Original Research Paper
J. Jpn. Soc. Colour Mater., **90** 〔9〕, 305–314 (2017)

Evaluation of Particle Dispersion and Aggregation State of Various Nano-Particle Suspensions by Osmotic-Pressure Measurement

Takamasa Mori*,†, Takuya Muramatsu* and Tomoki Mori*

* *Department of Chemical Science and Technology, Faculty of Bioscience and Applied Chemistry, Hosei University, 3-7-2 Kajino-cho, Koganei, Tokyo 184-8584, Japan*
†*Corresponding Author, E-mail: tmori@hosei.ac.jp*

(Received May 18, 2017; Accepted July 27, 2017)

Abstract

The particle-dispersion state of nano-particle suspensions was evaluated by measuring their osmotic pressure. Zirconia suspensions with different particle-dispersion states were prepared by adjusting the pH value of the suspension, and their osmotic pressure and particle-size distribution were measured. For alumina and silica suspensions, the ionic concentration was adjusted to change the particle-dispersion state, and their osmotic pressure and particle concentration after centrifugation were also measured. The osmotic pressure was found to decrease with an increase in the ionic concentration due to particle aggregation caused by compression of an electrical double layer. A good correlation between the osmotic pressure and particle concentration after centrifugation of the suspensions was exhibited; thus, we can conclude that the osmotic-pressure measurement would be a useful tool to characterise the particle-dispersion state, especially for dense nano-particle suspensions.

Key-words: *Nano-particle suspension, Dispersion and aggregation, Osmotic pressure, Hydrostatic pressure*

1. Introduction

Recently, many research activities related to the application of nano particles have been conducted because various types of nano particles have been successfully fabricated[1-3]. Generally, handling particulate matters, especially nano particles, under dry conditions becomes difficult as the particle size decreases due to strong adhesion and flocculation. To solve this problem, nano particles are normally used as suspensions where they are suspended in appropriate media such as water, ethanol, and so on. Therefore, controlling particle dispersion state in slurry is very important for fabrication of better products, which means that a precise characterisation technique for particle-dispersion state is necessary.

To characterise the particle-dispersion state in slurry, many researchers have studied it using different methods. For example, in ceramic processing, the particle-dispersion state has been characterised by measuring the apparent viscosity of the slurry. In many cases, the apparent viscosity decreases when the particles in the slurry are well dispersed. However, in some cases, the apparent viscosity of the slurry was reported to not match the particle-dispersion state[4-7].

The sedimentation test is also a conventional technique to evaluate the particle-dispersion state in the slurry[8-10]. The sedimentation test is an easy and cost-effective method. However, it is not suitable for slurry with no clear interface between the slurry and supernatant because a reduced velocity at the interface is essential to estimate the particle or floc size, that is, the particle-dispersion state. To overcome the difficulty in the sedimentation test, we developed a novel technique based on sedimentation, namely, hydrostatic-pressure measurement[11-14]. In this method, the time change in the hydrostatic pressure at the bottom of the slurry is measured during the sedimentation test. The hydrostatic pressure rapidly decreases when the particle forms large flocs. Thus, we can evaluate the particle-dispersion state by comparing the decreasing rate of hydrostatic pressure[11-14]. Because we can obtain the hydrostatic pressure of any slurry regardless of the presence of a clear interface, the hydrostatic-pressure measurement would be a powerful tool for slurry characterisation. However, considering its application to nano-particle suspension, the applicability of this method is limited because the settling velocity of nano particles must be extremely small. Some commercial sedimentation-test devices are available that use visible light to detect the settling particles in which the concentration profile of the settling particles is automatically recorded[15,16]. However, limitations remain.

On the other hand, other experiments that use dynamic light scattering (DLS) have been undertaken[17,18]. DLS is one of the particle-size measurement methods, especially for nano particles. Thus, the evaluation of the particle-dispersion state is attempted from the measured median diameter or particle-size distribution. However, DLS is applicable only for diluted suspensions. In other words, incommensurable dilution of