Just Add Water and Table Salt: Electrochemical Exfoliation of Graphite in Sodium Halide Electrolytes Towards High Quality Graphene for Energy and Environmental Applications

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Graphene materials have shown great promise in many technological applications, but their large-scale production and processing by simple and cost-effective means still remain as a hurdle in the path of their practical implementation. Here, we investigate a straightforward method for the preparation of a ready-to-use and low oxygen content graphene material that is based on the anodic exfoliation of graphite in aqueous medium using sodium halides as the electrolyte. Sodium halides have been previously been reported as not been able to promote the anodic exfoliation of graphene, but here we show that proper choice of both graphite anode (e.g., graphite foil) and sodium halide concentration leads to the generation of large quantities of single-/few-layer graphene nanosheets with a degree of oxidation lower than that typical of anodically exfoliated graphenes (O/C ratio down to ~0.06). We also discuss the role of halide anions in mitigating the oxidation of the graphene lattice during exfoliation. The as-exfoliated graphene materials exhibited a three-dimensional morphology that was suitable for their practical use without the need to resort to any kind of processing. When tested as dye adsorbents, they outperformed many previously reported graphene-based materials (e.g., they adsorbed ~920 mg g−1 for methyl orange) and were useful sorbents for oils and nonpolar organic solvents. Supercapacitor cells assembled directly from the as-exfoliated products delivered energy and power density values (up to 15.3 Wh kg−1 and 3220 W kg−1, respectively) competitive with those of many other graphene-based devices but with an extremely simple preparation process. We acknowledge funding through grant MAT2015-69844-R and pre-doctoral contract FPU14/00792.

References

[1] J. M. Munuera, J. I. Paredes, M. Enterría, A. Pagán, S. Villar-Rodil, M. F. R. Pereira, J. I. Martins, J. L. Figueiredo, J. L. Cenis, A. Martínez-Alonso, J. M. D. Tascón, ACS Appl. Mater. Interfaces, 9 (2017) 24085

Figures

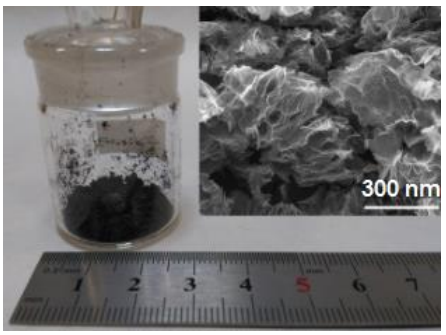

Figure 1: As-prepared anodically exfoliated graphene powder, SEM image of the same material (inset)

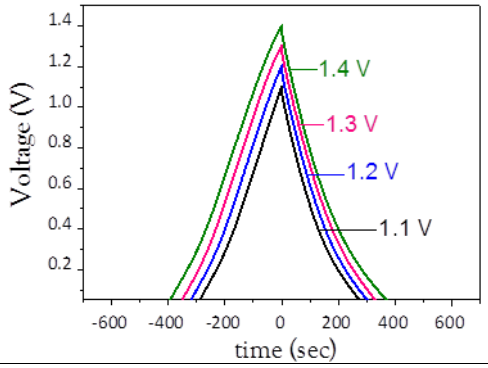

Figure 2: Galvanostatic charge-discharge profiles from the as-prepared anodically

exfoliated graphene at different potential windows.