Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

MIS31-P04 会場:コンベンションホール 時間:5 月 19 日 18:15-19:30

コロイド結晶化メカニズム解明に向けた少数クラスター系における荷電粒子間の静電相互作用
The electrostatic interaction between charged particles in small-number clusters for the colloidal crystallization

仙波 稔己 [1*], 三浦 均 [1], 石川 正道 [2], 塚本 勝男 [1]
Toshiki Senba[1*], Hitoshi Miurah[1], Masamichi Ishikawa[2], Katsuo Tsukamoto[1]

[1] 東北大学大学院理学研究科, [2] 理化学研究所
[1]Graduate School of Science, Tohoku University, [2]RIKEN

Colloidal crystals are regular arrays formed by self-assembly of charged particles in suspension. In self-assembly, the interaction between particles plays an important role. The interaction between particles is explained by DLVO theory, which predicts a purely repulsive electro-static interaction between the particles. In contrast, a number of experimental evidences such as void formation suggest the existence of a long-range attractive force between charged particles.

Many studies have been carried out to measure the interaction of charged colloids in the equilibrium system. However, the existence of the long-range attractive force has not been confirmed yet. To understand the interaction of colloids deeply, a new experimental approach which is different from the former is needed.

As the new experimental approach, I observed the dynamics of a small-number cluster in the non-equilibrium system. I prepared a regular-hexagonal colloidal cluster composed of seven polystyrene particles in dilute dispersions by using holographic optical tweezers. Due to Brownian motion of each particle, a disordering arises in the hexagonal structure with time progresses. If some interaction force exists between particles, the disordering process will be different from what assumed the Brownian motion only. I defined the cluster lifetime as the time when the colloidal cluster does not satisfy the condition of a regular-hexagon. I measured the lifetime under different experimental condition (salt concentration of colloidal dispersions) and considered the interaction which works between colloidal particles (repulsive or attractive force).

From the experimental results, I found that the cluster lifetime became maximum at a certain salt concentration. In addition, the average distance between particles when the cluster collapsed was almost independent of the salt concentration within the experimental error. These results suggest the existence of some interaction between particles.

To consider the magnitude and direction of the interaction force, I carried out numerical calculations of the process that the cluster collapsed by Brownian dynamics (BD) method. As the interaction between particles, I considered three cases: DLVO, Lenard-Jones and Sogami-Ise potentials. The DLVO potential includes only the force of repulsion: on the other hand, the others include the force of repulsion and long-range attraction. In the numerical results using the DLVO potential, the cluster lifetime got longer depending on potential parameters. Simultaneously, the average particles distance when the cluster collapsed increased. On the contrary, in the results using Lenard-Jones and Sogami-Ise potentials, the average particles distance did not change with the increase in the lifetime.

These results suggest the existence of the long-range attractive interaction between charged colloidal particles.
Keywords: electrostatic interaction, small-number clusters, non-equilibrium system, optical tweezers, Brownian dynamics method