SAXS investigations on shear orientated nanoparticle lattices

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The formation of oriented lattices such as face centred cubic (fcc) is well known from block copolymer gels[1]. We succeded to create a similar gel system with CdSe and Fe_3O_4 nanoparticles surrounded by polystyrene with a diethyltriamine (DETA) anchor group. This nanocomposite is forming gels in a certain concentration range in toluene. Depending on the molecular weight of the polystyrene and the characteristics of the nanoparticle, fcc or body centred cubic (bcc) lattices are formed. Furthermore the distance of the nanoparticles can be varied by using polymers of different molecular weight.

The characterisation of the gels has been done by small-angle x-ray scattering (SAXS). For the measurements we have used the SAXS setup of the beamline A2 and the 2-dimensional CCD at a distance of 0.8 m and 1.5 m (sample-detector). A volume of some µL sample was placed on a kapton foil and covered with a second foil. With a cylinder the sample was sheared and the lattices oriented along the shear direction (figure 1).

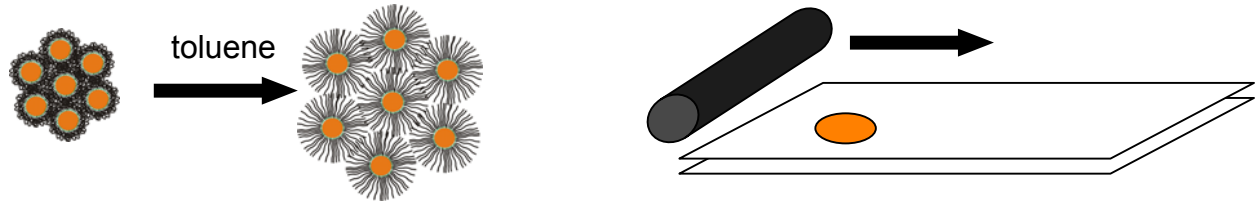

Figure 1 Left: Formation of a gel. Right: Application of shear stress on the sample between kapton foils.

Table 1 gives an overview on the used functionalised polystyrenes obtained by living anionic polymerisation.

	M(PS) [g/mol]	**n (styrene)**
PS-1	3300	31
PS-2	7600	72
PS-3	16100	153

Table 1: Molecular weight and number of momers for the used polystyrenes.

Figure 2 shows the anisotropic patterns for CdSe nanoparticles (D = 4 nm) surrounded with functionalised polystyrenes of different molecular weights.

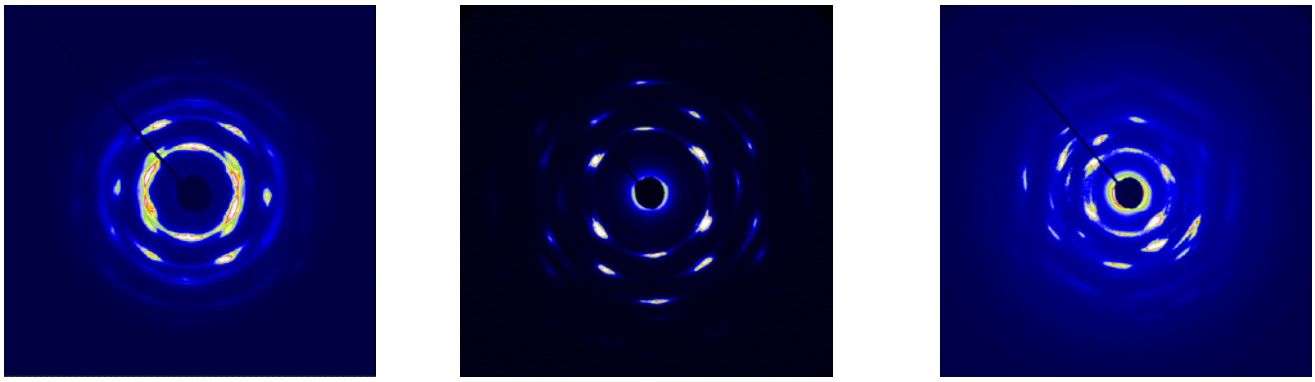

Figure 2: Left to right: Nanocomposites of CdSe with PS-1, PS-2 and PS-3.

Figure 3 shows the anisotropic patterns for Fe_3O_4 nanoparticles (D = 9.6nm) surrounded with functionalised polystyrenes.

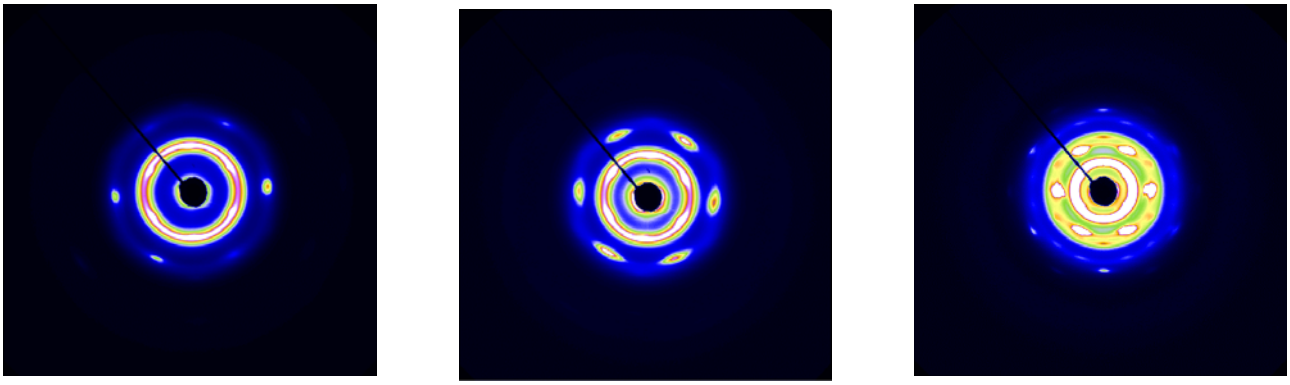

Figure 3: Left to right: Nanocomposites of Fe_3O_4 with PS-1, PS-2 and PS-3.

The obtained anisotropic pattern can be used to determine the lattice type, lattice constant, and nearest neighbourhood distance (NND). For the characterization the *Scatter* software was used [2].

	Lattice type	**Lattice constant (nm)**	**NND (nm)**
CdSe PS-1	fcc	17	12
Cd Se PS-2	bcc	17	14
Cd Se PS-3	bcc	25	22
Fe_3O_4 PS-1	fcc	27	19
Fe_3O_4 PS-2	fcc	30	21
Fe_3O_4 PS-3	fcc	43	30

These promising results show the possibility to enlarge the nearest neighbourhood distance with greater functionalized polystyrenes. These experiments may be improved by applying a more defined shear method on the sample.

References

[1] S. Förster, A. Timmann, C. Schellback, A. Frömsdorf, A. Kornowski, H. Weller, S. V. Rorth, P. Lindner, *Nature. Materials*, Vol 6, (**2007**).

[2] S. Förster, *Scatter*,Version 1.0.