-powered bath-type ultrasonicator, Treatment period, Droplet size, Colloidal stability, Continuous manufacturing*

1. Introduction

An emulsion is a transient mixture of two immiscible liquids such as oil and water prepared with the aid of mechanical mixers (e.g., homogenizers) and surface active agents[1-3]. Since the interfacial free energy (G) of the emulsion (mixture of oil and water) becomes higher due to the increase in the interface area (A) between oil and water (see equation 1), oil and water naturally separate from each other with the elapsed time after preparation[1-3].

$$G = \gamma A \quad \cdots\cdots (1)$$

where γ is the interfacial tension between oil and water. Thus, the lower γ and the resulting lower G are required to retain the emulsion state for a longer period. Therefore, in general, the emulsifiers such as surfactants are required for the long-term colloidal stabilization of emulsions because the emulsifiers decrease the interfacial tension (γ) between oil and water. On the other hand, we have investigated the colloidal stability of oil-in-water (O/W)[4-12] and water-in-oil (W/O) emulsions[13-15] prepared with the ultrasonicator in the absence of any emulsifiers such as surfactants, which were named as emulsifier-free (EF-) O/W and W/O emulsions, respectively. We found that the long-term colloidal stabilization of EF-O/W and EF-W/O emulsions prepared with an ultrasonicator was achieved by optimization of oil type and composition[4-15]. Moreover, in recent years, the EF-emulsion products are strongly demanded because of the biocompatibility of emulsion products and environmentally benign approaches for manufacturing emulsion products[16-24].

Then, in this work, the manufacturing methods of EF-O/W emulsions were examined for practical applications. A commercially available both-type ultrasonic cleaner (Bath-US; 42 kHz, 26 W), a commercially available horn-type ultrasonic homogenizer (Horn-US; 19.5 kHz, 600 W), a high-powered bath-type ultrasonicator (HPBath-US; 28 kHz, 300 W) that we developed and a

【Figures and illustrations】 Figures and illustrations published in black and white in the journal can be seen in color at our public website「J-STAGE」. Please make use of it.