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FACHBEREICH PHYSIK

›Allgemeines Physikalisches Kolloquium

Donnerstag, 11.04.2019 um 16 Uhr c.t.

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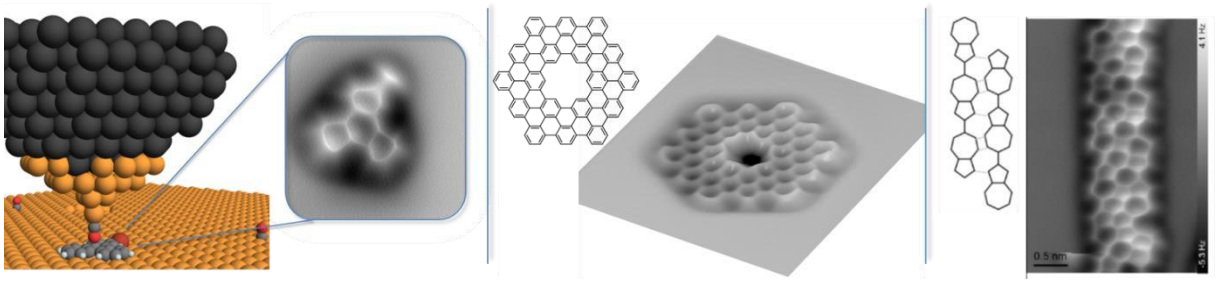
„Bottom-up Construction of 2D Nano-Materials using New Strategies in on-surface synthesis“

The in-depth knowledge about on-surface reaction mechanisms is crucial for the tailor-made design of covalently bonded organic frameworks, for applications such as nanoelectronics, novel 2D materials or quantum structures. Latest developments in atomic force microscopy, which rely on functionalizing the tip with single CO molecules, allow imaging molecular systems with chemical bond resolution, from flat aromatic to bulky aliphatic molecules like chiral diamandoids [1]. Using this technique we followed each step of the on-surface Ullmann coupling between bromo-triphenylenes on a Cu(111) surface [2], a chemistry textbook reaction, and discovered new reaction pathways, like hierarchical dehydrogenation reactions [3] and the dissymmetric activation of symmetric molecules [4].



But the true power of this combination of scanning probe techniques with organic on-surface synthesis lies in the exploration of new strategies for engineering molecular systems. For example, in our lab we synthesized graphene nanoribbons consisting exclusively of 5 and 7 carbon rings that have very unique electrical properties. The second example are nanographenes (NGs), i.e. segments of graphene with nanometer sizes in one or two dimensions. Size control at the sub-10 nm scale induces quantum confinement effects and allows tuning electronic bandgaps. Here we exploited the 2D confinement of a Au(111) surface to obtain planar benzo-fused perihexacenes, and measured the energy gaps of the new nanographenes. The last example are Graphene Quantum Rings (GQR), i.e. nanorings cut-out from graphene with atomic precision. These graphene

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rings represent model quantum materials for the exploration of geometry-dependent chemical and physical properties of nanographenes, e.g., the Aharonov-Bohm effect, whispering gallery modes and persistent ring currents. Based on the high-dilution principle we synthesized a novel hexagonal cycloarene containing 108 sp^2 carbons by hierarchical Ullmann coupling and cyclodehydrogenation.
These examples demonstrate how new strategies in on-surface synthesis allow engineering the physical properties of novel nano-architecures, including band gaps, topological states, magnetic phases and quantum states for applications in nanoelectronics, spintronics and quantum physics.

[1] Ebeling, Sekutor, Tschakert, Carlson, Schirmeisen, Schreiner, NATURE COMM. **9** (2018) 2420
[2] Zint, Ebeling, Schlöder, Ahles, Molenhauer, Wegner, Schirmeisen, ACS NANO **11** (2017) 4183
[3] Li, Yang, Björk, Zhong, Zhang, Shi, Zhang, Ebeling, Schirmeisen, Zhu, Chi, JACS **140** (2018) 6076 [4] Zhong, Ebeling, Tschakert, Gao, Bao, Du, Li, Chi, Schirmeisen, NATURE COMM. **9** (2018) 3277

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