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Organogel-in-Water Emulsions as Thermal-Energy Storage and Heat Transfer Fluids

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Abstract

We report here on the potential of organic phase-change material gel-in-water (OPCMG/W) emulsions as thermal-energy storage and heat transfer fluids. Gelation of OPCM droplets in OPCM/W emulsions enhanced the colloidal stability against temperature change in the range of −1 to 40℃ and prevented the supercooling of OPCM droplets in the emulsions. Furthermore, the thermal properties of OPCMG particles in OPCMG/W emulsions were similar to those of OPCM alone.

Key-words: *Organic phase-change material, Organogel-in-water emulsion, Thermal-energy storage, Heat transfer fluid, Supercooling*

1. Introduction

Organic phase-change materials (OPCMs) such as paraffin have attracted attention as effective thermal-energy storage materials because of their high energy storage density afforded by the latent heat of OPCM during the phase change process, the tunability of phase-transition temperature by OPCM type and mixing of different OPCMs above 0℃ and the reusability of OPCMs due to the chemical stability[1-7]. The OPCM-in-water (OPCM/W) emulsions are also attracting attention as thermal-energy storage and heat transfer fluids because of their thermal conductivity and thermal-energy transport due to the fluidity of the OPCM/W emulsions even below solidifying-temperature of OPCM, the heat-transfer rates to the OPCM enhanced due to large specific surface area of OPCM and the tunability of temperature change of whole OPCM/W emulsions by combining latent heat of OPCM with sensible heat of water[1-7]. In order to apply the OPCM/W emulsions as thermal-energy storage and heat transfer fluids to the practical thermal management system, higher colloidal stability of OPCM/W emulsions and control of supercooling of OPCM droplets in the emulsions are required[7-21]. Then, we have investigated the effect of surfactant on the colloidal stability of OPCM/W emulsions and supercooling of OPCM droplets in the emulsions. We found that surfactants with longer hydrocarbon chain as a hydrophobic group are effective to enhance the colloidal stability of OPCM/W emulsions and prevent the supercooling of OPCM droplets in the emulsions[22].

In this work, we examine the potential of organic phase-change material gel-in-water (OPCMG/W) emulsions as thermal-energy storage and heat transfer fluids. We consider that the gelation of OPCM droplets in OPCM/W emulsions should enhance the colloidal stability of OPCM/W emulsions because the gelation of OPCM droplets in emulsions is expected to prevent the coalescence (fusion) of OPCM droplets even upon collision of OPCM droplets due to the higher viscoelasticity than liquid droplets. Also, the gelation of OPCM droplets in OPCM/W emulsions should prevent the supercooling of OPCM droplets in OPCM/W emulsions because 3D network formed in OPCM droplets should act as nuclei for solidification of OPCM droplets in emulsions.

2. Experimental

OPCMG/W emulsions (OPCM content in water = 30 vol%) were prepared by mixing of OPCM containing an organic gelator (*N*-Lauroyl-*L*-glutamic acid di-*n*-butylamide; LGBA, AJINOMOTO Co., Inc.) and ethanol (C_2H_5OH, Wako) with water using a rotor-stator homogenizer (CLEARMIX CLM-0.8S, M-Technique) at 60℃ (see **Fig. 1**). Hexadecane ($C_{16}H_{34}$, 99.2%, Tokyo Chemical Industry Co., Ltd) was used as an OPCM in this experiment. Colloidal stability and fluidity of hexadecane gel-in-water (HDG/W) emulsions were confirmed by monitoring the emulsion state before and after cooling (from 40℃ to −1℃) and heating (from −1℃ to 40℃). Solidifying-temperature (T_s) and -period (t_s) of HDG particles in HDG/W emulsions were determined from the temperature stagnation caused by phase transition from liquid to solid and the period that temperature reached to 2℃, respectively, during the cooling process of HDG/W emulsions from 40℃ to −1℃ (see upper panel of **Fig. 2**). The melting-temperature (T_m) and -period (t_m) of HDG particles in HDG/W emulsions were determined