Efficient ferronematic coupling with polymer brush particles

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The ability to control nematic phases in thermotropic liquids by external fields is of great importance for their application, e.g. in optical devices. While it is common to use electric voltage in such devices, the employment of magnetic fields is less straight forward due to the low magnetic anisotropy of the mesogens.

However, as already predicted by deGennes and Brochard in 1970, the incorporation of dipolar magnetic particles is expected to result in nematic phases that are readily manipulable at moderate magnetic field strength.[1] Nonetheless, one of the main challenges for the experimental realization is strong tendency to agglomerate of the nanoparticles, as a consequence of the strong molecular interactions of the mesogens and the dipolar interactions between the particles.[2] Thus, up to now, experimental evidence for such coupling is rare.

Our new approach to circumvent this problem, and to achieve ferromagnetically doped liquid crystals with enhanced volume fraction and stability, is based on nanoparticles that are surface-modified with a side-chain LC polymer brush. Thereby, a variation of shell thickness, mesogen density and the spacer length is possible. With this approach, a higher compatibility between the particle surface and the mesogenic matrix, and an effective steric stabilization of particles against agglomeration is obtained.

The impact of the doped particles on the phase behavior of 5CB (B_{th} = 250 mT at a layer thickness of d = 25 µm) is investigated with respect to particle concentration. Up to a concentration to 0.2 vol% particles can be stabilized in 5CB. By addition of 9OCB-PHMS functionalized magnetic particles, the order parameter of the system increases, indicating an effective coupling between the particles and the LC matrix. The magnetic response of the ferronematic phases is investigated by capacitance measurements in a magnetic field (Figure 1b). As compared to 5CB, the critical field strength and the shape of the Fréederickzs transition is strongly is affected by the particle volume fraction. In fact, at a field as low as 20 mT, 5CB doped with 0.1 vol% magnetic particles can readily be manipulated.

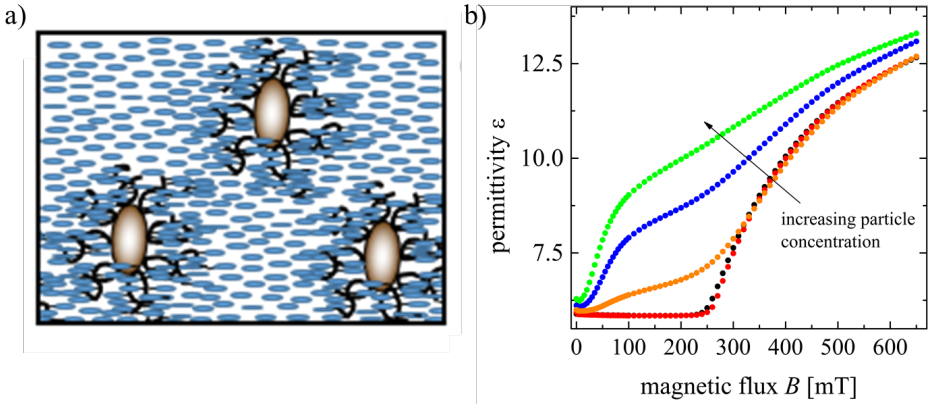

Figure 1:a) Scheme of LC polymer brush particle, b) Capacitance measurements with parallel B and E field for pure 5CB(black) and 5CB doped with a) 9OCB-PHMS@$CoFe_2O_4$ and in volume fractions from 0.01 vol% up to 0.1 vol%..

References

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