Magnetic Field Effects on Colloids and Surface Phenomena

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Magnetic property is one of universal properties of materials, which arises from angular momentum of an electron and nucleus. Diamagnetism and paramagnetism result in orbital motion and spinning of electrons. Therefore, any material will interact with magnetic fields. If the structures and properties of materials are controlled by magnetic fields, we may be available for a general method of materials processing.

Magnetic fields affect chemical reactions,[1,2] chemical equilibria,[3-5] structures and physical properties of materials[6-7] via both the direct effects such as quantum mechanical, thermodynamic, and mechanical effects and the indirect effects such as convection, concentration changes, and temperature changes. However, since the magnetic energy of diamagnetic and paramagnetic materials is much smaller than the thermal energy at moderate temperature, it was believed to be insufficient to overcome the activation energy associated with chemical and physical processes. The magnetic energy (12.5 mJ mol^{-1}) of an electron spin in a field of 1 T corresponds to the thermal energy of 0.67 K or electric energy of 58 μV, and is about only 10^{-5} of the thermal energy of 205 kJ mol^{-1} at 300 K.[8] Therefore, thermal energy disturbs magnetic effects in feeble magnetic systems. Consequently, it does not seem that magnetic field effects appear even at moderate temperatures at which materials are processed. However, a variety of magnetic field effects were found in fact using high magnetic fields in appropriate systems and sophisticated techniques.

Magneto-Science,[8-10] a new science of materials using magnetic fields, is recently developed all over the world. Magneto-Science covers mainly the subjects on feeble magnetic materials such as soft matters, carbons, ceramics, organometals. Colloidal and interfacial systems under magnetic fields are very attractive and important because the dimension is very much sensitive to magnetic fields. In this review we introduce several examples in colloid and interface chemistry under magnetic fields. Molecular assembles such as micelles, bimolecular membranes, and vesicles were changed in shape and, in some cases, size by magnetic fields. Since mesophases are sensitive to relatively low magnetic fields, magnetic fields controlled not only its own structures and functions but also cooperatively other magnetically-insensitive materials. Moreover, a few interesting magnetic response in hydrogels are summarized.

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