Development of a Rotating Magnetic Field Generator for Real-time Observation of Orientation Processes

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When a magnetic field is applied to diamagnetic materials with anisotropic magnetic susceptibility, the crystalline inside the materials are oriented in the direction of axis of easy magnetization. This phenomenon is called magnetic field orientation. When a rotating magnetic field is applied to the diamagnetic materials, both of the easiest and second easiest magnetization axes are aligned, and magnetic field orientation occurs efficiently. Controlling diamagnetic crystal orientation is crucial for enhancing metal and ceramic materials, with rotating magnetic fields proving to be vital for complete alignment. Until now, the mainstream method has been to rotate the sample in a static magnetic field; however, we designed and manufactured a quadrupole electromagnet to rotate the magnetic field directions themselves as shown Fig.1[1]. The developed device simplifies the process and does not affect the suspension convection, even during high-speed or repeated rotation. Fig. 2 shows micrographs of cellulose microcrystals, illustrating their state before and after the application of a rotating magnetic field. The rotating magnetic field was applied with an angle interval of 1 degree and a period of 80 seconds. It is known the long direction of cellulose crystals is the hard axis of magnetization. Consequently, the application of this rotating magnetic field caused the crystals' hard axis of magnetization to orient perpendicular to the plane of rotation field.

From the above, we have successfully developed a system capable of applying a rotating magnetic field simply by placing the sample, simultaneously enabling comprehensive in-situ observation of the process. It achieves this by allowing for the real-time control of various parameters like magnetic field strength, rotation direction, period, and angle interval, which in turn enables the determination of the most efficient alignment conditions.

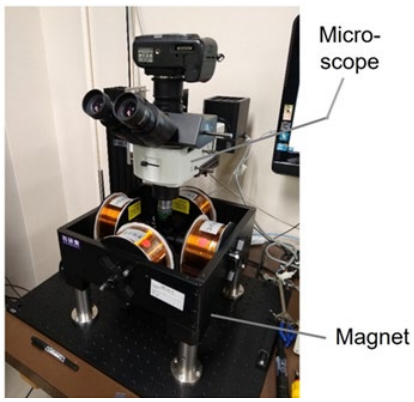

Fig. 1 The rotating magnetic field generation system

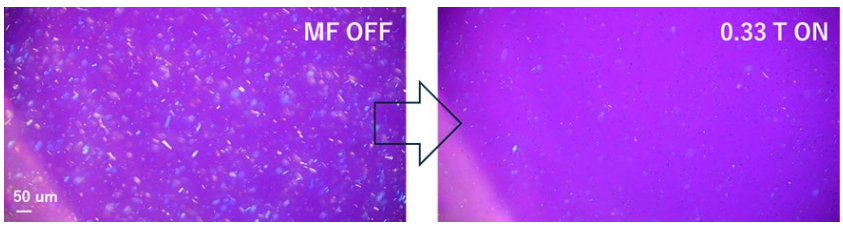

Fig. 2 The micrograph of cellulose crystals under a rotating magnetic field

[1] Y. Takeuchi, H. Kawaguchi, M. Matsuda and A. Hamasaki, Appl. Phys. Express 14 (2021) 057002.