Controlled functionalized graphene nanoribbons produced from carbon nanotubes.

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Abstract

Graphene nanoribbons (GNR) have received a great deal of attention due their promise for electronics and optoelectronic applications [1]. Recently, the formation of GNR was observed "in situ" by unzipping of carbon nanotubes under ultra-high vacuum scanning tunneling microscopy (UHV STM) [2]. The CNT under observation were functionalized by the 1,3-dipolar cycloaddition reaction [3], in which the concentration of covalently bonded functional groups can be controlled by the experimental functionalization conditions. This functionalization route was responsible for the unzipping of the CNT, and thus the GNR formation by unzipping of functionalized CNT was repeated in ethanol suspension. The present work demonstrates the formation of graphene nanoribbons in solution by unzipping of functionalized carbon nanotubes. The formation of the GNR prepared in solution was studied by UV-visible spectroscopy, and the GNR obtained by solvent evaporation were analyzed by Raman spectroscopy, transmission electron microscopy (TEM), X-ray diffraction (XRD) and scanning tunneling microscopy (STM). TEM and STM images demonstrated the formation of few layer graphene ribbons, and this result was confirmed by Raman spectroscopy. Molecular modeling was applied to study the crystalline stacking of functionalized GNRs yielding interlayer distances of 0.51 nm, in agreement with STM and XRD analysis. It was demonstrated that this interlayer distance was required to accommodate the functional groups attached to the graphene. Figure 1 depicts the Raman spectra of the functionalized carbon nanotubes and resulting GNR, showing evidence for the formation of few-layer graphene.

References

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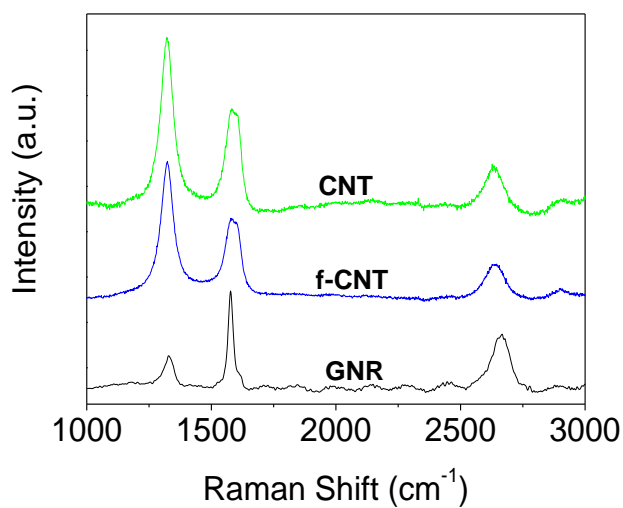
Figure 1: Raman spectra of the carbon nanotubes, the functionalized carbon nanotubes and the graphene nanoribbons