Carbon nanomembranes and graphene from organic monolayers

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In this talk it will be demonstrated how monolayers of aromatic molecules can be employed to engineer free-standing ultrathin 2D carbon materials. By electron or photon irradiation, aromatic monolayers are converted into dielectric carbon nanomembranes (CNMs) with a thickness of one molecule, which can be tuned from ~0.5 to 3 nm. CNMs possess high mechanical stability and similar to graphene or other atomically thin 2D materials (e.g., hBN, MoS2) can be separated from their original substrates and transferred onto a variety of new substrates, fabricated as suspended sheets or stacked into multilayer films with precise control over their thickness. By annealing CNMs are converted into graphene. This approach enables both scalable production of graphene and direct writing of CNM or graphene micro and nanostructures employing e-beam or extreme UV lithography. Layer-by-layer assembly of vertical CNM/graphene heterostructures opens many doors to the engineering of novel 2D materials with tunable physical, chemical and biofunctional properties. As CNMs are flexibly chemically functionalized on both faces, they can be employed for the engineering of advanced support films for high resolution transmission electron microscopy (HRTEM) of biological samples. The characterization of CNMs by complementary electron spectroscopy, HRTEM, scanning tunnelling microscopy, experiments on specific immobilization of biomolecules to their surfaces, their characterization by TEM and nanopatterning will be presented.

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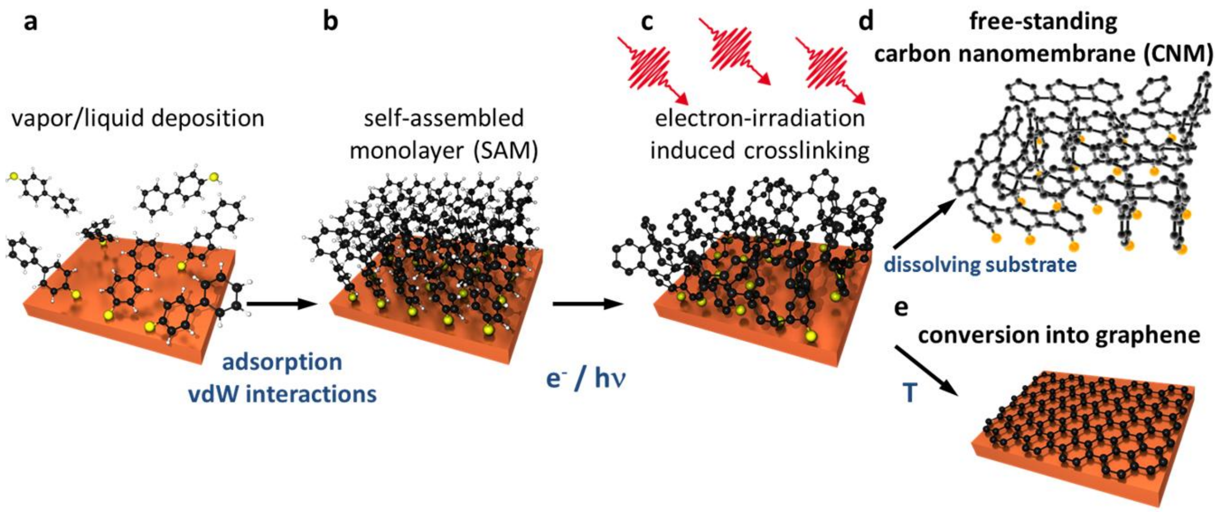

Fig. 1. Schematic representation of the conversion of aromatic self-assembled monolayers (SAMs) into carbon nanomembranes (CNMs) and graphene. a, Deposition of molecules on a substrate; here, vapour deposition of biphenyl-thiols (BPT). b, Formation of a SAM. c, Electron/photon-irradiation-induced crosslinking of the BPT SAM into a carbon nanomembrane (CNM). d, Formation of a free-standing CNM via dissolving of the substrate. e, Conversion of the CNM into graphene via annealing.