

1. Growth of Interface-floated Lysozyme Crystals (Videos: 1-4)

<Explanation>

We have developed a method of magneto-Archimedes levitation for diamagnetic protein crystals (lysozyme) by making a protein solution become paramagnetic with the use of paramagnetic gadolinium chloride as a precipitation agent.

While lysozyme is floating up, the following three forces are exerted on the crystals:

- (1) Upward magnetic force exerted on the diamagnetic crystals
- (2) Upward force as a reaction to the downward magnetic force exerted on the paramagnetic solution
- (3) Buoyancy force received from the crystal solution

Since the specific gravity of lysozyme crystals is slightly greater than that of water, more than 90% of the gravity exerted on the crystals in the solution is canceled by their buoyancy. In contrast, the magnetic force exerted on the crystals in (1) is negligibly small. Therefore, the force in (2) can cause magnetic levitation.

<Notes for videos>

When the magnetic force is weak (3.0T), the crystals cannot float up. The crystals are in a state of deposition on the bottom of the vessel (**Video 1**).

When the magnetic force is slightly stronger and its intensity is equal to that of the gravity in the center of the vessel (3.5 T), the effect of gravity exerted on the crystals is canceled and the crystals assume a state of pseudo-zero gravity. At that time, the crystals are deposited in the gas-liquid interface and on the bottom of the vessel (**Video 2**).

When the magnetic force becomes even stronger (3.9 T), all the crystals are deposited in the gas-liquid interface (**Video 3**).

When sodium chloride is used as a precipitation agent instead of gadolinium chloride, the crystals are deposited on the side surface in addition to the bottom of the vessel (**Video 4**), even when a magnetic field is applied (4.5 T).

(Note: The specimen was handled 40mm higher than the center of the magnet.)

<Place of execution>

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(Note: The reproducibility of the same phenomenon has been confirmed through experiments at the Faculty of Pharmacy, Osaka Ohtani University.)

<Research paper>

S. Maki, Y. Oda, and M. Ataka,

“High-quality crystallization of lysozyme by magneto-Archimedes levitation in a superconducting magnet”,

Journal of Crystal Growth **261**, pp.557-565 (2004).

<Patents>

Patent No. 3711386, (patent application number 2002-213229 in Japan)

Patent No. 4273222, (patent application number 2002-360069 in Japan)