Laboratory of organic nanomaterials synthesis

HEAD:

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RESEARCH PROFILE:

Organic nanomaterials, organic derivatization of nanomaterials, organic semiconductors. The first two rely on using organic chemistry techniques in nanotechnology. The purpose is to prepare nanomaterials with prospective applications in optoelectronics and medicine as well as study the relation between molecular structure and self-assembled state. We work with metallic, semiconductor and ferrite nanoparticles, as well as with graphene derivatives. By grafting surface of these nanomaterials with organic compounds designed in our laboratory we have the capability to control stability, spatial arrangement, solubility and biological activity of nanocomponents. In the field of semiconductors we give new life to old organic dyes by preparing their new derivatives with the view on using them in photonic technologies.

CURRENT RESEARCH ACTIVITIES:

Currently we are actively working in few different directions. All of them concern organic synthesis (liquid-crystals, organic semiconductors) and often synthesis of nanoparticles. By careful choice of the building blocks we can prepare a variety of nanomaterials with different applicative potential.
In one branch of projects we are aiming at the synthesis of reconfigurable assemblies of nanoparticles

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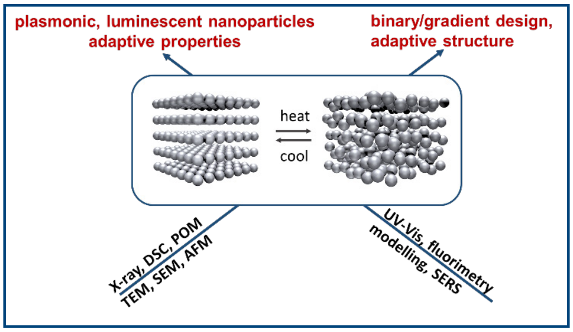

Fig. 1. Key tools and goals of achieving reconfigurable assemblies of nanoparticles.

(NPs). We are interested in such materials since it has been shown that in future they can solve a variety of technological problems of modern optoelectronic devices (low efficiency of light emitting diodes and solar panels, or assure access to optical computers). One of the very few methods that allows to achieve reconfigurabile nanoparticle assemblies is covering NPs with liquid crystals (LCs). Thus, in our work we synthesize various types of NPs (PbS, Au, Ag, Fe_3O_4 and other), design and synthesize liquid crystalline compounds and finally combine these building blocks. We have already prepared thermo-, light- and magneto-sensitive materials in which nanoparticle arrangement (thus properties of such materials) can be precisely controlled with external stimuli.

In another set of projects we seek for efficient drug delivery carriers based on nanoparticles. This work requires the synthesis of water-soluble nanoparticles and combining these materials with drugs. By assuring high stability and compatibility with biological media we allow the NPs to circulate in living organisms, while clever organic reactions program the carried drug to be released preferentially in the cancer cells.

Apart from the utilization of organic molecules to modification of the surface of the large variety of nanoparticles our research efforts are dedicated to organic semiconductors. We design and synthesize new derivatives of organic dyes which are known for a long time (such as diketopyrrolopyrrole or perinone). In the next step we characterize their optical, electrochemical and structural properties. The compounds of the best physicochemical properties are applied in test devices (OLED, OFET, OPVC).

Self-assembled and self-organized liquid crystals are function materials in many fields of advanced technologies. It is well established that the type of the mesophase, and thus material properties, are determined to large extent by the shape of mesogenic molecule and various non-covalent, intra- and intermolecular interactions. It is very important to find the connection between architecture of soft matter and nanostructures they create.

To face these needs, we synthesize a number of mesogens and investigate the molecular systems they form. All of the obtained compounds are physicochemically tested using a wide number of complementary methods such as: polarizing microscopy, microcalorimetry, X-ray techniques (SAXS, GADDS), as well as AFM and STM measurements.

SELECTED PUBLICATIONS:

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4. J. Matraszek, N. Topnani, N. Vaupotic et al., Monolayer Filaments versus Multilayer Stacking of Bent-Core Molecules, Angewandte Chemie-International Edition. 55(10) (2016) 3468-3472.
5. W. Lewandowski, M. Fruhnert, J. Mieczkowski et al., Dynamically self-assembled silver nanoparticles as a thermally tunable metamaterial, Nature Communications. 6 (2015) 6590.

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