Dipole moment effects of side chain in calamitic liquid crystals on carrier mobility

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Since the electronic conduction was established in discotic and smectic liquid crystals, charge carrier transport properties in various liquid crystals have been studied, and it is clarified that carrier mobility in liquid crystalline phases is increased step-wisely when the phase transition takes place from a lower ordered phase to a higher ordered phase. [1] The highest mobility reaches up to 0.5 cm²/Vs in highly ordered phase of SmE. However, it has not been clarified much how the chemical structure of liquid crystals affects charge carrier transport [2]: as for the dipole moment in the core part of liquid crystals, it is clarified that the dipolar core gives a wider distribution of Gaussian density of states for carrier to hop, which is due to disorder of core parts in smectic layers, resulting in a lower and temperature-dependent mobility.[3]

In this report, we have focused on the effects of the dipole moment in the side chains in smectic liquid crystals on charge carrier transport properties with phenynaphthalene derivatives for a model compound, i.e., two 2-octylphenyl-6-alkoxyanaphthalene derivatives with same core structure and same side chain length but different chemical structures as shown in Fig.1. We studied the carrier transport properties of these materials by the time of flight method. Fig. 2 shows hole mobility as a function of temperature in these two liquid crystals (I,II).

In spite of same core structure (same reorganization energy) and the same phase of SmE, these liquid crystals give a big difference in mobility and its temperature dependence as shown in Fig.2. The Gaussian widths of the density of states for the SmE phase of these liquid crystals were estimated to be 50meV and 100meV from the Bässler’s disorder formalism, respectively. The wider distribution of the density of states in liquid crystal (II) is attributed to the effect of polar CF3-substituent at the end of alkyl chain, which are randomly aligned because of a flexible alkyl chain. In addition, we are investigating the effect of dipolar group on the charge carrier transport as a function of distance from the core part of phenynaphthalene, and will discuss a total view of the effect of dipole moment in the side chains on the charge carrier transport in liquid crystals.

Fig.2. Temperature dependence of carrier mobility of compound I,II.

References
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