Liquid Crystal Physical Gels:
Self-Organized Structures and Electrooptical Properties

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Organic physical gels have been fabricated by fibrous self-assembly of low molecular weight gelators in organic solvents. As a new class of anisotropic soft materials, we have developed liquid crystal physical gels by introducing self-assembled fibers of gelators into liquid crystal materials. Here we show that liquid crystal physical gels with random and oriented microphase-separated structures have great potentials as functional materials.

Self-Organization of Liquid Crystal Physical Gels: For liquid crystal physical gels, isotropic–anisotropic transitions of liquid crystal components and sol–gel transitions induced by the fibrous aggregation of gelators are observed independently. The different order of the two transitions results in either of two types of phase behavior, Type I and Type II, as shown in Fig. 1. These structural transitions give different microphase-separated structures to liquid crystal gels. For the Type I gels, gelators form randomly dispersed networks in isotropic media. In contrast, for the Type II gels, anisotropic fibrous assembly is induced in the liquid crystal media, resulting in oriented liquid crystal gels. These random and oriented gels are applicable to a variety of electrooptical applications.

Liquid Crystal Gels with Random Structures (Type I): Liquid crystal gels with random structures function as high-contrast light scattering electrooptical materials (Fig. 2). For the mixture of liquid crystal 5CB and gelator Lys18 showing phase behavior of Type I, the fibers of Lys18 are dispersed in the nematic phase of 5CB, inducing effectively the formation of liquid crystal polydomains. Due to such polydomain structures, the liquid crystal gels show high light...
scattering in ITO cells (Fig. 2a). The light scattering states can be electrically switched to transparent states, in which liquid crystal molecules are realigned along the applied electric fields (Fig. 2b). The light scattering–light transmission switching is reversible. The electrooptical properties are tunable by the choice of gelators and their concentrations.

Liquid Crystal Gels with Oriented Structures (Type II): In nematic liquid crystal 5PCH, fibrous aggregates of Lys18 develop in the direction parallel to the liquid crystal alignment. The 5PCH/Lys18 mixtures filled in twisted nematic (TN) cells form oriented microphase-separated structures along TN alignment. The oriented gels show fast and high-contrast electrooptical switching. As for smectic materials, oriented fibers formed in aligned smectic A and chiral smectic C phases have great effects on ferroelectric responses. Figure 3 shows an oriented structure of a ferroelectric gel. The introduction of well-controlled microphase-separated structures into liquid crystals is one of the useful approaches for developing novel functional materials.

Fig. 2 Photographs of the liquid crystal cell filled with the 5CB/Lys18 gel: (a) light scattering state (0 V); (b) light transmission state (100 V). The distance between the cell and the displayed letters is 12 mm.

Fig. 3 Polarized optical photomicrograph of a ferroelectric liquid crystal gel filled in a parallel rubbed cell (a) and schematic illustration of the oriented structure (b).

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