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Colloidal guest particles stabilize cubic structures of monoolein in water

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Introduction

The cubic mesostructures (Ia3d, Im3m, Pn3m) of monoolein (MO) in water have attracted a lot of interest[1] because of their possible applications in membrane protein crystallography[2,3], catalytic surface reactions, and drug delivery[4,5]. The presence of small particles in the nanoscopic range within the aqueous phase may though disturb the initial structure and result in the formation of modified phases, with consequences regarding the above-mentioned applications. Here we present results from a systematic study of such systems, based on MO, water and small water-soluble nanoparticles (NPs) of gold.

Method

• Instrument

The samples were studied by SAXS/WAXS with an operation energy of 11.6 keV at the MS-powder beamline X04SA at the PSI, Villigen, Switzerland.

• Sample preparation

Samples were prepared in narrow (0.5mm) glass capillaries as schematically shown in Fig. 1. The aqueous phase (with or without NPs) was added such that it was in contact with the dry MO.

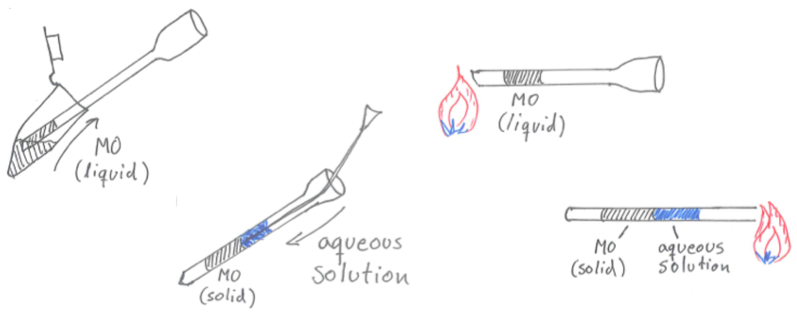
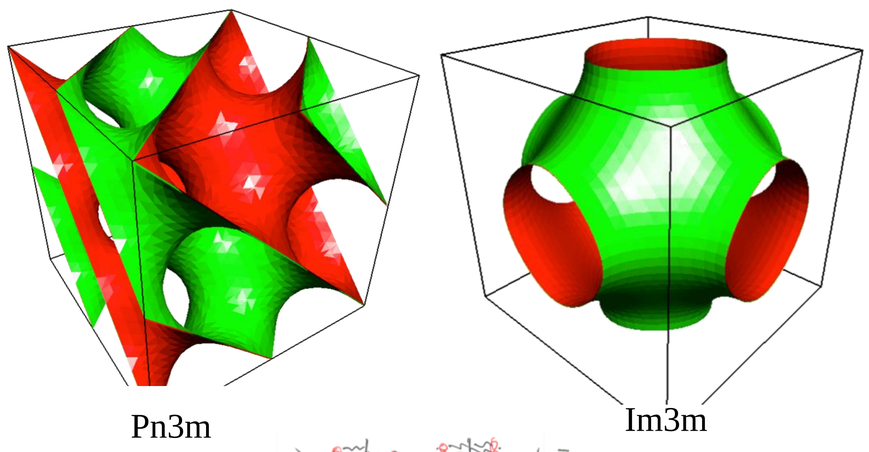


Figure 1: Procedure for preparing samples in glass capillaries.

• Cubic phase



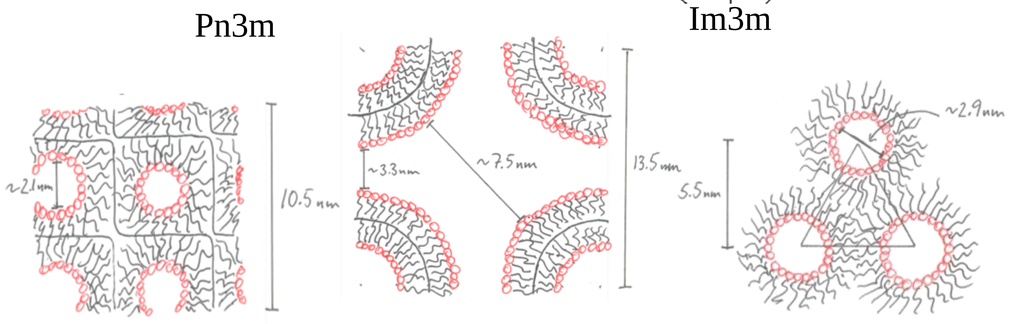


Figure 2: Top: 3D representation of the minimal surfaces Pn3m and Im3m. Bottom: Schematic 2D projections of MO-H_2O systems organized as Pn3m, Im3m, or H_{II} structure (from left to right).

• Analysis

Scattering signals were analysed for patterns agreeing with the known structures for MO (Pn3m, Im3m, Ia3d, hexagonal, and lamellar) From the peak position the lattice constant *a* was determined.

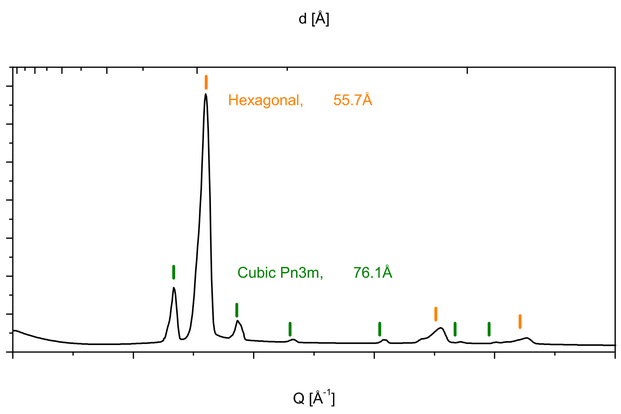


Figure 3: Example of scattering pattern from sample with coexisting structures (MO and H_2O with 5nm NPs, 0.09% v/v at 65° C)

Results

• Reference behavior

The results are summarized in a plot with the found lattice constant as a function of temperature shown in Fig. 4.

The reference behavior of the system without NPs is compared to equilibrium data from the literature[6] .

The system has not reached equilibrium but exhibits transitory structures.

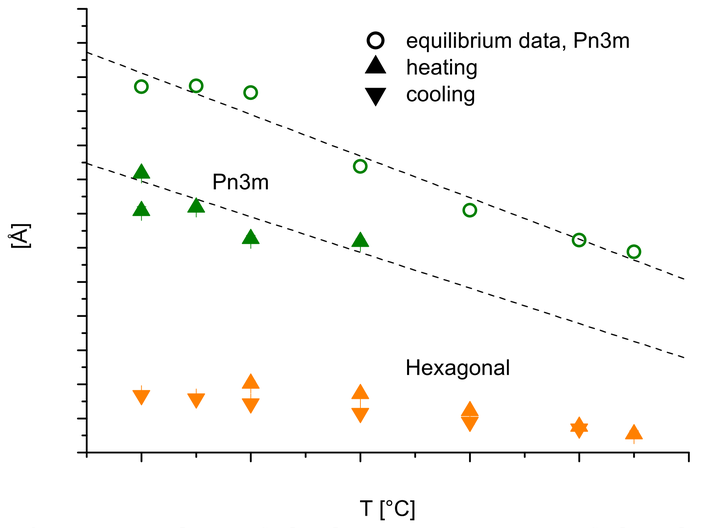


Figure 4: Values of the lattice constant *a*, of the identified mesophases, as a function of temperature. Cubic phases in green and hexagonal in orange. Literature data from an equlibrated Pn3m phase in open circles.

• Effect of incorporated NPs

The cubic structures are **stabilized** with increasing concentration of NPs

An initial Im3m phase is induced by the presence of the big (5nm) NPs

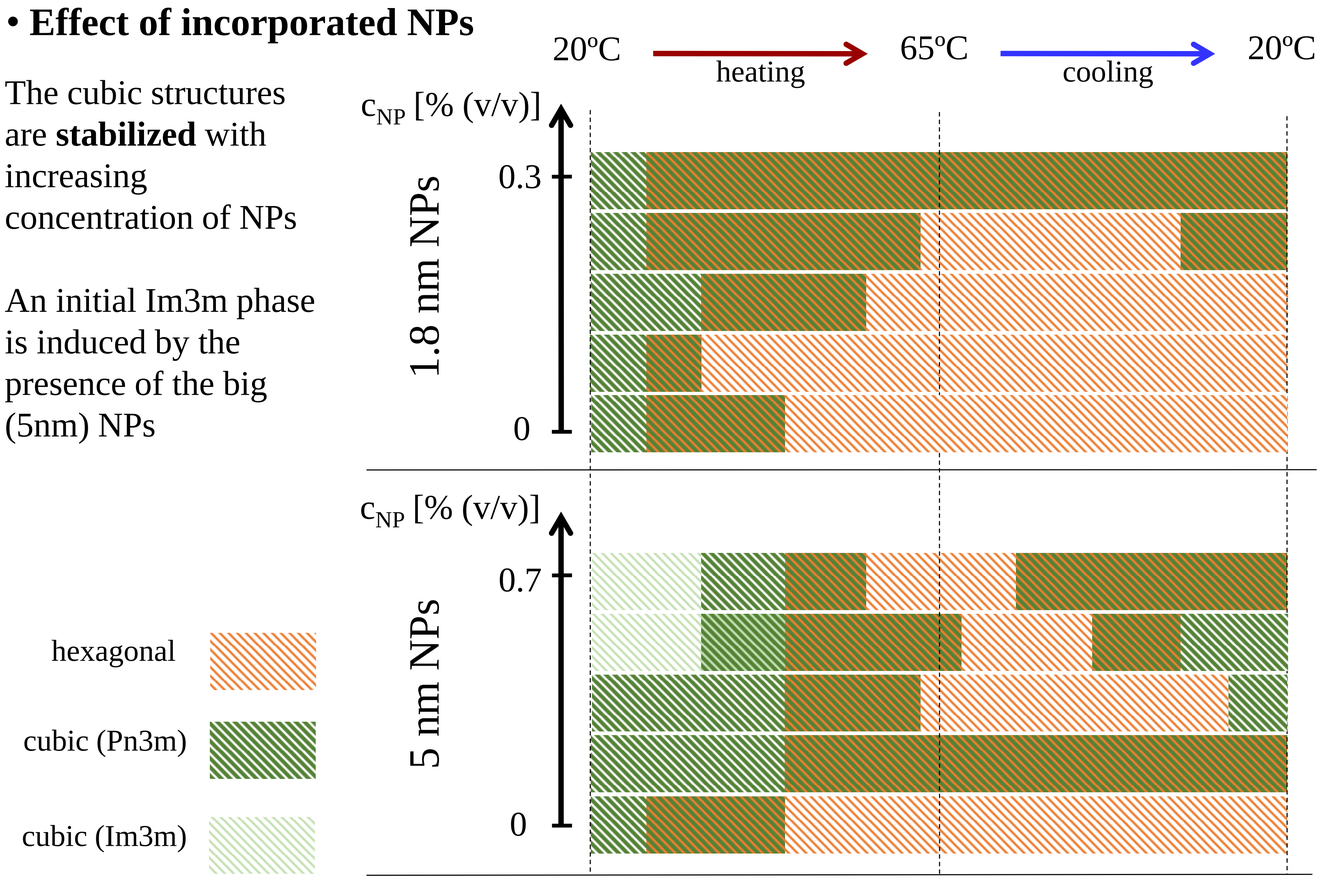


Figure 5: Transitory structure diagrams for systems with varying concentration, c_{NP}, of 1.8nm NPs and 5nm NPs in the aqueous phase. The effective concentration in the cubic phase is unknown. Reference state shown corresponds to absence of NPs.

Conclusion

The systematic study on the structure of a MO cubic in the presence of Au-NPs shows that

- **guest particles modify the details** of the host cubic phase
- the solid metallic **NPs stabilize the cubic structure** of their host
- the equilibrium structures containing NPs are left to be found
- possibly the presence of the big NPs enforces the Im3m symmetry as equilibrium structure

References:

1.Kulkarni, C. V, Wachter, W., Iglesias-Salto, G., Engelskirchen, S. & Ahualli, S. Monoolein: a magic lipid? *Phys. Chem. Chem. Phys.* **13**, 3004–21 (2011).
2.Landau, E. & Rosenbusch, J. Lipidic cubic phases: A novel concept for the crystallization of membrane proteins. *Proc. Natl. …* **93**, 14532–14535 (1996).
3.Caffrey, M. & Cherezov, V. Crystallizing membrane proteins using lipidic mesophases. *Nat. Protoc.* **4**, 706–31 (2009).
4.Larsson, K. Aqueous dispersions of cubic lipid–water phases. *Curr. Opin. Colloid Interface Sci.* **5**, 64–69 (2000).
5.Shah, J. C., Sadhale, Y. & Chilukuri, D. M. Cubic phase gels as drug delivery systems. *Adv. Drug Deliv. Rev.* **47**, 229–50 (2001).
6.Angelov, B. et al. Small-angle neutron and X-ray scattering from amphiphilic stimuli-responsive diamond-type bicontinuous cubic phase. *J. Am. Chem. Soc.* **129**, 13474–13479 (2007).

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