The Synthesis of SiO_2 Particles with CTAB as Surfactant and Its Foam Stability for Decontamination Process

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1. Introduction

The decontamination and decommission technology have been considered as one of the controversial issues in the nuclear society. For the decontamination, chemical decontamination method was widely employed to remove the surfaces contaminated by radionuclides such as radio active Co, and Cs. However, a large amount of liquid waste can be generated when the chemical method was used. Recently, the decontamination foam consisting with surfactant and nanoparticle has been regarded as an another method to remove the contaminated surface. Because the foam could reduce the volume of secondary waste. However, foam is actually a thermodynamically unstable system. Therefore, foam stability is key factor for decontamination. The foam stability can be tuned by mixing surfactants and nanoparticles. Our group reported that the foam stability of surfactant was improved with silica nanoparticle as a foam stabilizer. Thus, it is desirable when the surfactant or nanoparticle can be reduced for foam generation.

In this work, we synthesized silica particle with low surfactant for decontamination foam by using co-condensation method based on sodium hydroxide catalyzed reactions of tetraethoxysilane (TEOS) with the cetyltrime- thyammonium bromide (CTAB) as a surfactant. Its foam stability of as-synthesized silica was investigated as a function of different synthesis conditions.

2. Experimental

For the SiO_2 preparation, CTAB and 2 M NaOH solution were added in DI water and heated at 80°C. After 1 h, TEOS was added to the above solution followed by stirring for 2 h. The SiO_2 particles were washed by water and methanol, and dried under vacuum oven. The morphology and structure of SiO_2 were analyzed by FE-SEM and XRD, respectively. Thermogravimetric analysis (TGA) was carried out to measure the amount of CTAB in SiO_2 under flowing nitrogen with a heating rate of 5°C min^{-1}.

The foam stability and liquid volume of foam were analyzed with commercially available Foamscan instrument (Teclis/IT Concept, France). In order to measure the foam properties, the SiO_2 souition that SiO_2 particles (1 wt.%) are dispersed in 100 ml of deionized water at pH 2 was prepared. The solution was poured into cylinder glass column and bubbled by sparging nitrogen gas at a folw rate of 200 ml/min through the SiO_2 solution. After the foam volume was achieved at 200 ml, its foam and liquid volume were recorded by monitoring the change in foam volume and liquid volume using CCD camera and measuring the conductivity as a function of time. For comparison, 1 wt.% fumed silica nanoparticle with 1 wt.% Elotant™ Miloside 100 as a surfactant was also dispersed in 100 ml deionized water. All the measurements were carried out at room temperature.

3. Results and discussion

Fig. 1a shows the small-angle XRD patterns of as synthesized SiO_2 particles. The SiO_2 samples show an intense (100) peak and three (110), (200), and (210) peaks (except for NaOH-10). The main peak (100) of SiO_2 particle was slightly shifted toward higher 2 Θ angles with increasing to the NaOH amount, indicating the creation of larger *d*-spacing. The amount of CTAB in SiO_2 particle was less than 40% as shown in Fig. 1b.

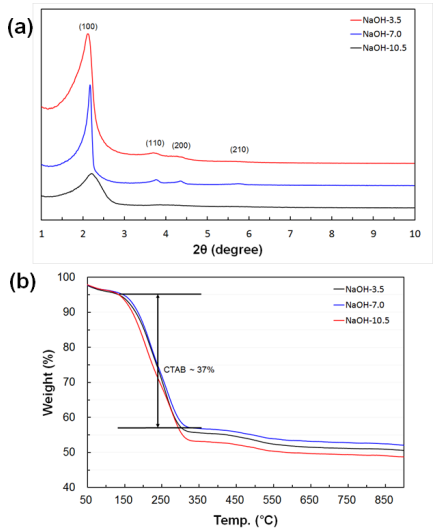

Fig. 1. Small-angle XRD patterns (a) and TGA profiles (b) of as-synthesized SiO_2 particles.

The morphology of SiO_2 particles are observed by FE-SEM and shown in Fig. 2. It is clearly reveal that the particle size of SiO_2 increased as a function of NaOH amount. The particles exhibited tubular shape (Fig. 2a), but the other samples show irregular and micron-sized particles. The particle size was increased from 400 nm to 2 µm.

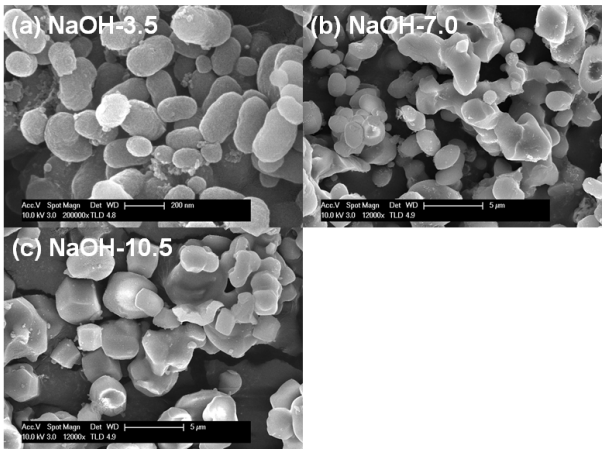

Fig.2. SEM images of SiO_2 particles according to the amount of NaOH.

For the foam stability measurement, the aqueous foam was generated and its stability was recorded by using Foamscan analyzer. Fig.3 shows the foam volume of SiO_2 particle (M-5, 1-5wt%) with surfactant (1wt% EM-100) at pH 2. The foam volume of SiO_2 nanoparticle with surfactant retained at 165 ml until 50 min, but dramatically decreased after 60 min due to the liquid drainage during foam ageing. However, the foam stability of as -synthesized SiO_2 particle was improved (except for NaOH-3.5). As the amount of NaOH and CTAB increase, the foam stability retained at highest foam volume retention during foam scanning, idicating that the higher amount NaOH leads to improve the foam stability of as-synthesized SiO_2 particles.

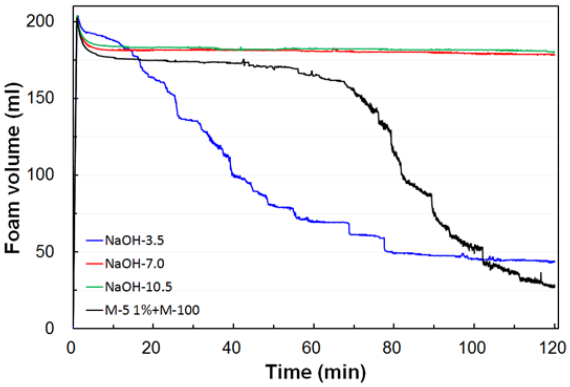

Fig. 3. Foam stability of SiO_2 nanoparticles containing surfactant (1wt% M-100) with different NaOH amount.

4. Conclusions

In this work, we have synthesized the SiO_2 particles based on sodium hydroxide catalyzed reactions. The structure and morphology of SiO_2 particle were depending on the NaOH amount. In the foam measurement, the amount of SiO_2 played critical role in the foam stability. We also investigated the foam stability of SiO_2 particles according to different synthesis conditions.

5. Acknowledgements

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6. Reference

[1] I.-H. Yoon, C.-H. Jung, S.B. Yoon, S.Y. Park. J.-K. Moon, W.-K. Choi, Effect of silica nanoparticles in the stability of decontamination foam and their application for oxide dissolution of corroded specimens, Ann. Nucl. Energy, 73 (2014) 168-174.