Environmental remediation of oxidised graphene nanocarbons: 2D sheets degrade faster than 1D tubular-shaped structures

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Graphene nanocarbons are currently fuelling a revolution in science and technology in areas ranging from aerospace engineering to electronics [1]. Unlike their pristine forms, the oxidised derivatives of those nanostructures are water dispersible that allows their application to areas such as biology and medicine [2]. There is a need for efficient and viable means of degrading these engineered structures that is relevant to their potential biological uses but also for environmental purposes [2, 3]. The aim of the present study was to assess the potential of the widely used sodium hypochlorite, NaClO, (1% by chlorine content) to degrade oxidised graphene nanocarbons within a week. NaClO was found by a risk assessment report completed by the European Union (EEC 793/93) to be safe for the environment with regards to its standard usage which includes domestic sanitation as well as municipal water and waste disinfection. We compared the morphological changes that occur during degradation of graphene oxide to two other oxidised graphene nanocarbons, namely oxidised multiwalled carbon nanotubes and oxidised carbon nanohorns. Degradation was monitored closely using a battery of techniques including UV-Vis, Raman spectroscopy, transmission electron microscopy and atomic force microscopy. The results demonstrate that graphene oxide was degraded into a dominantly amorphous structure lacking the characteristic Raman signature and microscopic (TEM/AFM) morphology. Oxidised carbon nanotubes underwent degradation via a wall exfoliation mechanism, yet maintained a large fraction of the sp^2 carbon backbone, while the degradation rate of oxidised carbon nanohorns was observed at a somewhat intermediate rate to that for the other two types of nanostructures.

References

[1] Geim, A. K. & Novoselov, K. S., *Nat Mater,* **6** (2007) 183-91.
[2] Kostarelos, K. & Novoselov, K. S., *Science,* **344** (2014) 261-263.
[3] Lalwani, G., Xing, W. & Sitharaman, B., *J Mater Chem B Mater Biol Med,* **2** (2014) 6354 6362.

Figures

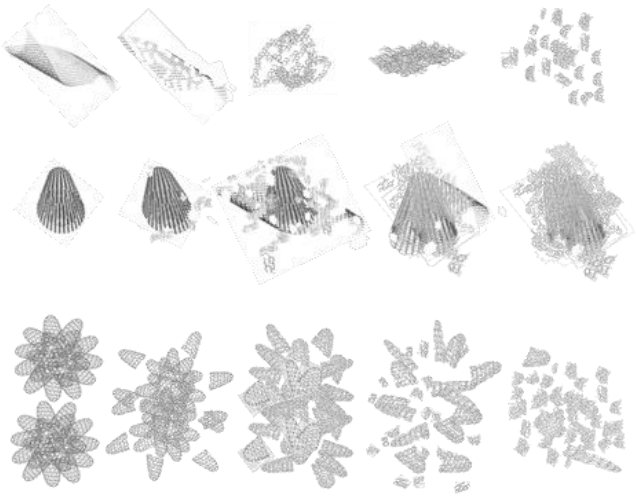

Figure 1: Schematic representation of the inferred progressive decay of structural integrity of graphene oxide, oxidised multiwalled carbon nanotubes and oxidised carbon Nanohorns over time when incubated in NaClO 1%.