Carbon-heteroatom bond formation by ultrasonic spray chemistry for energy storage system

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Abstract

The direct formation of C-N and C-O bonds, while essential in chemical/biological processes and energy storage systems, remains technologically challenging[1-3]. We describe a simple and ultrafast method to form these bonds in reduced graphene oxide (RGO) and carbon nanotubes (CNTs) by ultrasonic chemical reaction for application in energy storage systems. Electrodes of nitrogen- or oxygen-doped RGO (N-RGO or O-RGO, respectively) are fabricated by the collision between N_2 or O_2 carrier gas molecules and ultrasonically activated RGO (Figure 1). The doped products exhibited much higher capacitance than the undoped material (133, 284, and 74 F g^{-1} for O-RGO, N-RGO, and RGO, respectively). Furthermore, doped two-dimensional RGO and one-dimensional CNT materials are deposited layer-by-layer by ultrasonic spray to form three-dimensional porous electrodes with very high specific capacitances (62.8 mF cm^{-2} and 621 F g^{-1} at 10 mV s^{-1} for N-RGO/N-CNT with 1/1 (v/v)), high cycling stability, and structural flexibility (Figure 2).

References

[1] D. E. Canfield, A. N. Glazer, P. G. Falkowski, Science, 330 (2010) 192-196
[2] E. M. Lodwig et al., Nature 422 (2003) 722-726
[3] T. Q. Lin et al., Science, 350 (2015) 1508-1513

Figures

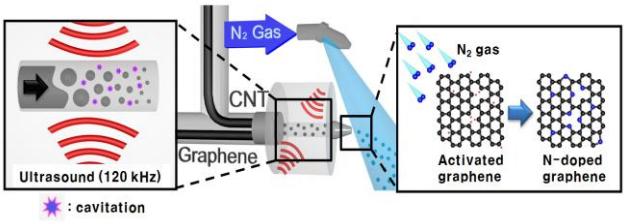

Figure 1: Schematic illustration of the proposed mechanism of heteroatom fixation into graphene by ultrasonic spray

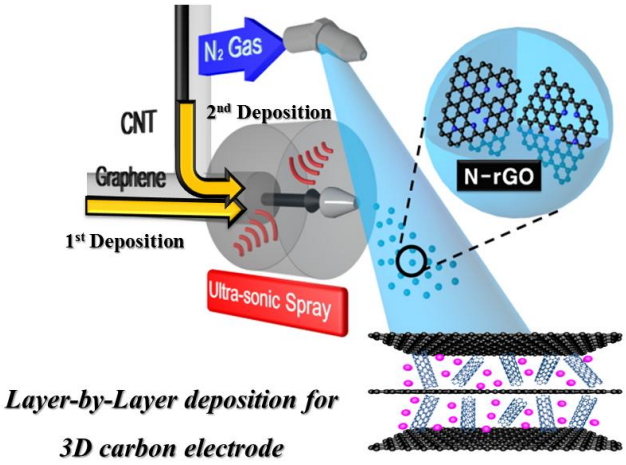

Figure 2: Schematic illustration of the layer-by-layer deposition process of ultrasonic deposition and 3D carbon electrode structure.