IX-X Effects of High Magnetic Field on Chemical and Physical Processes

We have studied the effects of high magnetic field on chemical reaction and physical processes of diamagnetic and paramagnetic materials to unravel the mechanisms of the interaction of matter and magnetic field and to develop unique methods controlling chemical and physical processes and improving chemical and physical properties of functional materials. Currently we are using a vertical superconducting magnet which can generate high magnetic fields (15 T, 1500 T^2/m) in a 40 ϕ bore tube. Last year, we have succeeded, for the first time, to induce 3-dimensional morphological chirality in zinc silicate membrane tube using a high magnetic field. This year, from *in situ* observation, we have verified the mechanism. The Lorentz force on ions induces remarkable convection of a solution in silicate garden reaction. Some other interesting effects of magnetic fields were also studied.

IX-X-1 3-Dimensional Morphological Chirality Induction in Silicate Garden Reaction Using a Magnetic Field

DUAN, Wenyong[1]; UECHI, Ichiro[1]; KITAMURA, Shu[2]; FUJIWARA, Yoshihisa[2]; TANIMOTO, Yoshifumi[1]
([1]IMS and Hiroshima Univ.; [2]Hiroshima Univ.)

We have reported that *three-dimensional morphological chirality* can be induced in silicate membrane tubes formed from the reaction of sodium silicate aqueous solution and zinc sulfate crystals by using vertical magnetic fields (5–15 T).[1)] In magnetic fields right-handed helical tubes grow along the inner surface of the vessel wall, whereas left-handed tubes grow along the outer surface of the glass rod placed in the vessel. In order to examine whether this new effect is generally observed in silicate garden reaction, we have studied many silicate garden reactions using different metal salt crystals. Morphological chirality is induced in membrane tubes prepared from magnesium chloride, copper sulfate, manganese sulfate, and iron sulfate crystals, indicating that this effect is common in silicate garden reaction. Paramagnetism of metal ion such as copper ion is unimportant for chirality induction, indicating that magnetic force cannot induce morphological chirality. Furthermore, in magnetic fields membrane tubes grown apart from the vessel wall are twisted to the opposite direction to those grown along the inner surface of the wall, as shown in Figure 1.

In order to verify the mechanism, *in situ* observation of the reaction using magnesium salt crystals was carried out in a bore tube of a magnet. At zero field, no convection of sodium silicate aqueous solution was observed regardless of magnesium chloride crystals. In the presence of 15 T vigorous convection was observed only when the crystals were added to the solution. It was shown that helical tubes near the vessel wall grow along the convection, whereas tubes apart the wall are twisted by the convection. It is now verified that Lorentz force on ions blowing out from the membrane tubes induces remarkable convection of the bulk solution.

Reference

1) I. Uechi, A. Katsuki, L. Dunin-Barkovskiy and Y. Tanimoto, *J. Phys. Chem. B* **108**, 2527–2530 (2004).

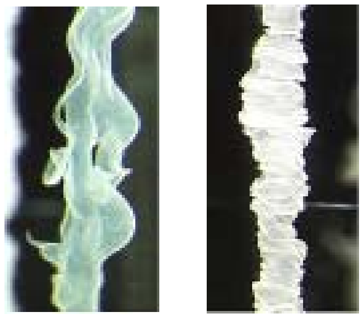

Figure 1. Photos of zinc silicate membrane tubes grown apart from a vessel wall at zero field (left) and 12 T (right). (Magnification; 175)

IX-X-2 *In Situ* Observation of the Effects of a High Magnetic Field on the Growth of Silver Dendrites

KATSUKI, Akio[1]; TANIMOTO, Yoshifumi
([1]Shinshu Univ.)

We have showed 3-dimensional morphology and chemical yields of silver dendrites generated by the liquid/solid redox reaction between silver ion and copper metal were remarkably affected by *vertical* high magnetic fields.[1)] In order to clarify the mechanisms, we have undertaken *in situ* observation of the silver dendrite formation reaction in 2-dimensional system. A thin plate of zinc metal (0.1 mm × 20 mm × 5 mm) was sandwiched with two plastic plates (2 mm × 20 mm × 55 mm), and silver nitrate aqueous solution was added to the space between two plates. At zero field, dendrites on the upper side of the metal plate grew steadily and no convection of the solution was observed. At 15 T, the top of dendrites underwent precession with bottom fixed. This unique phenomenon indicates that the solution near the dendrites undergoes convection due to the Lorentz force on the flow of ions. Because of concentration gradient of silver ions near the reactive zone of dendrites, silver ions move to dendrite surface and Lorentz force affects the flow of silver ions, leading to the convection of the solution near dendrites. Since dendrites are composed of many small crystals, they are not rigid but flexible. Circular convection of the solution near the dendrites induces precession of the flexible dendrites. This means that Lorentz force is very important for the reaction where concentration gradient of ions is induced during the reaction.

Reference

1) A. Katsuki, I. Uechi and Y. Tanimoto, *Bull. Chem. Soc. Jpn.* **77**, 275–279 (2004).

IX-X-3 Formation of Protein Crystals (Orthorhombic Lysozyme) in a Pseudo-Microgravity Environment Obtained by a Superconducting Magnet

YIN, D. C.[1]; WAKAYAMA, N. I.[2]; HARATA, K.[3]; FUJIWARA, Masao; KIYOSHI, T.[2]; WADA, H.[2]; HUANG, W. D.[4]; TANIMOTO, Yoshifumi
([1]NIMS and Northwestern Polytechnical Univ., China; [2]NIMS; [3]AIST; [4]Northwestern Polytechnical Univ., China)

[*J. Cryst. Growth* **270**, 184–191 (2004)]

As one of the best candidates for simulating the microgravity conditions in space, low gravity environments provided by applying an upward magnetic force has been considered to grow protein crystals. Since 2002, the stable and long-time durable microgravity generated by a superconducting magnet has been available for protein crystal growth. In this paper, for the first time, we grew protein crystals (orthorhombic lysozyme crystals) at pseudo- microgravity. The present study showed that pseudo-microgravity improves the crystal quality effectively and reproducibly. The application of strong magnetic field also improves the crystal quality. Further verification of the combined effects of microgravity and magnetic field itself may lead to a more general means to grow high quality protein crystals.

IX-X-4 Magnetic Field Effects upon Macroscopic Plastic Deformation of Diamagnetic Single Crystals Containing Paramagnetic Impurity

DUNIN-BARKOVSKIY, L. R.; MORGUNOV, R. B.[1]; TANIMOTO, Yoshifumi
([1]IMS and ISSIP, Chernogolovka)

It is known that macroscopic magnetoplastic effects in inorganic crystals containing paramagnetic impurity are mainly caused by spin-dependent solid reactions in the system of crystal structure defects. In spite of wide interest to the topic, there is so long a lack of understanding of the mechanisms of such effects. In this work we studied magnetic field effects on plastic deformation of NaCl:Eu single crystals. The crystals were annealed at 770 K and quenched to room temperature. Then they were deformed at room temperature in the absence and presence of a magnetic field (15 T). The field affects the shape of stress-strain diagram, in particular decreases the yield stress by approximately 100%, as shown in Figure 1. Besides, partial or complete suppression of the drop deformation (*i.e.*, Portevin-Le Chaterlier effect), caused by dynamic interaction between movable dislocations and atoms of dissolved impurity, was observed for the first time.

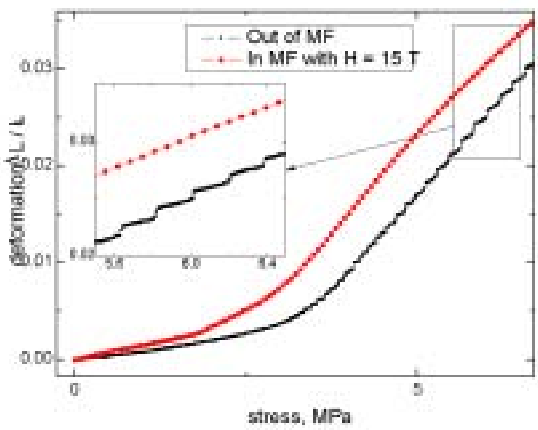

Figure 1. Magnetic field effects on stress-strain diagram of NaCl:Eu single crystal.

IX-X-5 Effect of Horizontal High Magnetic Field on the Movement of *E. coli*

TANIMOTO, Yoshifumi[1]; OGAWA, Seiji[2]; FUJITANI, Kiyomi[2]; FUJIWARA, Yoshihisa[2]; IZUMI, Shunsuke[2]; HIRATA, Toshifumi[2]
([1]IMS and Hiroshima Univ.; [2]Hiroshima Univ.)

[*Environ. Sci.* in press]

Effects of a high magnetic field gradient (8 T, *ca*. 400 T^2/m, horizontal) on the behavior of *E. coli* were examined. An *E. coli* suspended solution was injected in one end of a glass tube (5 mmϕ × 150 mm) filled with viscous medium containing sodium nitrate. They move along the tube axis because of chemotaxis to nitrate ion. The speeds for movement from a high (8 T) to a low field (1.5 T) and for the opposite movement are 1.35 and 0.49 cm/h, respectively; it is 0.65 cm/h at a zero field. It is found that the magnetic force hastens the downfield movement of *diamagnetic E. coli* and impedes the up-field movement.