IN THE PIPELINE

Crystalline semiconducting polymer particles through direct polymerization

Particles of anisometric shape are difficult to obtain when applying traditional emulsion- and dispersion-polymerization protocols. In research program 1 (Synthiofluidics), the groups around Andrij Pich and Alexander Kuehne apply these methods to produce semiconducting polymer particles with non-spherical shape and anisotropic properties. In the first example, PEDOT, an electrically conducting polymer, has been polymerized from the liquid monomer EDOT. This conjugated monomer forms liquid crystalline emulsion droplets in water, generating PEDOT-nanospindles after polymerization (Fig. 1). The liquid crystalline templates are facilitated through the interaction of EDOT with an amphiphilic stabilizer compound PDPSA bearing a long alkyl chain on one side and a sulfuric acid group on the other. The PEDOT nanospindles exhibit good electrical conductivity and thermal stability of up to 300 °C, suggesting their application in high temperature nanoelectronics.

In a second approach, polyfluorene is polymerized in an alcohol and the content of a polymeric stabilizer called PVPVA is varied (Fig. 2). At high stabilizer content, spherical particles are obtained as expected from a dispersion polymerization. However, when decreasing the concentration of PVPVA, one can access different morphological phases, polyfluorene is known for. As the morphology can be tuned, changes the appearance of the monodisperse particles can be produced. At low PVPVA content, almost monodisperse spherulites become apparent with clear semi-crystalline signals in the XRD analysis and characteristic bow-tie shaped particles displaying clear birefringence.

Both approaches represent fundamental contributions to understanding and improving materials with anisometric shapes, for anisotropic high charge transport and improved macromolecular alignment. The materials are appealing as they are handled and processed as particle dispersions.

Fig. 1: PEDOT nanospindles imaged using TEM.

a) displays a lower resolution sample overview. Nanospindle development during synthesis: b) after 6 h, c) after 12 h and d) after 12 h. e) a single nanospindle showing subnanofibrils and f) close-up on a PEDOT nanospindle.

Fig. 2: Influence of the PVPVA stabilizer concentration on the morphology and shape of polyfluorene particles. a) shows spherulitic particles, b) shows bow-tie shaped particles as an intermediate state and c) displays spherical particles with a residual degree of crystallinity as seen by the lamellar surface structure. The insets show close-ups of particles.