Orientational order, phase separation effects and chain formation in liquid crystals doped with nanoparticles.

M. A. Osipov$^1$ and M.V.Gorkunov

1. Department of Mathematics and Statistics, University of Strathclyde, Glasgow, Scotland, UK
2. Institute of Crystallography of Russian Academy of Sciences, Moscow, Russia

It is well known that various properties of nematic liquid crystals can be significantly modified by adding metal, dielectric or semiconductor nano-particles and changing their concentration and structure. Firstly we describe the effect of nanoparticles embedded in the nematic liquid crystal on the orientational ordering and the N-I phase transition [1,2]. We show that isotropic nanoparticles effectively dilute the liquid crystal medium and decrease the N-I transition temperature. At the same time, anisotropic nanoparticles are aligned by the nematic host and, reciprocally, improve the nematic ordering. A considerable softening of the first order N-I transition caused by strongly anisotropic nanoparticles is also predicted [1].

The N-I transition temperature generally decreases with the increasing concentration of isotropic nano-particles. As a result the free energy density of the composite material increases with the increasing nanoparticle concentration which may lead to a phase separation between the isotropic and the nematic phase with different concentrations of nano-particles that can reduce the total free energy. Usually nanoparticles undergo a special chemical treatment in order to increase their solubility. Thus the system is unlikely to demix in the isotropic phase. However, phase separation can be induced by the N-I transition. One notes that the properties of nanoparticles are very much different from those of mesogenic molecules, and thus the separation effects may be much stronger than those found in binary mixtures of nematics.

We present the results of the molecular-field theory of N-I transition in a system of uniaxial molecules doped with spherical nanoparticles which takes into account the possibility of phase separation [3]. It has been shown that a number of different phase separation scenarios are possible depending on the nanoparticle size, interaction between nanoparticles and mesogenic molecules and between nanoparticles themselves: In particular, a very large region of phase separation, which may be as broad as the nematic phase itself, has been found in the case of very strong interactions between nano-particles and the mesogenic molecules [3,4]. In the context of the present model the phase separation is not possible at very low concentration of nano-particles and in some cases it may occur only within a finite concentration range.

Finally we present preliminary results of the theory which accounts for the formation of chains of strongly anisotropic (i.e. dipolar) nano-particles. Distribution of chains of different length has been calculated, and the contribution of polar chains to the dielectric anisotropy of the nematic phase has been evaluated with a specific emphasis on the role of dimers.

References:

* presenting author; E-mail: m.osipov@strath.ac.uk