POSITRON SPECTROSCOPY OF LIQUID CRYSTALLINE ORGANIC MATERIALS CONTAINING C_{60} FULLERENES

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Introduction

Lanthanum laurate $La(C_{12}H_{25}COO)_3$ exemplifies ionic metal mesogenes, which are known to form thermotropic and liotropic liquid crystals [1]. Anisotropy and high molecular mobility are essential properties of liquid crystals, which ensure the fast rate of information processing systems on their base. Molecular mobility is also known to depend on the presence of the free-volume defects. These are intermolecular cavities (nanovoids) or atomic-size vacancies.

Lanthanum laurates in crystalline (powder) and liquid-crystalline states, as well as after dissolution of C_{60} fullerenes were studied by means of the positron annihilation technique which is extremely sensitive to the free-volume defects.

Lanthanum laurates were prepared as in Ref. [2]. The spectra of the angular correlation of annihilation photons (ACAP) were measured in a standard long-slit geometry using ^{22}Na radioactive isotope as a positron source.

Results and discussion

Positronium (Ps) annihilation probability in the nanovoids of the samples in initial state is found to be 11.13 %, whereas the mean nanovoid radii for the crystalline and liquid-crystalline samples are 0.33 and 0.28 nm, respectively. After dissolution of C_{60} fullerenes probability of Ps annihilation in nanovoids is decreased by the factor of 2.7. At the same time the mean nanovoid radius, sampled by Ps, increases to 0.39 nm. This is an evidence that annihilation in small nanovoids is strongly suppressed. Observed changes are accompanied by the increase in the positron annihilation probability on oxygen anions from 77.3 to 87.7 % and the decrease in their radius from 0.160 (±0,001) to 0.156 nm.

The van der Waals bonds between carbon atoms in C_{60} fullerene molecule and the outer nanovoid surface ensures the decrease in the surface energy and increases thermodynamic stability of resulting clathrate. Taking into account that the van der Waals bond energy between carbon layers is in the range of 0.44 – 0.88 eV, the inclusion of single molecule into organic matrix results in the decrease of the system's free energy by about 40 eV per C_{60} molecule. Isolated in the matrix C_{60} fullerene is supposed to form solvate cover with neighbouring hydrocarbon radicals. Electrostatic potential on the surface of spherical fullerene-like cluster is a major factor that affects the ordering processes during hybride nanostructure formation.

References

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