STABILITY ANALYSIS OF MODULATED STRUCTURES BASED ON NEMATIC LIQUID CRYSTAL FILLED WITH INTERACTING SPHERE-LIKE IMPURITY PARTICLES

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ABSTRACT

The filled nematic liquid crystal (i.e. highly-disperse suspension of impurity particles within the nematic liquid carrier) is considered. The spatial distribution of rigid-sphere-like impurity particles (with radii of several μm) within the host nematic liquid crystal is studied. When such impurity is intruded into the nematic host, the liquid-crystal director becomes distorted. This distortion is caused by the presence of anchoring between the LC molecules and the impurity surface. The characteristic size of director-field distortions may be much larger then the volume per one impurity particle. If the areas of director inhomogeneity, which were induced by different impurity particles, are overlapping and interfering with each other, then indirect interaction between particles through the director field appears. An indirect effective interaction between the impurity particles by means of nematic medium is considered as being responsible for the formation of (modulated) superstructures. In the general case, total interaction between the impurity particles includes two contributions—Van der Waals-type direct interaction (at short distances between the particles) and indirect interaction (through both the director-field distortions and the density inhomogeneities). The last one depends on the temperature, density of the nematic host medium and impurities concentration. As shown, there are long-range and quasi-oscillation characters of such an interaction in its energy dependence on the distance between impurity particles. This effective interaction controls the structure formation and properties of a system. Using continuum-mechanics and statistical-thermodynamics approaches, the necessary thermodynamic conditions for the formation of the modulated lamellar structures are analyzed. These conditions allow to calculate the temperature of homogeneous-distribution stability loss and to estimate the period of the appearing structure. The results of our calculations are in a qualitative agreement with the available experimental data and computer simulations. This theoretical approach can be used to forecasting other anisotropic and inhomogeneous mesomorphic systems, which may find applications in different optical devices.