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P02

Colloidal Clusters 宇宙実験における会合体形成の検討

Cluster Formation of Oppositely Charged Colloidal Particles in Colloidal Clusters Space Experiment

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1. Introduction

Positively and negatively charged colloidal particles self-assemble in aqueous dispersions, and form association structures (clusters) due to Coulomb force (**Fig. 1(a)**). Tetrahedral clusters (**Fig. 1(b)**) are of particular interest, because they are units of diamond lattice, which has been expected as a novel photonic material. The complete photonic band gap of the colloidal diamond lattice is formed when the refractive indexes of the particles is more than two times larger than that of medium. Titania (titanium dioxide) has a high refractive index (approximately 2.0) and useful as the photonic materials. However, materials having high refractive index often possess high specific gravity. Therefore, microgravity environment would be ideal for the structure formation of colloidal particles having high refractive index.

The clustering experiment (Project name: Colloidal Clusters[1)]) was performed under a microgravity environment of ISS in July 2020. The samples made in space have returned to the ground in Mach 2021 and under investigation. Here, we report the preparation for ethe space experiments and preliminary analysis of the clusters.

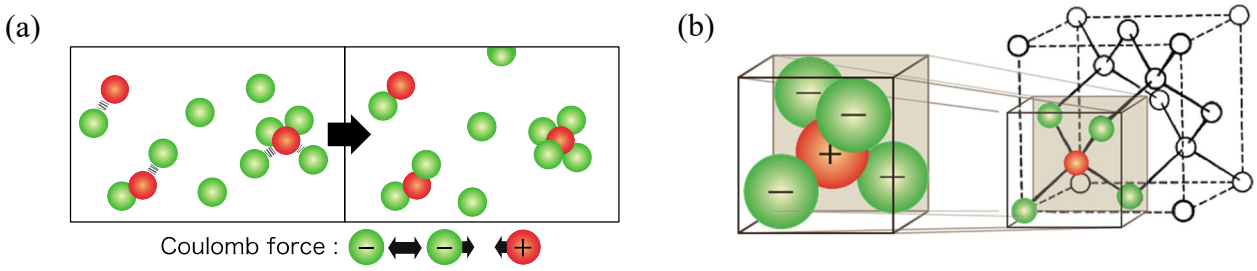

Fig. 1 Illustrations of (a) clustering of oppositely charged particles because of Coulomb attraction (b) tetrahedral cluster and diamond lattice.

2. Clustering of Charged Particles

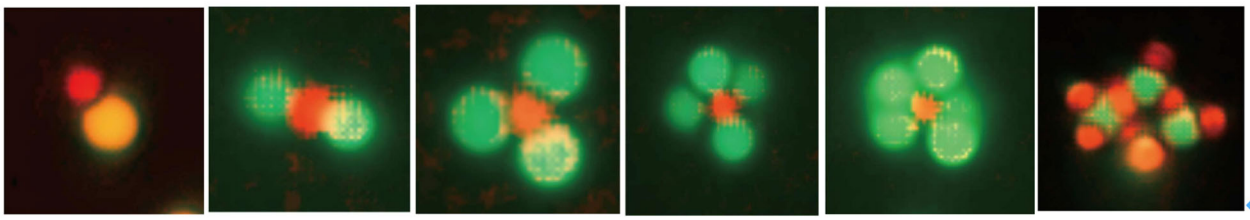

Fig. 2 Colloidal clusters of positively (red) and negatively (green colored) charged polystyrene particles having various association numbers. Obtained in reference experiments performed on ground. Particle diameter = 800 nm and 1000 nm.

An example of the microscopic image of the clusters of charged polystyrene particle mixtures obtained in the ground study is shown in **Fig. 2**. The distribution of the number of clusters is shown in **Fig. 3**. Polystyrene can be tested on the ground because of its low specific gravity, but titania has high specific gravity and we conducted a space experiment.

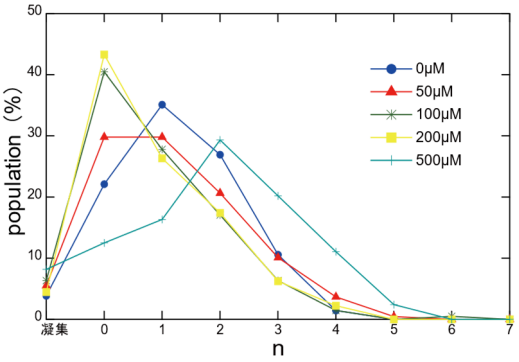

Fig.3 Distribution of association numbers of charged polystyrene particles at various NaCl concentrations.

3. Space Experiments

Fig. 4 presents the sample bag used for the space experiments. Dilute aqueous dispersions of negatively and positively charged colloidal particles (approximately 0.05 vol% in total) are introduced in plastic bags (volume = 3 mL each), separated by a breakable seal. We used charged polystyrene (n_r = 1.60; ρ = 1.05), silica (n_r = 1.45; ρ = 2.1) and titania (TiO_2, n_r = 2.0; ρ = 3.0). The samples contained UV-curable gelation reagents. After mixed, the samples were maintained in ISS for 2 days, and then gelled by an UV irradiation.

Fig. 4 A sample bag having a breakable separator. Two rooms are filled with red and blue colored liquids.

We confirmed that All the space samples were successfully fixed with gel. Supernatant region due to precipitation was not observed in all the samples, and the colloidal particles were quite uniformly distributed. Microscopic observation of the polystyrene particle samples showed that the colloidal clusters were formed in the space sample, with various association numbers, including tetrahedral clusters. The distribution of the association number was almost the same as that obtained in the laboratory beforehand, confirming that the space experiment was conducted as expected.

At present, we are analyzing titania samples. We are going to evaluate the elasticity of the gel matrix, identify the clusters of the titania particles, by microscopy and neutron scattering.

Acknowledgment

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References

1) JAXA Web page, https://humans-in-space.jaxa.jp/kibouser/subject/science/70504.html