Colloidal Quasicrystals

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The very first Quasicrystals have been found by Dan Shechtman in ternary alloys in the early 1980ies. These materials show sharp diffraction peaks but have no translational periodicity and also can have rotational order that is forbidden in regular crystals like 5, 8, 10 or 12 fold. The latter causes diffraction images with 8-, 10- or 12-fold rotational symmetry. More than one hundred binary and ternary alloys with quasicrystalline order have been discovered since then. In the last 20 years a small number of reports have been published Quasicrystals in Soft Mattter systems like dendrimers or triblock starpolymers. This shows that quasicrystals are not restricted to hard matter systems and the formation of quasicrystals may be based on more general principles.

We have reported lyotropic liquid quasicrystalline solutions of PI-PEO block copolymer micelles in water which exhibit 12-(Q12) and 18-fold (Q18) rotational symmetry [1]. In our latest research we found a new micellar system. PI-PS block copolymer polymer micelles in the high boiling solvent diethylphthalate form lyotropic liquid crystalline and liquid quasicrystalline phases (Fig. 1). In addition, the PI-PS block copolymer was functionalized with the 2-ureido-4[1]-pyrimidinone (Upy) end group which allowed us to prepare mixtures of the pure and the functionalized block copolymer. The latter can form dimers via hydrogen bonding. The stability range of these phases and the phase transitions into the disordered phase, FCC and BCC depend on the temperature, the concentration and the block length of the block copolymers and have been determined by Rheo-SAXS. Furthermore, concentration series have been measured both of the pure block copolymer and of a mixture of the pure and the functionalized block copolymer in diethylphthalate d14 with SANS. We were able to determine where the system is crystalline, where only a liquid structure factor occurs and which dimensions the micelles themselves have. The experiments are supported by molecular dynamics simulations which take the core/shell ratio of the colloidal particles, the volume fraction and the interaction potential into account [2]. The understanding of the formation of colloidal quasicrystals with length scales up to the range of visible light would open up the pathway to photonic applications.

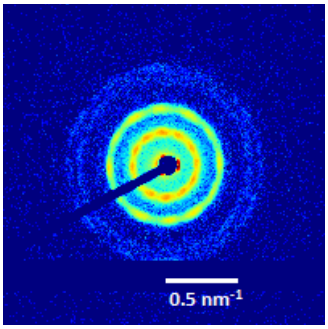

Figure 1. Q12 phase of the PI-PS block copolymer in diethylphthalate.

[1] S. Fisher et al., *PNAS* **108 (No. 5)** (2011), 1810-1814.
[2] H. Schoberth et al., *Soft Matter* **12** (2016), 7644-7654.