

Supporting Information

Enhancement of quaternary nitrogen doping of graphene oxide via chemical reduction prior to thermal annealing and an investigation of its electrochemical properties

Tran Ngoc Huan^a, Tran Van Khai^b, Youngjong Kang^a, Kwang Bo Shim^b and Hoeil Chung^{a}*

IR spectroscopy was used to investigate the structural changes of graphene occurred during N-doping. **Figure S1** shows IR spectra of graphite, GO, RGO and N-doped RGO at 900°C. Graphite clearly shows the characteristic peak at 1550 cm⁻¹ corresponding to *sp*² carbon network. In the case of GO, the 1724 cm⁻¹ band assignable to C=O stretching of COOH groups in GO sheets are clearly observed. In addition, diverse peaks at the 1625 cm⁻¹ (aromatic C=C), 1386 cm⁻¹ (stretching/deformation of O-H), 1230 cm⁻¹ (C-O stretching of epoxy) and 1075 cm⁻¹ (C-O stretching of alkoxy) are present [1-4]. It indicates that diverse functional groups are introduced into carbon frameworks by Hummers method. In the case of RGO, the intensity of 1724 cm⁻¹ band (C=O) greatly decreases, indicating significant elimination of oxygen. This result is clearly accordant with that from XPS analysis as shown in Table 1. Moreover, new bands appear at 1551, 1406 and 1188 cm⁻¹ correspond to aromatic C=C bonds, C-N stretching and C-C stretching, respectively [5-7]. It demonstrates that the restoration of *sp*² carbon networks and incorporation of N atoms into graphene lattice after chemical reduction of GO. When RGO is annealed at 900°C under nitrogen gas, the bands at 1559 and 1207 cm⁻¹ assignable to C=N and C-N stretching in benzenoid rings [8], respectively, are observed. The advent of both peaks indicates the increased nitrogen content. The 1207 cm⁻¹ band would be partially from quaternary N-doping possibly; however, the more specific analytical method such as XPS analysis should be necessary for the clear confirmation of quaternary N-doping.

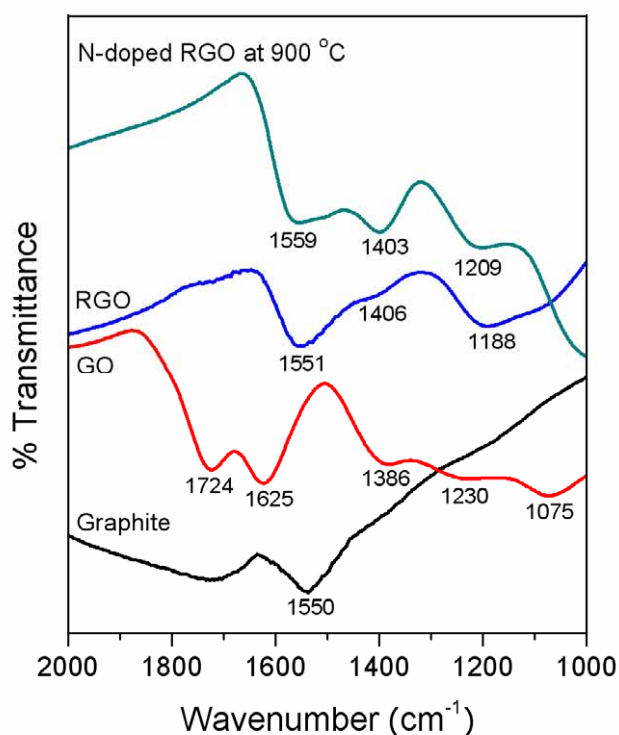


Fig. S1. IR spectra of graphite, GO, RGO and N-doped RGO at 900°C.

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