Pulsed Magnetic Field Effects on Ice Crystal Formation in Biological Aqueous Solutions

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Biological effects of magnetic fields are categorized to two mechanisms; the direct effects of magnetic fields and the induced electric field effect which is generated in a medium exposed to a time-varying magnetic fields. Huge numbers of application of the time-varying magnetic fields were reported in biological studies, however, many phenomena remains underlying mechanisms to be clarified. For example, an effect and its mechanism of pulsed magnetic fields on freezing processes of food are not clarified. In the present study, we observed an ice crystal formation process in biological aqueous solutions under a pulsed magnetic field exposure with 10Hz and 10mT.

The experimental system was consisted of a solenoidal coil set in a freezing box which changed the temperature in the box from 9°C to -30°C for 90 min. The solenoidal coil generated 10mT at the edge of coil. An optical microscope with CCD mono zoom lens was set at the edge of solenoidal coil and a real time image of ice crystal was obtained during freezing process. Also by utilizing a time-resolved spectrophotometer with a fiber attachment module in the coil, we observed the change in optical absorption of the freezing sample.

The microscopic observation of aqueous solution at the bottom of a glass container provided us a difference between pulsed magnetic field exposed and non-exposed sample, as shown in Fig.1. The magnetic field exposed sample had broad areas with a uniform ice while the non-exposed sample showed grid patterns. Also the time courses of the optical absorption at 500nm ~ 1000nm showed that the pulsed magnetic field exposure prolonged the time to reach coagulation temperature of aqueous solution as well as the period between coagulation and re-coagulation after dissolution by latent heat. Provably the effect was due to the eddy current which was induced by the magnetic field. The observed phenomenon seems to be one of the mechanisms for effective applications of time-varying magnetic fields for the freezing process of water-containing materials such as food.

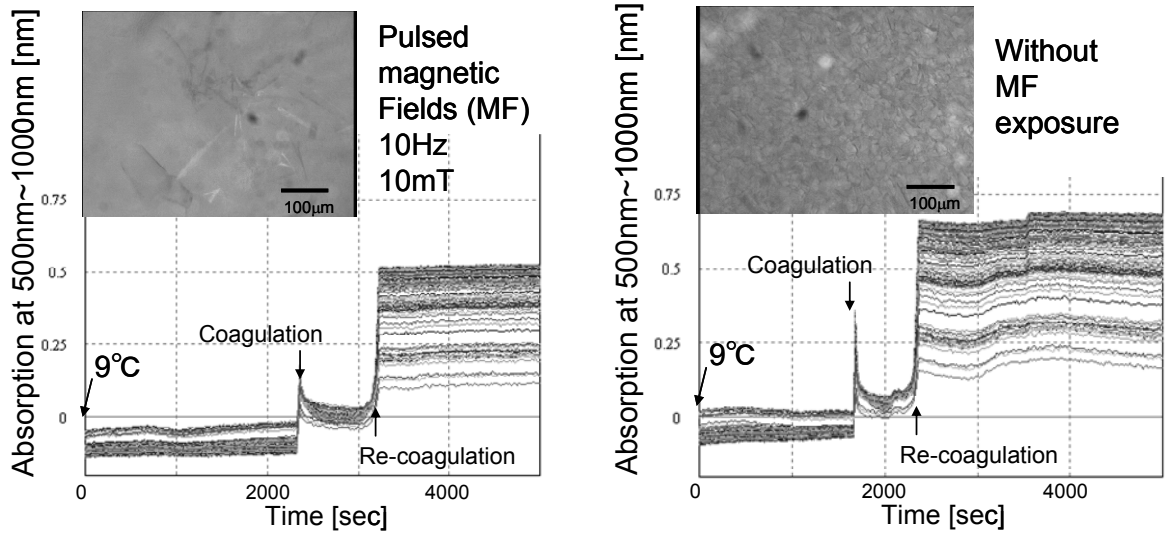

Figure 1. Effects of pulsed magnetic fields on ice crystal formation processes. Optical absorptions and real time images of ice after re-coagulation are shown.