Chemical modification of individual carbon nanotubes

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Single-walled carbon nanotubes (SWCNTs) with a diameter in the nanometer range and with a length up to several micrometers, are promising candidates for a future carbon based nanoelectronics due to their unique physical and chemical properties. Depending on chirality, the SWCNTs behave as metallic or semiconducting, quasi 1D-systems. The electronic properties can be further tailored by linking of functional groups in controllable amount.

Here we present two complementary approaches for the controlled chemical modification of SWCNTs; the photochemical reaction with osmium tetroxide and the electrochemical attachment of substituted phenyl groups. The electrochemical approach is particularly suitable for the chemical alteration of single molecular objects, as their electrochemical potential, which determines the extent of reaction, can be directly adjusted by the applied potential. Our results show that functional groups can be controllably attached to appropriately contacted nanotubes. We demonstrate two types of coupling reactions, working under oxidative (anodic) or reductive (cathodic) conditions. While the transport properties are not affected in the oxidative coupling, a substantial increase of the resistivity is observed for the reductive coupling.

The presented methods are approaches to the adaptation of the surface chemistry of nano-sized charge-transport channels for use in electrical devices. Chemical modification can be useful in transforming metallic SWCNTs into semiconducting tubes, which are of interest for field-effect devices. The attachment of ligand- or receptorlike functionalities offers the potential of producing nanowires that are compatible with biological structural motifs for applications such as single molecule detection or contacting of nerve cells.