Colloidal self-assembly and advanced synchrotron small-angle x-ray scattering

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Spontaneous self-assembly on the nanometre scale plays a key role in many recent developments in nanomaterials science. Synchrotron small-angle x-ray scattering (SAXS) offers unique opportunities for their detailed structural investigation. The high penetration power of X-rays makes SAXS applicable to almost all system types. In addition, the intrinsically low contrast of X-rays ensures, in the vast majority of cases, high quality of the scattering data that is free of multiple scattering contributions. SAXS also gives access to a broad range of spatial scales from a nanometre to microns. Moreover, as will be discussed in more detail in the lecture, microradian resolution can be achieved using synchrotron sources and refractive optics [1]. This provides access to periodicities up to several microns and to positional correlations on distances up to submillimetre, which can be accessed from the width of diffraction peaks. Applications will be illustrated by a number of examples. In particular, the structure of rhombic crystals spontaneously formed by cubic colloids with rounded corners will be discussed [2,3]. Another example will be the transition to a lower-symmetry body-centred tetragonal structure in a system of magnetic core-shell spherical colloids, which is induced by dipole-dipole interactions between colloids [4]. A short overview of some of our studies of lyotropic colloidal liquid crystals spontaneously formed by highly anisometric colloidal particles [5,6] will be given. Finally, in-situ studies of the self-ogranization of semiconductor quantum dots of different shape at a liquid interface [7-9] using grazing-incidence SAXS will be illustrated.

[1] A.V. Petukhov et al., Curr. Opin. Coll. & Interf. Sci. 20 (2015) 272–281.
[2] J.-M. Meijer, PhD thesis, Utrecht University, 2015; J.-M. Meijer *et al*., to be published.
[3] J.-M. Meijer et al., Soft Matter 9, 10729-10738 (2013).
[4] A. Pal et al., Angew. Chem. Int. Ed. 54 (2015) 1803.
[5] A.V. Petukhov et al., Phys. Rev. Lett., 95 (2005) 077801.
[6] E. van den Pol et al., Phys. Rev. Lett., 103 (2009) 258301.
[7] F. Pietra et al., Nano Letters, 12 (2012) 5515.
[8] M.P. Boneschanscher et al., Science, 344 (2014) 1377.
[9] W. van der Stam et al., Nano Letters, 16 (2016) 2608.