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主　論　文　の　要　旨

論文題目　STUDIES ON SOLID-LIQUID SEPARATION OF O/W EMULSION
(O/Wエマルションの固液分離に関する研究)

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論　文　内　容　の　要　旨

In today's world, science and technology have been progressing with each passing day. Advanced solid-liquid separation technologies have become indispensable in many fields such as environmental protection and new-product development. Physical solid-liquid separation is one of the most significant methods because no chemical additives are needed to avoid secondary pollution. Particularly, the separation of deformable and/or multicomponent materials has become significant. The current research involves the solid-liquid separation of oil-in-water (O/W) emulsion. This dissertation is composed of 5 parts. Chapter 1 gives general introduction about theory and literature review, in which mechanical separation theories, evaluation of filtration characteristics, nonlinear filtration behaviours, separation of O/W emulsion and separation of binary suspensions were introduced.

In Chapter 2, downward and upward membrane filtration experiments under constant pressure conditions were conducted for O/W emulsion using a dead-end filter and their filtration behaviors were compared. In downward filtration, the Ruth plot, in which the reciprocal filtration rate was plotted against the filtrate volume per unit membrane area, was obtained as an upward convex curve, while it showed a linear relationship in upward filtration

in accordance with the Ruth filtration rate equation. In view of the difference in the filtration behaviors of both filtration methods and the density contrast between the oil droplet and continuous phase, it was anticipated that the filter cake exfoliation occurred in downward filtration. The infinite average specific cake resistance was calculated from the experimental results of flux decline behaviors, assuming that the solid mass of filter cake is increased in direct proportion to the filtrate volume. The specific resistance in downward filtration became smaller with the progress of filtration due to the exfoliation of filter cake. In contrast, the specific resistance in upward filtration was maintained virtually constant and considerably larger than that in downward filtration. The value obtained in upward filtration was considered to be the true value that was uninfluenced by the exfoliation of filter cake. It was therefore concluded that the upward dead-end filtration test is quite effective for the evaluation of filtration properties in membrane filtration of O/W emulsion.

In Chapter 3, upward dead-end filtration tests accompanied with a sudden reduction in the cake surface area during the course of filtration were proposed in order to determine the properties of the filter cake formed during microfiltration of O/W emulsion. Both upward and downward dead-end filtration tests were conducted under constant pressure conditions by using a filter having a sudden reduction in its filtration area, and the filtration characteristics between the two were compared. Consequently, it was found that the filtration rate in downward filtration was much higher than that in upward filtration as a result of cake exfoliation which occurred in downward filtration, leading to lower specific cake resistance. Moreover, when the average cake porosity was evaluated on the basis of an overall mass balance of dead-end filtration on the assumption that the cake was not exfoliated, the cake porosity in downward filtration became much lower than that in upward filtration for a similar reason. It was revealed that the correct values of cake properties were obtained from the data of upward dead-end filtration in which the exfoliation of the cake did not occur. It was necessary to consider the influence of the cake porosity in the calculation of the average specific cake resistance when an O/W emulsion was not dilute. On the basis of upward

dead-end filtration tests, the power law relationship was applicable in order to represent the effects of the applied pressure on both the average volume fraction of oil droplets and the average specific resistance of the cake comprised of oil droplets. It was found that the cake formed during filtration of O/W emulsion was highly compressible due to the deformability of oil droplets. Moreover, the average volume fraction of oil droplets and the average specific cake resistance were kept constant throughout the course of filtration.

In chapter 4, the centrifugal separation characteristics of emulsion-slurry which contained both oil droplets and colloidal SiO_2 particles were investigated using the microprocessor controlled analytical photocentrifuge, LUMiFuge, in this study. It was clarified that oil droplets and SiO_2 particles in emulsion-slurry were separated completely after centrifugation, due to flotation of oil droplets and sedimentation of SiO_2 particles resulting from the density difference. The flotation velocity of oil droplets and the settling velocity of SiO_2 particles through emulsion-slurry became larger than those of the single dispersions (O/W emulsion and SiO_2 suspension) with the corresponding volume fraction. The acceleration effects of flotation and sedimentation through emulsion-slurry were examined by using the flotation and sedimentation coefficients in which the effect of centrifugal acceleration on the flotation and sedimentation velocities was cancelled. Both the flotation and sedimentation coefficients increased with increasing volume fraction of SiO_2 particles or oil droplets in emulsion-slurry, and the acceleration effect of the flotation coefficient was noteworthy due to the marked increase in the density difference between oil droplets and emulsion-slurry with increasing volume fraction of SiO_2 particles. The flotation and sedimentation coefficients through emulsion-slurry were experimentally described by using two types of void functions and well described the acceleration effect in centrifugal separation of emulsion-slurry.

Finally, Chapter 5 gives the summary of the main results obtained from the studies.