Probing homogeneity and appropriateness for display applications of liquid crystalline nanocomposites using dielectric spectroscopy

Martin Urbanski[1,2] and Jan Lagerwall[1]
[1]Physics & Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg.
Tel.:+352-46-6644-6219, E-mail: Martin.Urbanski@lc-science.info
[2]Dept. of Chemistry, University of Paderborn, Paderborn, Germany.

Functional composites of nanoparticles (d < 5 nm) dispersed in liquid crystals enjoy high attention due to promising opportunities for both basic science and innovative display applications. Since the pioneering work of Qi et al. [1] numerous studies revealed that doping nematic liquid crystals with small amounts of spherical nanoparticles can significantly alter the alignment and the electro-optic response of the host. However, the studies published during the last decade draw an inconsistent picture on the benefit of nanoparticle doping on the electro-optic performance of nematics, mainly due to a lack of control over the nanoscale homogeneity of the dispersions.

Our recent studies clearly showed that the electro-optical performance of a nematic nanodispersion does not only depend on the bulk properties of the composite, but also strongly on the impact of dopants on the boundary conditions at the confining substrates [2]. We found that observable doping effects are strongly connected to the quality of the nanoparticle – liquid crystal dispersion, i.e. the compatibility of dopant and host which determines the homogeneity of the nanocomposites. The extent of dispersibility plays a major role for the electro-optical performance of the composite, yet its determination so far required laborious and time-consuming measurements. Our latest results indicate that the analysis of polarization processes such as interfacial or Maxwell-Wagner-Sillars (MWS) polarization (Fig. 1) offers a fast and cost-efficient tool to estimate the homogeneity of dispersions on the nanoscale [3]. The presence of MWS-polarization processes in the kHz- frequency regime indicates a heterogeneity on the mesoscale and thus an insufficient dispersibility of particles in the liquid crystalline host. Our studies aim to provide a feasible tool to estimate the homogeneity of liquid crystalline nanocomposites and will help to develop reliable design principles for obtaining highly stable nanodispersions for applications.

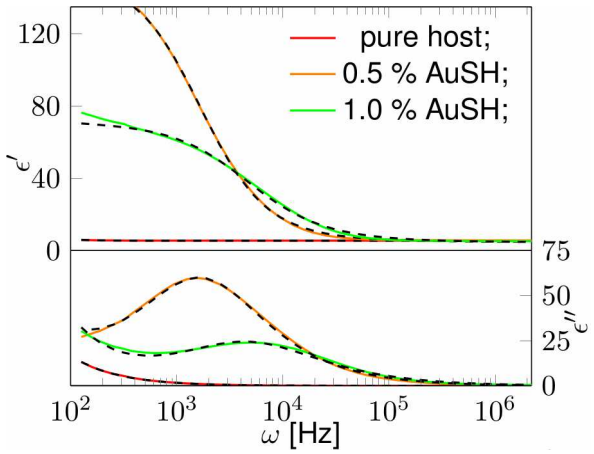

Fig. 1. Dielectric spectroscopy data (real and imaginary parts of permittivity, ε' and ε'', respectively, vs. frequency ω) showing nanoparticle-induced MWS-polarization processes in a nematic host containing thiol-functionalized gold nanoparticles.

Acknowledgment

The present project is supported by the National Research Fund, Luxembourg. Financial support by the Deutsche Forschungsgemeinschaft (DFG GRK1464) is gratefully acknowledged.

References

1. H. Qi and T. Hegmann, J. Mater. Chem. 16, 4197-4205 (2006).
2. M. Urbanski, J. Mirzaei, T. Hegmann and H.-S. Kitzerow, ChemPhysChem. 15, 1395-1404 (2014).
3. M. Urbanski, Liq. Cryst. Today (2015) submitted.