Collaborative Research Centre 1415 "Chemistry of Synthetic Two-Dimensional Materials"

CRC Seminar Series

DATE: 08 October 2020
TIME: 3:00 PM – 5:00 PM
LOC: New Chemistry Building / Lecture Hall S89
Bergstraße 66, 01069 Dresden

GUEST SPEAKER:
Professor Klaus Müllen
Max Planck Institute for Polymer Research, Mainz, Germany

TITLE:
"Small, Medium, Large – A Chemical Graphene Story"

ABSTRACT:
Benzene is a universal module of chemistry. It occurs in linear (1D) polyphenylene chains, (2D) graphene sheets and (3D) dendrimer spheres. In these cases, dimensionality is the overarching guideline. The second, equally powerful guideline is size. Within the graphene world, we have prepared i) polycyclic aromatic hydrocarbons (PAHs) (small), graphene nanoribbons (GNRs) (medium) and III) graphene flakes (large). Chemical expertise is always mandatory, even in top-down protocols of electrochemically assisted graphite exfoliation. In all instances of bottom-up procedures, precision (polymer) synthesis is an essential tool.

Nanometer-sized PAHs and quasi-1D graphene subunits, the GNRs, can be made using our precursor protocol, which is now applied worldwide. This starts from highly branched (dendritic = treelike) polyphenylenes which are then subjected to an electron-transfer induced dehydrogenation (flattening „graphitization"). Solution-made GNRs can be 600 nm long and several nm wide, but are still solution processable. On-surface synthesis of graphenes after UHV-deposition of specially designed monomers on metal surfaces and subsequent polymerization is a new method which can furnish graphenic structures hitherto unaccessible by conventional routes.

Synthetic breakthroughs also open the door to unprecedented functions. PAHs, when obtained larger and larger, are unique models of graphene and phase-forming semiconductor materials. GNRs are the long sought-after link between conjugated polymers and graphenes. Due to their tunable electronic band gaps, they are efficient semiconductors, but can also give rise to topological insulators and are essential for new computing techniques. Likewise, PAHs and GNRs offer opportunities for stimulated emission and non-linear optics. Another synthesis-driven aspect is the creation of GNRs with zigzag-edges. They exhibit edge-localized electronic states, which can also be spin-polarized and are of high relevance for a future spintronics.

Finally, the polyphenylene dendrimers are (3D) carbon reservoirs for graphene formation, but also extremely useful functional nanoparticles in their own right. When being decorated with patched surfaces from alternating polar and unpolar groups, they serve as efficient vehicles for gene transfection.

References

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PROFILE OF PROFESSOR KLAUS MÜLLEN:

Prof. Klaus Müllen was director at the Max Planck Institute for Polymer Research and is continuing research at the universities of Heidelberg and Cologne. His broad research interests range from new polymer-forming reactions, to the chemistry and physics of single molecules as well as graphenes, dendrimers and biosynthetic hybrids. He published about 2000 papers. He received many awards, honorary doctorates and honorary professorships and he is member of national and international academies. From 2008-2009 he served as president of the German Chemical Society (GDCh). In 2013-2014, he was president of the German Association for the Advancement of Science and Medicine. In 2010, he won an ERC Advanced Grant for his work on nanographenes. He is associate editor of the Journal of the American Chemical Society.