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# Preparation of W/O emulsions by membrane emulsification with a mullite ceramic membrane

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**Abstract**

Monodispersed W/O emulsions were prepared by using submerged membrane emulsification apparatus with a mullite ceramic membrane. Kerosene was used as the continuous phase and water was used as the dispersed phase. The effects of stirring speed and transmembrane pressure on droplet size and dispersed flux were studied. The droplet size of the emulsions decreased with increased stirring speed but increased with increasing transmembrane pressure. The flux of the dispersed phase was proportional to transmembrane pressure, decreased with increasing stirring speed at a low transmembrane pressure and increased slightly at a high transmembrane pressure. The effect of pre-soaking time on the emulsification result was also investigated.

*Keywords:* Mullite membrane; Membrane emulsification; W/O emulsions

## 1. Introduction

Membrane emulsification is a new technology for producing emulsions. The dispersed phase is pressed through the pores of a membrane into the continuous phase flowing alongside the membrane surface where droplets form. The technique is highly attractive given its simplicity, potentially lower energy demands, need for less surfactant and the resulting narrow droplet-size distributions [1].

The preparation of W/O emulsions is difficult compared to the preparation of O/W emulsions since the aqueous phase droplets are hard to stabilize by an electrical double-layer repulsion force in the oil phase with a low dielectric constant. In addition, diffusion of surfactant

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molecules through the oil phase is slower than through the water phase because the oil has a higher viscosity than the water. Thus, stabilization of newly formed water droplets is slower and coalescence cannot be avoided [2]. The low flux of the dispersed phase through membranes and the possibility of droplet coalescence could be limiting factors for large-scale applications. Schröder et al. [3] reported that pre-soaking membranes in solutions containing surfactants or emulsifiers could improve the flux of the dispersed phase. Moreover, most of the research [1,4] indicated that only polydispersed emulsions could be obtained using ceramic membrane since the ceramic membrane has a small number of coarse pores.

In our experiments we focused on the method for obtaining monodispersed W/O emulsions with ceramic membrane and observing influence of pre-soaking time on the dispersed phase flux. A mullite ($3Al_2O_3{\cdot}2SiO_2$) membrane was used as support material of a ceramic membrane for good chemical stability and a stable temperature-independent oxygen vacancy structure up to the melting point, low thermal expansion coefficient, low thermal conductivity, low dielectric constant, high deformation resistance at high temperatures and low fracture toughness. However, emulsions prepared from a mullite membrane have not been reported yet. In this paper, monodispersed W/O emulsions were prepared by using submerged membrane emulsification with a mullite membrane. Meanwhile the effects of stirring speed, transmembrane pressure and pre-soaking time on droplet size and the flux of the dispersed phase were studied.

## 2. Experimental

The W/O emulsions were prepared using a submerged membrane emulsification apparatus with a mullite ceramic membrane [5]. The dispersed phase was put into the pressed container, and then pressed through the pores into the continuous phase flowing outside the membrane. The droplets formed on the external surface of the mullite ceramic membrane and were detached from the surface with a low shear force produced by the rotating flow of the continuous phase. The stirring speed was adjusted by a variable-speed, magnetically driven impeller to obtain different shear forces.

The outer diameter of the mullite ceramic membrane is 11 mm and the membrane surface area is $3.6{\times}10^{-3}$ m$^2$. A SEM image of the top surface and the side surface of the mullite ceramic membrane is shown in Fig. 1. The mean pore size is 0.68 μm.

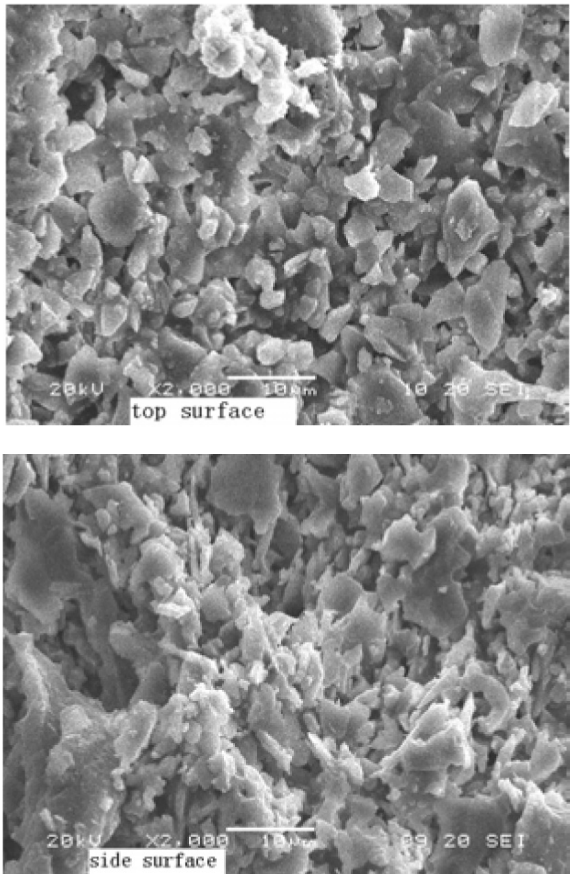


Fig. 1. SEM images of the top surface and side surface of the mullite support.