1. Title
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2. Research Term
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3. Research Fields
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4. Research Categories
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5. Research Theme
Single-component and double-component dispersions of colloidal particles as studied by the Kossel diffraction and ultra-small-angle X-ray scattering

6. Investigators
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8. Summary of Research
Objective/Significance: We prepare small colloidal particles of materials having relatively large densities, which are not substantially influenced by the gravitational sedimentation on earth, and their colloidal crystals in aqueous media are investigated under the normal gravity condition by using a recently developed, lightweight and automated Kossel diffraction apparatus and an ultra-small-angle X-ray scattering (USAXS) setup. The Kossel diffraction technique of laser beams is found to have high precision, and can detect a very small effect of the gravity on colloidal crystals. The purpose of the proposed study is to accumulate information of the performance of the Kossel diffraction apparatus and to find out necessary technical details to be improved before the final version of the apparatus can be brought up to the space laboratory.

Colloidal crystals of various particles having large refractive index and large density, which may be potentially of practical importance, are also studied in their one- and two-component dispersions. Accumulating these data is indispensable to development of the new materials in space. Studying the gravitational effects on such colloidal systems with high accuracy is very significant not only in search of the practical applicability of the new materials but also in advancing the understanding of the basic physical properties of condensed systems.

Methods: After extensive dialysis with pure water and deionization by ion-exchange resin particles, colloidal dispersions (of polystyrene-based latex particles, silica particles and titanium oxide particles) were diluted in single- or mixed-dispersions with various combinations and number-ratios of different particles. These specimens were introduced into quartz glass cuvettes. We observed crystallization processes in colloidal dispersions by using Kossel diffraction method. We developed a compact and lightweight Kossel diffraction apparatus, which can be employed with a greater ease in space laboratory. Furthermore, theoretical investigation was made on interaction between colloidal particles.

Results: The main results obtained by this research are as follows.
(1) The most important subject of this research is to design and prepare a practical apparatus which can be used in space experiments. We developed the apparatus so as to reduce burden to space crews in the
(2) By using the Kossel diffraction method with high precision, we succeeded in measuring distortions of pillar-shaped single crystals of silica colloids by the normal gravity on the ground.

(3) We prepared colloidal particles of large sizes with comparatively high monodispersities. The samples to be used in space experiments are thus already in hand, and we plan to continue to improve the quality of these particles.

(4) Two kinds of latex particles were chosen out of three kinds (particle diameters: 220nm, 156nm, 77nm), and their colloidal alloy crystals were studied by the Kossel diffraction method for binary mixtures of particles of different sizes.

(5) For binary dispersions of silica and titanium oxide particles, the Bragg-diffraction signal was detected and we succeeded in photographing the Kossel diffraction images. It became clear that their crystals had face-centered cubic structure and face-centered cubic twin structure, which had not been observed in the one-component silica dispersions.

(6) The principal investigator constructed a new mean field theory for macroionic dispersions and derived exact integral representations of the Helmholtz and Gibbs free energies without resort to the linear approximation.

(7) The Helmholtz and Gibbs free energies of highly-charged plates immersed in a 1:1 electrolyte solution in a finite container were investigated.

Potential for space experiment: Since the Kossel diffraction analysis method has high precision and since we have made progress in making the apparatus light, compact and highly automated, this method is concluded to be especially useful for structural analysis of colloidal crystals under the space environment. The observation of the new structure in the binary dispersion system of silica particles and titanium oxide particles, which had not been found in the one-component silica dispersions, indicates the high reliability of our plan to observe crystallization in colloidal dispersions of heavy titanium oxide particles under micro-gravity conditions.

9. Publication List

1) Ise, N. and Sogami, I. S., Structure Formation in Solution -Ionic Polymers and Colloidal Particles-, Springer-Verlag, in press.


10. URL