The 4th Polish-Slovenian International Seminar on Young4SoftMatter DAY

2nd February 2026

Soft Matter

unipress

Broadband Dielectric Spectroscopy Investigation of E7 Liquid Crystal with $BaTiO_3$ and C_{60} Nanoparticles

Mateusz Kotowski[1], Jakub Kalabiński[1], Aleksandra Drozd-Rzoska[1], Sylwester J. Rzoska[1]

[1]Institute of High Pressure Physics, Polish Academy of Sciences, Warsaw, Poland

*Corresponding Author: mkotowski@mail.unipress.waw.pl

1. Introduction

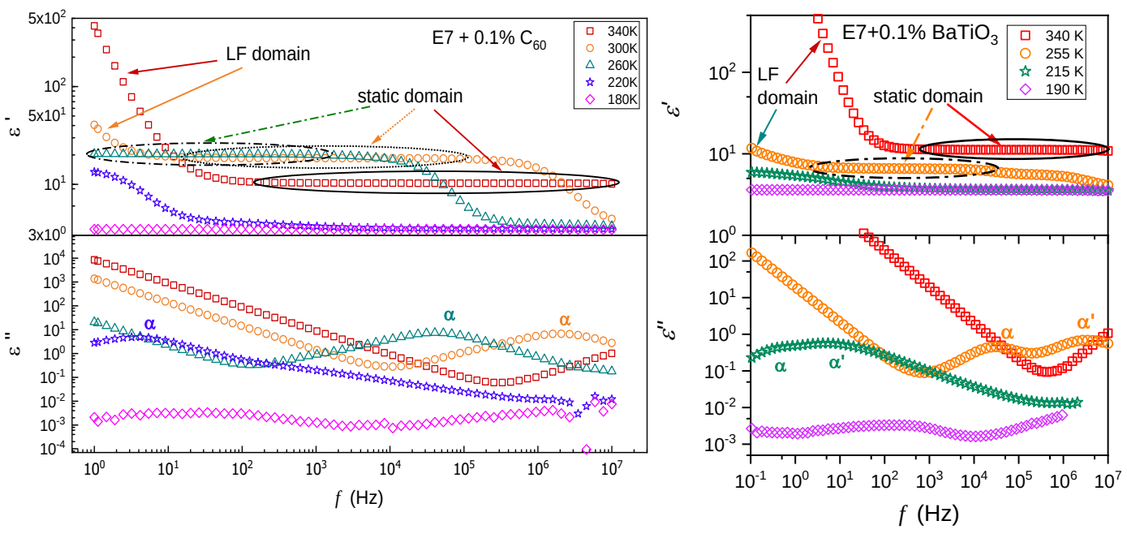
Liquid crystal-based nanocomposites represent a promising frontier in materials science, combining the anisotropic properties of liquid crystals with the unique characteristics of nanoparticles. This study investigates the previtreous behavior of glass-forming E7 nematic mixture-based nanocolloids containing two structurally distinct nanoparticles: $BaTiO_3$ and C_{60} fullerenes.

2. Materials and methods

The E7 eutectic mixture, composed of four cyanobiphenyl and cyanoterphenol components, exhibits unique glass-forming behavior in the supercooled nematic phase, with glass transition temperature $T_g = 211.2$ K.

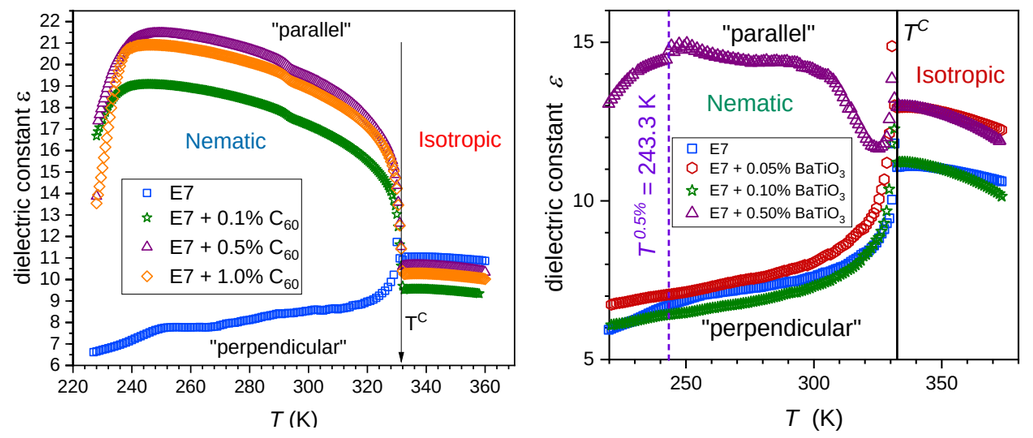
Two types of nanoparticles were used to create nanocolloids, paraelectric $BaTiO_3$ (ø=50 nm) and C_{60} fullerenes. Three different concentration were used 0.1 wt.%, 0.5 wt. % and 1 wt. % for C_{60} and 0.05 wt. %, 0.1 wt. % and 0.5 wt. % for $BaTiO_3$. Broadband dielectric spectroscopy (BDS) measurements were performed with frequency scans from 1 Hz to 10 MHz, and temperature range from 178 K to 360 K, encompassing isotropic liquid, nematic, and supercooled nematic phases.

3. Dielectric spectra



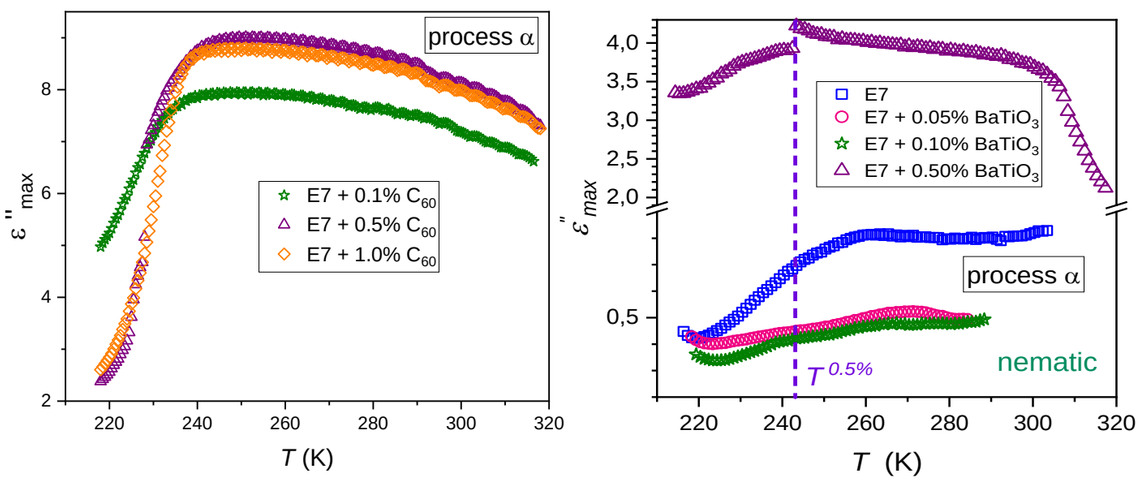
The real part of dielectric permittivity (ε') exhibits a pronounced temperature dependence in static domain. In the imaginary part of dielectric permittivity (ε"), a clear temperature induced shift of the α-relaxation is observed. With addition of 0.1 wt. % C_{60} α'-relaxation disappears.

4. Dielectric constant



The solid arrow indicates the clearing temperature at $T^C = 332.9$ K, related to weakly discontinuous I-N phase transition. 'Parallel' and 'Perpendicular' denote dielectric responses resembling those of nematic samples with the probing electric field oriented parallel or perpendicular to the long molecular axis, respectively. Introducing even a small concentration of C_{60} results in a shift of the preferred alignment toward the parallel-like response.

5. Loss curve maximum



Temperature evolutions of α process primary loss curve maximum in the nematic phase of E7 and related nanocolloids with $BaTiO_3$ and C_{60} nanoparticles. On the right chart the discontinuous change emerges for 0.5 wt. % $BaTiO_3$. The loss curve peak $\varepsilon''_{peak}(T)$ shapes strongly depend on NPs types and concentrations.

6. Summary

Broadband dielectric spectroscopy of E7 revealed strong temperature-dependent dielectric behavior and a shifting α-relaxation across phases. Adding nanoparticles modified this response: C_{60} suppressed the α-relaxation at 0.1 wt. %, while 0.5 wt. % $BaTiO_3$ caused a discontinuous change. Even small C_{60} amounts shifted alignment toward a parallel-like dielectric response.

References

[1] Drozd-Rzoska, Nanomaterials, 15(8), 597. doi:10.3390/nano15080597

[2] Rzoska, S. J., Nanomaterials, 10(12), 2343. doi:10.3390/nano10122343

[3] Rzoska, S. J International Journal of Molecular Sciences, 26(20), 9849. doi:10.3390/ijms26209849

Acknowledgments

This work was supported by the National Science Center (NCN Poland), grant number: 2022/45/B/ ST5/04005, the project headed by Sylwester J. Rzoska.