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Control of ions in molecular liquid crystals using multiple nanoparticles

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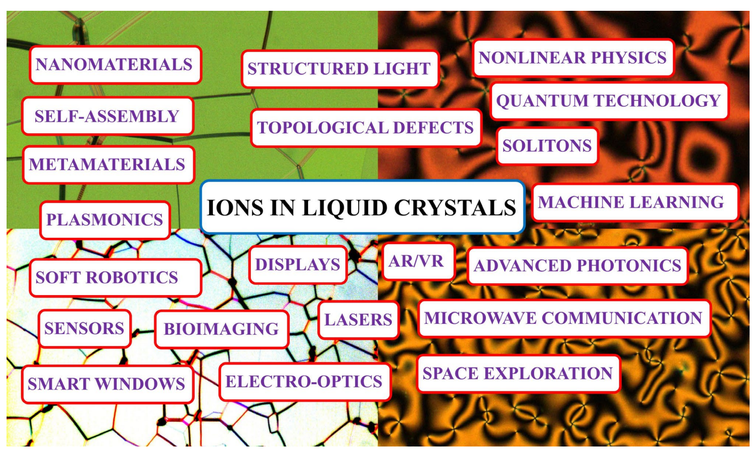
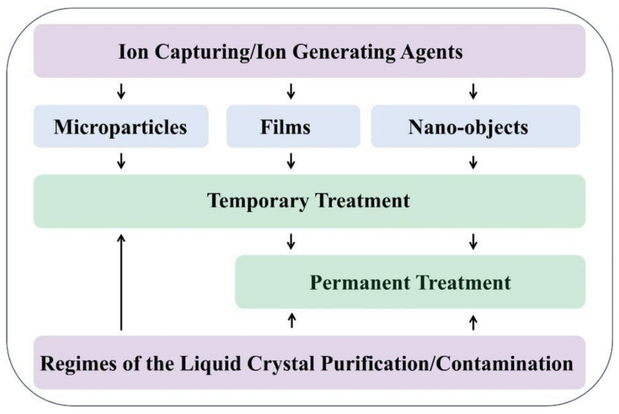
INTRODUCTION & AIM

Recent advances in molecular engineering and nanotechnology have resulted in virtually infinite possibilities for creating multifunctional mesogenic materials using molecular and nano-dopants, thus benefiting a wide range of tunable liquid crystal devices. As a rule, their tunability is achieved by taking advantage of the electric field-induced reorientation of liquid crystal molecules. This reorientation can be affected by ions always present in molecular liquid crystals. **Therefore, developing new ways to control ions in molecular liquid crystals is critical for their existing and emerging applications. This presentation discusses how nanoparticles can be used to control the concentration of mobile ions in liquid crystals.**

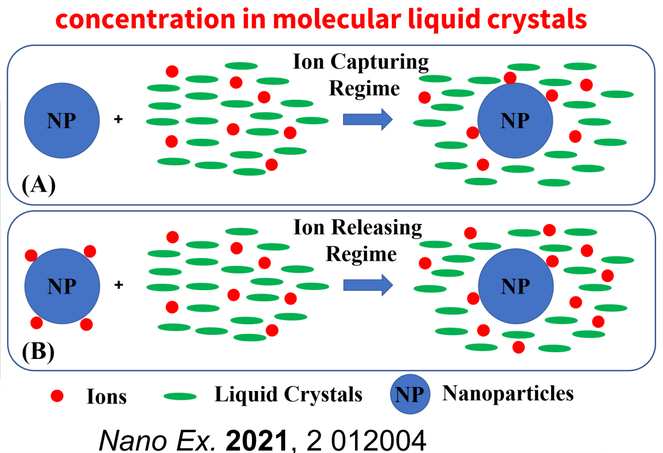


METHOD

General strategy to control the concentration of ions in molecular liquid crystals



Nanomaterials for controlling ion concentration in molecular liquid crystals



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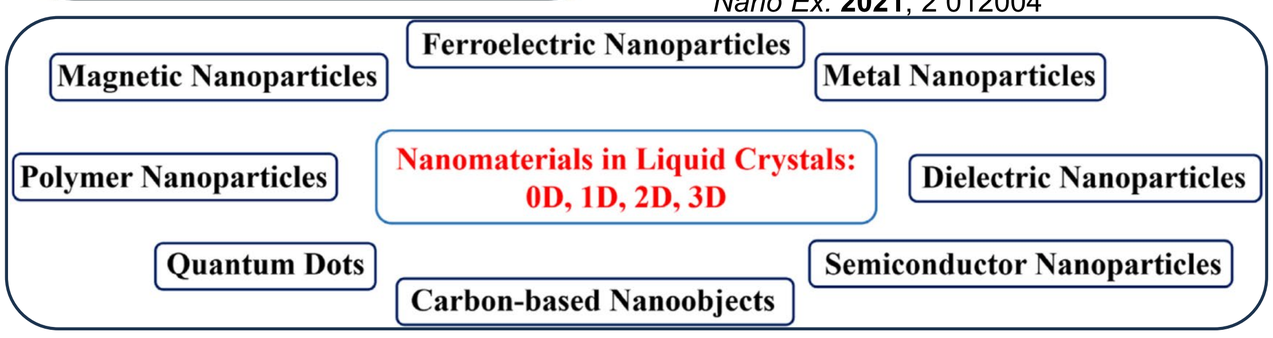
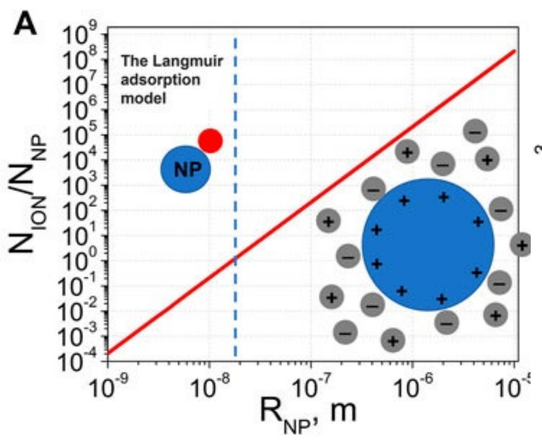
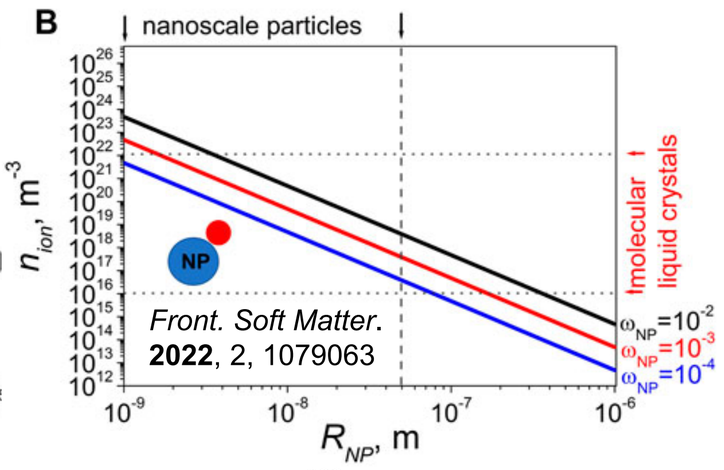


MODEL

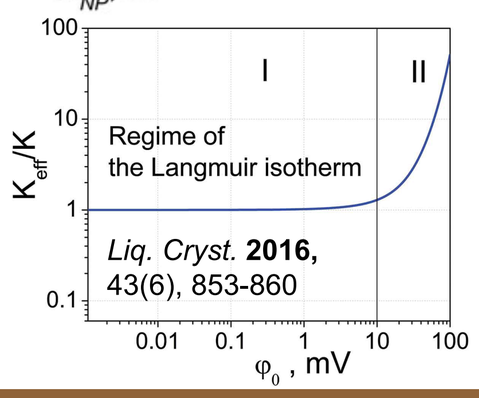
Molecular liquid crystals are characterized by a relatively small concentration of mobile ions. Very often the concentration of colloidal particles can become comparable to the concentration of ions in liquid crystals. As a result, in this region of particle sizes (essentially, nanoscale domain) ion-capturing and ion-releasing processes can be described by applying the Langmuir adsorption model





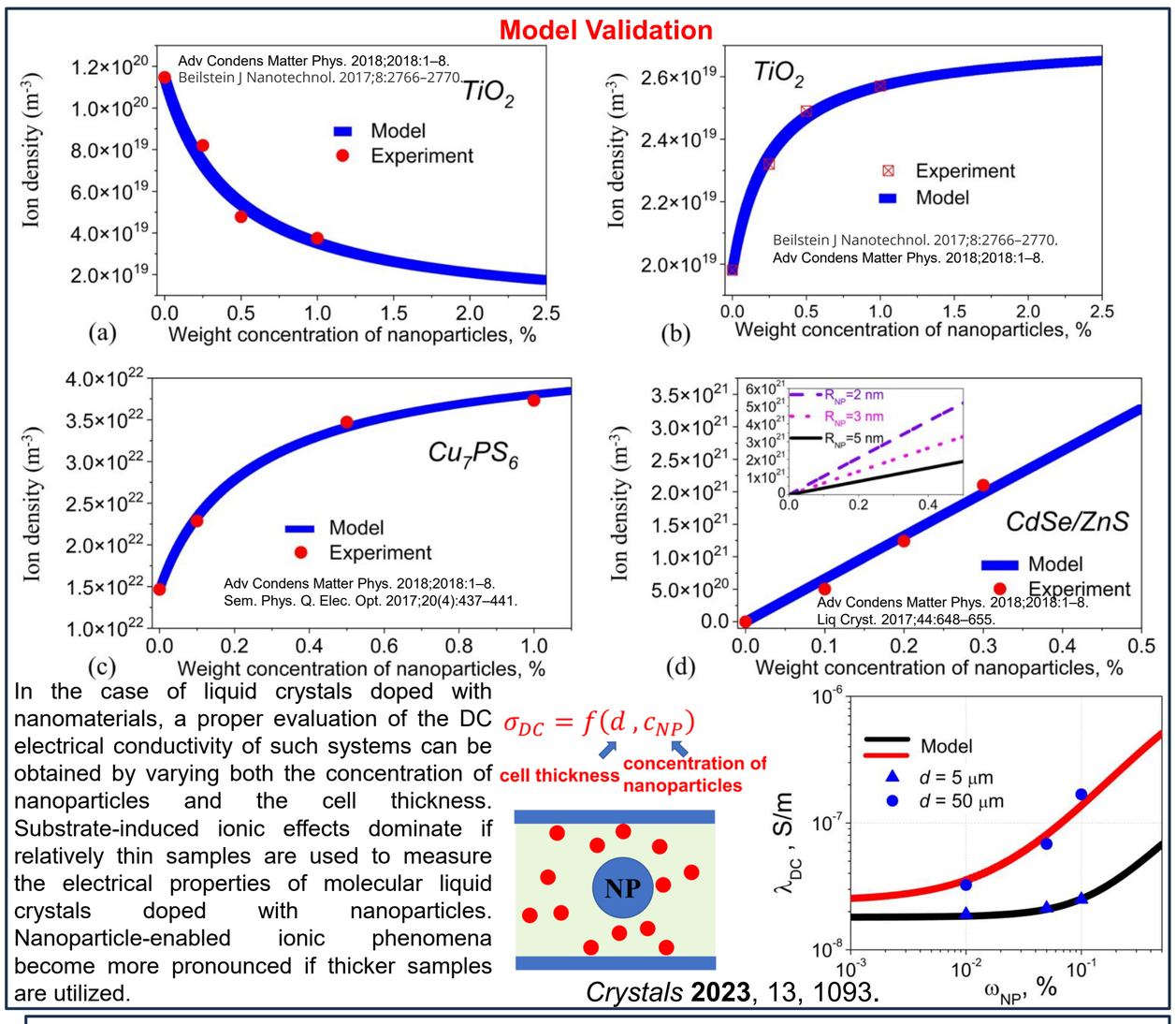
$$\frac{dn}{dt} = \underbrace{-k_a n n_{NP} A_{NP} \sigma_S (1-\Theta)}_{\text{Ion adsorption process (ion generation)}} + \underbrace{k_d n_{NP} A_{NP} \sigma_S \Theta}_{\text{Ion desorption process (ion trapping)}}$$

$$n_0 + \nu \sigma_S A_{NP} n_{NP} = n + n_a$$



RESULTS & DISCUSSION

Model Validation

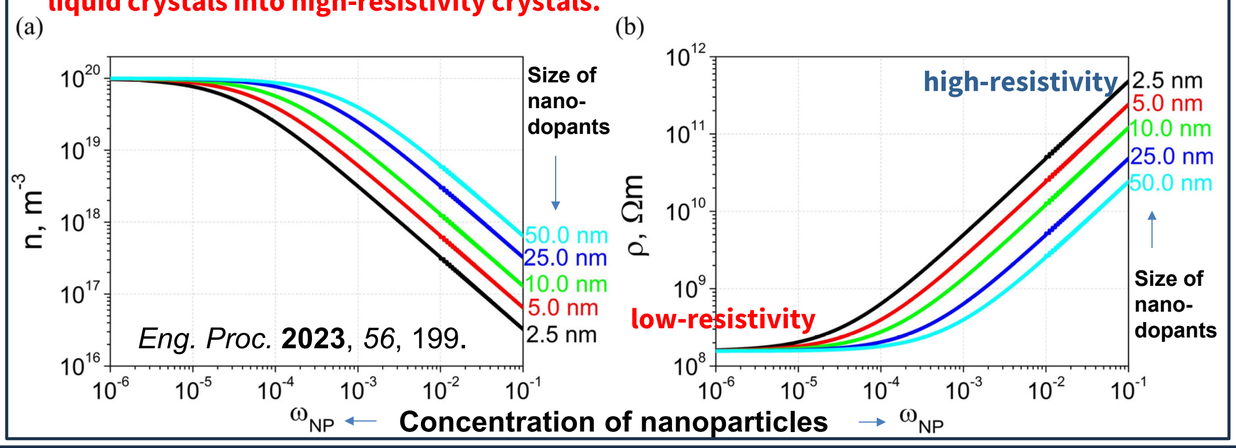


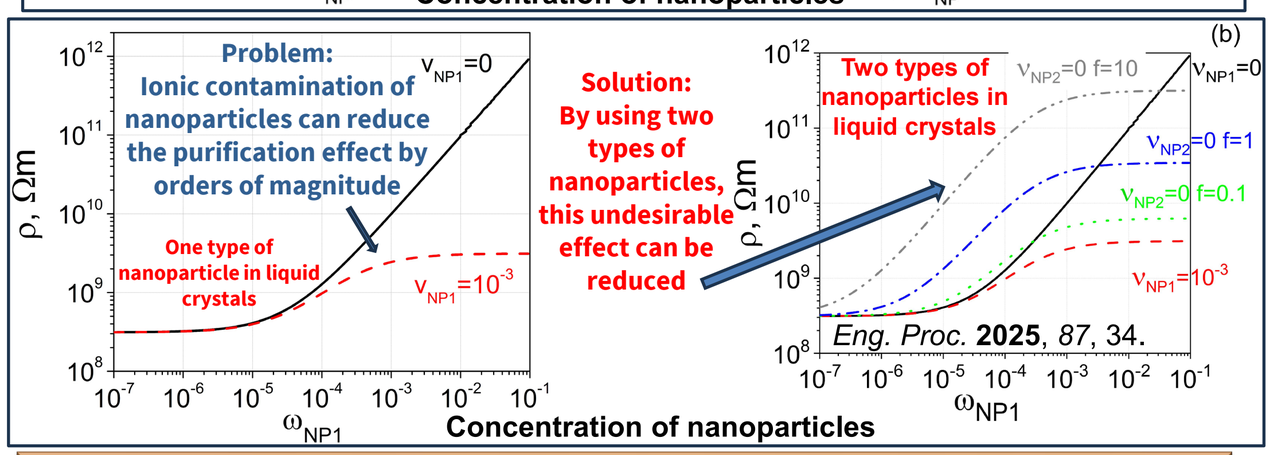
In the case of liquid crystals doped with nanomaterials, a proper evaluation of the DC electrical conductivity of such systems can be obtained by varying both the concentration of nanoparticles and the cell thickness. Substrate-induced ionic effects dominate if relatively thin samples are used to measure the electrical properties of molecular liquid crystals doped with nanoparticles. Nanoparticle-enabled ionic phenomena become more pronounced if thicker samples are utilized.

$\sigma_{DC} = f(d, c_{NP})$ (cell thickness; concentration of nanoparticles)

Crystals **2023**, 13, 1093.

If properly implemented, this nanotechnology-enabled method can convert low-resistivity liquid crystals into high-resistivity crystals.





CONCLUSION

Nanomaterials are important sources of ion generation and ion trapping in liquid crystal materials. The proposed Langmuir adsorption model accurately describes a wide variety of experimental results.

The conversion of low-resistivity liquid crystals into high-resistivity liquid crystals is highly sensitive to the ionic contamination of nanoparticles. Simultaneously using two types of nanoparticles in liquid crystals offers a promising approach to mitigate the effects of ionic contamination.

REFERENCES

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