

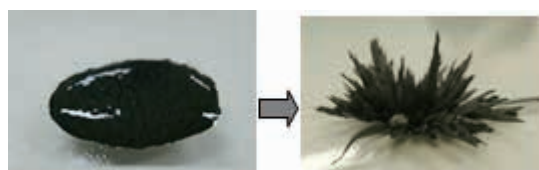
## Magnetic Functional Fluid Research and Interdisciplinary Research

IDO Yasushi\*



A magnetic fluid is a type of artificial fluid that was developed in the 1960s. The fluid consists of ferromagnetic fine particles, such as magnetite or manganese zinc ferrite, of a particle size of about 10 nm whose surface is coated with a surfactant such as oleic acid that are stably distributed within a carrier fluid, usually water or oil. The magnetic fluid has very interesting characteristics: it is attracted by a magnet and develops many protruding structures ("the spike structure") along the magnetic fluid interfaces. Apart from the magnetic fluid, there exists a magnetorheological (MR) fluid that ferromagnetic particles of a submicron to several micron grain size are distributed in a carrier fluid. This is a magnetic functional fluid that reacts with a magnetic field. As an example, Fig. 1 shows a droplet of an MR fluid that micron-sized ferromagnetic particles are distributed in a magnetic carrier fluid prepared in my laboratory. As shown in the figure, when a droplet is dropped on an acrylic plate and is applied with a magnetic field of a permanent magnet placed under the plate, the droplet shows a type of interfacial deformation. The photo shows that the droplet has a number of thorn-like projections. With its response characteristic in a magnetic field (i.e., it changes in viscosity when subjected to a magnetic field), the MR fluid has found its application in and been commercialized as adjustable shock absorbers and other products.

I started my career as a researcher in a university's laboratory where I encountered "the magnetic fluid". Although the term "nanotechnology" did not exist at that time, we knew that particles distributed in a magnetic carrier fluid were of nanometer size. That might be the early days of nanotechnology. When I was a student in a graduate school, I reported findings from my research in an academic conference for magnetic fluid specialists. The participants



**Fig. 1** Interfacial deformation of magnetic functional fluid when subjected to a magnetic field

included, not only mechanical engineering researches specialized in fluid engineering and thermal engineering including me, but also researchers from material engineering, physics, chemistry or electrical engineering. The conference was also joined even by artists who tried to express the interfacial deformation of a magnetic fluid as a work of art. As I reported my research results mainly in this type of conferences in my school age, I took it granted that specialists and researchers from a variety of fields come together. Actually, it was when I found a job at a university for another academic field that I noticed it had been very rare for specialists from various fields to gather together under one roof. At that time (and probably even today as well), researchers generally tended to focus on their own field of research and would not interfere with the other fields so much. Communications with specialists from other fields have helped me promote subsequent interdisciplinary research a lot. Thereafter a social (particularly political?) pressure to promote research for an amalgam of different fields rose, but not so many successful cases have been apparently found. One of the problems with the promotion of an amalgam of different fields is that specialists from different fields use their own popular but specific words and terms if their fields are quite apart from each other. One from a field may not be able to understand what others from another field is talking. Still I think the most difficult barrier is that they believe they "cannot do it" or "have no time to try another field now" to begin with.

I think it will be possible for a group of specialists to promote a series of research including from material development, development of mechanisms/principles using the developed materials, to application research for commercialization, if a division of work among them is established well. I hope that the current situation in which researchers are loudly encouraged to be involved in interdisciplinary research but produce nothing is getting to be better even slightly.

Finally, we faced many difficulties with the pandemic of COVID-19 during 2020. The society not only in Japan but also worldwide has totally changed. In universities, professors and students are forced to face changing circumstances as in most classes held online. I definitely wish we will be able to recover from this tough situation as soon as possible.

\* Professor, Nagoya Institute of Technology