Carbon materials are of immense practical importance, but are often known as structurally ill-defined “black stuff” such as soot. Graphenes and graphene nanoribbons (GNRs), their geometrically restricted cutouts, are new additions to the carbon family which are widely praised as multifunctional wonder materials and rich playgrounds for physicists. Indeed, graphenes hold enormous promise as materials for energy technologies. Further, GNRs are regarded as a new generation of semiconductors superior to i) silicon in view of the required miniaturization of printed circuits and superior to ii) classical conjugated polymers due to better band structure control. Above all, however, graphene as a two-dimensional polymer and GNRs are true challenges for materials synthesis.

Herein, we approach graphene fabrication in two steps. “Top-down” protocols such as electrochemical exfoliation are applied for batteries, fuel cells and photodetectors. In the “bottom-up” synthesis of GNRs, repetitive cycloaddition reactions in solution are shown to afford multiply branched polyphenylene polymers which then serve as precursors for perfectly “graphitized”, solution-processable GNRs as long as 600 nm. An alternative on-surface synthesis utilizes immobilization of suitable monomers and in-situ STM-control of the polymerization to secure structural perfection.

It is thus a synthetic breakthrough which leads to new materials science and physics such as single-molecule field effect transistors from GNRs and even spintronics. The present fundamental study is far away from robust technologies, but an attempt can be made at predicting some future trends.

References