The Polymer Chemistry of Carbon Materials and Graphenes

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Research into energy technologies and electronic devices is strongly governed by the available materials. We introduce a synthetic route to graphenes which is based upon the cyclodehydrogenation ("graphitization") of well-defined dendritic (3D) polyphenylene precursors. This approach is superior to physical methods of graphene formation such as chemical vapour deposition or exfoliation in terms of its (i) size and shape control, (ii) structural perfection, and (iii) processability (solution, melt, and even gas phase). The most convincing case is the synthesis of graphene nanoribbons under surface immobilization and in-situ control by scanning tunnelling microscopy.

Columnar superstructures assembled from these nanographene discs serve as charge transport channels in electronic devices. Field-effect transistors (FETs), solar cells, and sensors are described as examples.

Upon pyrolysis in confining geometries or "carbomesophases", the above carbon-rich 2D- and 3D- macromolecules transform into unprecedented carbon materials and their carbon-metal nanocomposites. Exciting applications are shown for energy technologies such as battery cells and fuel cells. In the latter case, nitrogen-containing graphenes serve as catalysts for oxygen reduction whose efficiency is superior to that of platinum.

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