Functionalization of Graphene Nanoribbon Stacks

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Abstract

Graphene Nanoribbons (GNRs) are promising material with a high aspect ratio, possessing interesting mechanical and electrical properties. Thus it is a potential building block for numerous applications. However, two major issues need to be solved before full advantage of GNRs is to be taken: a) bulk preparation of well-defined GNRs and b) processability.

Various preparation techniques of GNRs have been reported by several groups, but processability still remains an opened challenge. Functionalization is one of the possibilities to enhance processability by introducing solvent compatible functional groups. We have developed one-pot reaction procedure for a preparation and *in-situ* functionalization of GNRs stacks from commercially available multiwalled carbon nanotubes (MWCNTs).[1] In the first step MWCNTs are longitudinally unzipped leaving activated carboanionic edges. Activated edges can then react with electrophiles or protons in the second step, yielding edge functionalized GNRs stacks or H-terminated GNRs respectively. Using iodoalkanes as electrophiles we have prepared alkylated GNRs.[1] Similarly, we have also prepared polymer-functionalized GNRs by adding vinyl or epoxide monomers in the second step.[2] Edge functionalized alkylated GNRs or polymer-functionalized GNRs showed greatly enhanced solubility in organic solvents without sacrificing a single ribbon conductivity. To enhance a bulk conductivity we have intercalated iron between functionalized graphene nanoribbon stacks.[3] Iron intercalated and edge-functionalized graphene nanoribbon stacks (Fe@F-GNRs) were then aligned in a magnetic field. Aligning the ribbons greatly enhanced bulk conductivity and electrical percolation at given concentrations in previously non-conductive solvents.

Above mentioned procedures can be easily scaled-up. Thus together with greatly improved processability, preserved conductivity and enhanced electrical percolation these materials could be of great interest for energy related devices, transparent touch screens, carbon fiber spinning, coating and polymer composites. Achieving enhanced electrical percolation at a given concentration, could also have an impact on volume and mass capacity of energy related devices such as in Li-ion batteries or ultracapacitors and conductive polymer composites. Further, this method is a cost-effective and potentially industrially scalable.

References

[1] B. Genorio, W. Lu, A. M. Dimiev, Y. Zhu, A.-R. O. Raji, B. Novosel, L. B. Alemany, and J. M. Tour, ACS Nano, vol. **6**, no. 5 (2012), 4231–4240.

[2] W. Lu, G. Ruan, B. Genorio, Y. Zhu, B. Novosel, Z. Peng, and J. M. Tour,, “Functionalized Graphene Nanoribbons *via* Anionic Polymerization Initiated by Alkali Metal-Intercalated Carbon Nanotubes” submitted.

[3] B. Genorio, Z. Peng, W. Lu, B. K. P. Hoelscher, B. J. Novosel, and J. M. Tour, ACS Nano, vol. **6**, no. 11 (2012), 10396–10404.

Figures

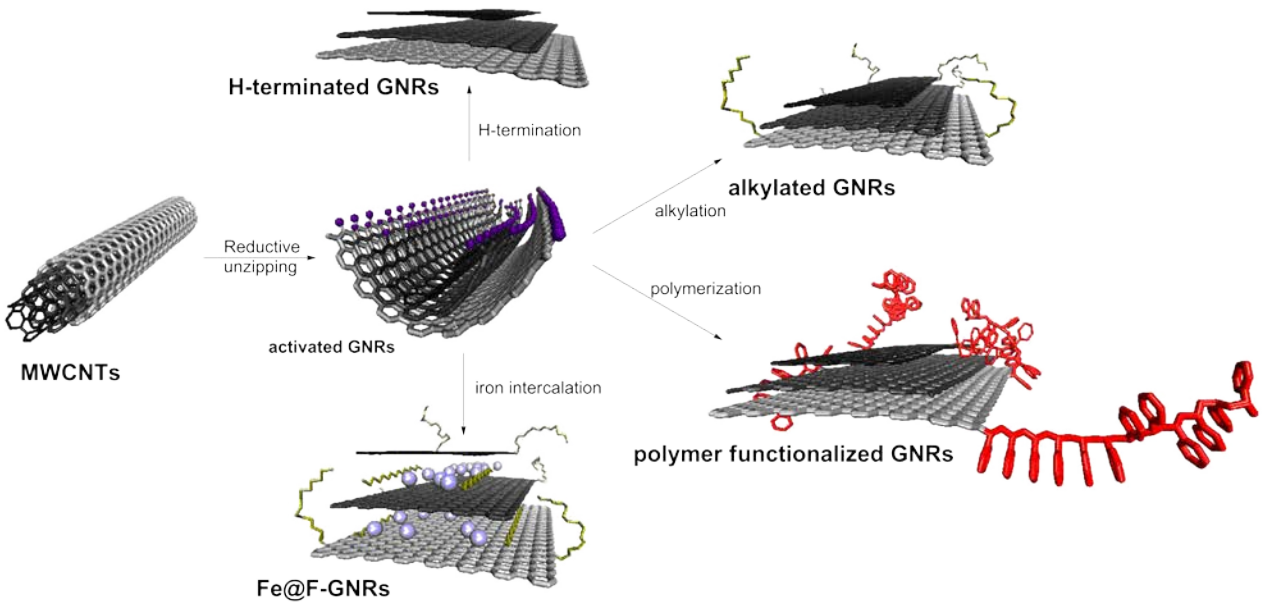

Figure 1. Proposed one-pot unzipping – *in-situ* GNRs functionalization scheme