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Original Research Paper

Measurements of size distribution of titanium dioxide fine particles in a highly concentrated non-aqueous suspension by using particle self-assembly under an electric field

Akira Otsuki [a,*], Gjergj Dodbiba [b], Toyohisa Fujita [b]

[a] Department of Metallurgical & Minerals Engineering, Western Australian School of Mines, Curtin University, Kalgoorlie, WA 6433, Australia
[b] Department of Systems Innovation, Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-8656, Japan

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ABSTRACT

This paper describes the measurement of size distribution of TiO_2 fine particles in a highly concentrated non-aqueous suspension by using self-assembly of particles under an electric field. Interactive force apparatus (IFA) was used to conduct the measurement. IFA first assembled pearl chains of particles between two electrodes, and then applied the compressive force to change the pearl chain structure by shortening the distance between electrodes. The repulsive force generated when the chain curved while the attractive force created when the chain was broken. The cycle of repulsive and attractive forces corresponds to the size of particles. The results obtained with IFA were compared with results obtained from size measurement by analyzing SEM photographs. IFA indicated the comparable results with the one obtained using SEM. The particle size distribution measured by IFA decreased as a result of increasing the supply voltages. Changes in correlation between size distribution measured by SEM and IFA at different supply voltages were observed in different size ranges. At smaller than 300 nm, result at 0.24 V fit well with the SEM result while at >600 nm gives better agreement with the results at 0.48 V. The difference is mainly due to the increase in number of particles in fine size fraction with increasing supply voltages. Decrease in size indicated that the breakage of aggregate particles and/or disintegration of doublet particles occurred due to the electrical fragmentation. The fragmentation was explained by monitoring the mean diameters and their deviation obtained from IFA measurements at different supply voltages.

1. Introduction

Particle dispersion and coagulation often strongly affect the capability of industrial processes handling fine particles. For example, proper particle dispersion is a key to achieve selective separation of valuable mineral particles from gangue minerals in mineral processing plants. Hence, precise characterisation and manipulation of particle dispersion and coagulation in various media are necessary to beneficiate many industrial processes [1,2]. Many techniques are currently available for characterising fine particles by measuring size [3], turbidity [4], contact angle [5], zeta potential [6], force between particle and plate [7] as well as combination of these techniques [8,9]. However, these methods usually are not suitable in highly concentrated suspensions and/or non-transparent suspensions. On the other hand, from the economical point of view, non-transparent concentrated suspensions are commonly handled in the many industrial processes, such as separation of mineral particles by froth flotation.

In this study, we present a novel method for measuring particle size in order to characterise fine particles in highly concentrated suspension. Size is one of the most important and basic physical properties of particles. It is also a good indicator to find out whether the particle disperse or coagulate in different environments where particle–particle interaction varies. Here, our target size range is single nanometers to ten micrometers. The conventional size distribution measurement technologies can be divided, by their applicable environments, into two categories, i.e. measurements in (i) dry conditions and (ii) wet conditions [2]. Microscopic analysis (e.g. scanning electron microscope (SEM), transmission electron microscope (TEM)) is common in dry conditions while the light scattering method (e.g. the dynamic light scattering, laser diffraction) is often used in wet conditions. Each of them has advantages, and some drawbacks. SEM and TEM are not a powerful method for the measurement in solvents. The light scattering method is not usually suitable for the measurement in high particle concentrations and/or the suspensions with no optical transparency.

* Corresponding author.
E-mail address: akira.otsuki@curtin.edu.au (A. Otsuki).

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