chem2Dmat
September 03-06, 2019 • Dresden, Germany
European Conference on Chemistry of Two-Dimensional Materials

Production of 2D nanocarbons through chemical, electrochemical, or mechanical methodologies

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Exfoliation of graphite through oxidation is a promising technique to produce two-dimensional nanocarbons especially graphene oxide (GO) on a large scale. We have achieved a 500 g scale production of GO in laboratory, and 10 kg production in prototype plant by optimized Hummers' method using $KMnO_4$ in H_2SO_4. These large-scale productions were achieved by mechanistic study of the oxidation process using in situ analyses, such as XRD and XANES analyses. Our optimized GO production processes enabled the control of the size, oxidation degree, and functional group distribution on GO [1]. However, the conventional oxidation of graphite uses a strong oxidant in concentrated sulfuric acid; thus, there are environmental and safety issues. In contrast, the electrochemical oxidation of a graphite electrode has recently attracted considerable attention because it does not require oxidants or sulfuric acid. GO produced through the existing electrochemical method is generally lacking in quality, due to the non-uniform destruction of the intermediately oxidized graphite. We developed a method for the non-destructive oxidation of graphite using specially designed electrolyte. It is confirmed that the choice of solvents and electrochemical conditions enabled fine control over the functionalization degree and type of functional groups on GO. Compared to chemically generated GO, the electrochemically generated GO exhibits similar or better physical and chemical properties toward lithium ion battery electrodes and water purification membranes. This electrochemical method is also applicable to a continuous flow system, thus promising the mass production of GO for future industrialization. Further, direct exfoliation of graphite in liquid was also achieved without oxidation.

References

[1] N. Morimoto, Y. Nishina, et al, Chem. Mater, 46 (2017), 4160–4165.

Figures

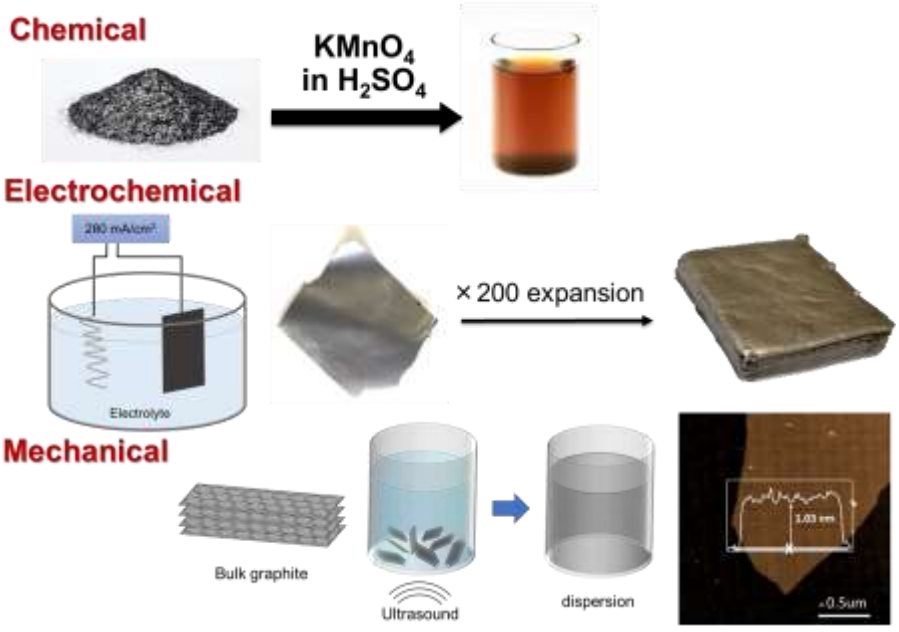

Figure 1: Methods for the production of 2D nanocarbons.