Formation of photo-responsive liquid crystalline emulsions by a microfluidic device and their photo-response

Shun Endo[1], Takahiro Sato[1], Woon Yong Sohn[1], Kenji Katayama[1,2]

[1]Department of Applied Chemistry, Chuo University, 1-13-27 Kasuga, Bunkyo, Tokyo 112-8551, Japan

[2]JST, PRESTO, 4-1-8 Honcho, Kawaguchi, Saitama, 332-0012, Japan

E-mail: kkata@kc.chuo-u.ac.jp

A micro-object whose motion is induced spontaneously by gradient of chemicals, light or heat, is referred as active matter, which has attracted much attention in recent years. As one of components for the active matters, liquid crystals (LCs) have been utilized, which have an ordered structure and features a long-range molecular interaction. In this study, a double emulsion consisting of the LC was formed by a microfluidic device that controls counter-flowing fluids with a capillary. Light irradiation induced photo-isomerization of the photo-responsive LC, causing a phase transition, which was confirmed from the defect pattern change. We successfully revealed the effect of the light irradiation on the phase transition by comparison with that induced by heat.

A microfluidic device was consisted of a square capillary and two round capillaries, which were inserted into square one in opposite directions. A double emulsion consisting of a LC was formed by this device that controls counter-flowing fluids in a capillary.[1] A inner fluid, which became the inner liquid for the emulsion was 5wt% PVA aqueous solution. A middle fluid for the shell part was N-(4-Methoxybenzylidene)-4-butylaniline(MBBA), which was photo-responsive LC or 4-Cyano-4'-pentylbiphenyl(5CB), which was non-photo-responsive LC. An outer fluid, which helped maintain the shape of a double emulsion, was 10wt% PVA aqueous solution. A double emulsion was observed by a polarized microscope. The phase transition induced by heat was observed by increasing temperature of the glass heater. The phase transition induced by light was observed by the irradiation of a UV light (365nm).

At least a single orientational defect of LC appeared on the shell of a double emulsion in both cases, MBBA and 5CB. We compared these emulsions by irradiation of light or applying heat. In the case of a double emulsion using MBBA, which had photo-isomerization site, phase transition induced by light took place locally from the center of the defect, and Schlieren texture disappeared, meaning phase transition to an isotropic phase. This state remained while the irradiation. In the case of 5CB, which did not have a photo-isomerization site, no reaction occurred. (Figure 1 left) On the other hand, phase transition was induced uniformly at the same temperature with pure LC in both cases, MBBA and 5CB. (Figure 1 right) Based on the results, we concluded that the local control of the structure is possible by using light.

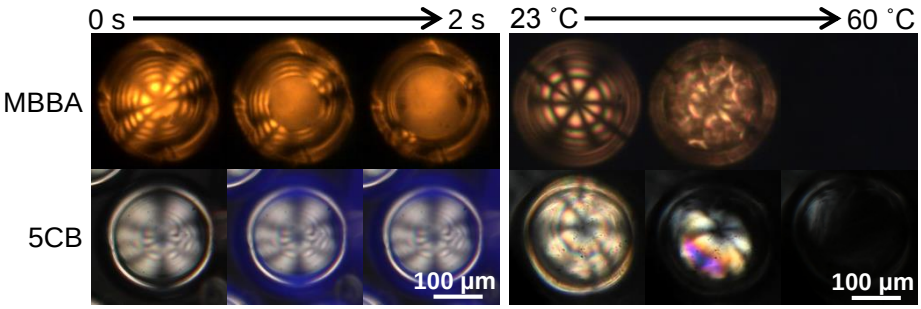

Figure 1 Microscopic images of the double emulsions made of MBBA and 5CB. In the left figure, the phase transition response was induced by a UV light irradiation, and in the right figure, the phase transition was induced by increasing temperature.

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References:

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