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Facile fabrication of honeycomb-like restacking-inhibited graphene architecture with superior electrochemical performance for energy storage

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ABSTRACT

In this work, we reported a facile fabrication of honeycomb-like restacking-inhibited graphene architecture with open pores. The graphene exhibits superior supercapacitive performance in 6 M KOH, a high specific capacitance of 335 F g^{-1} can be achieved at a current density of 0.5 A g^{-1}. This research provides an effective, scalable, low-cost and environmental compatible methodology to fabricate crumpled graphene for advanced energy storage applications.

1. Introduction

Graphene is a two-dimensional carbon material of only one-atom thickness with superior electronic, optical, mechanical and thermal properties, and has attracted great attention for wide potential applications in various fields [1–4]. Due to extremely high electrical conductivity and high theoretical specific surface area (2630 $m^2 g^{-1}$), graphene has been considered as a very promising material for energy storage applications [5,6]. However, graphene easily undergo restacking, accounting for a dramatic decrease of surface area and intrinsic property.

To date, great efforts have been devoted to exploring effective ways to fabricate restacking-inhibited graphene, which is very essential to realize practical applications for energy storage [7–9]. Luo managed to transform graphene sheets into crumpled paper-like balls by capillary compression, and the graphene balls do not aggregate in solution or restack in solid state [10,11]. Peng developed a rapid heating approach to produce holey graphene powders, and found that the specific capacitance of graphene intended to increase as more holes were created [12]. In this work, we reported a novel facile route to fabricate the crumpled graphene with open porous architecture. Furthermore, the as-fabricated honeycomb-like graphene architecture was investigated as electrodes for supercapacitors, which exhibits superior energy storage capability.

2. Experimental

Graphite oxide was prepared by a modified Hummers method [13]. 0.1 g of graphite oxide was probe-sonicated in 50 mL of distilled water to get a homogeneous solution of graphene oxide (GO), and then a certain amount of sodium chloride (NaCl) was added under stirring until a sol-like mixture was obtained. The mixture was put into a furnace that was preheated up to 300 °C. After 30 min, the product designated as NaT-rGO was washed with distilled water for several times, and dried at 120 °C for 12 h. For comparison, a similar procedure was performed but without NaCl, the product was designated as T-rGO. Additionally, the reduced graphene oxide (rGO) was also synthesized using the hydrothermal method that was conducted at 200 °C for 12 h in an autoclave, and designated as Hy-rGO.

The as-prepared samples were characterized by field-emission scanning electron microscopy (FESEM, Hitachi S4800), X-ray diffractions (XRD, Rigaku D/Max 2500), Raman spectroscopy (Thermo Scientific DXR), X-ray photoelectron spectroscopy (XPS, Thermo scientific K-Alpha), thermo-gravimetric analysis (TGA, TA Q500), and Fourier transform infrared spectroscopy (FTIR, Perkin-Elmer Frontier). The electrochemical measurements were performed in 6 M KOH using a three-electrode system that consists

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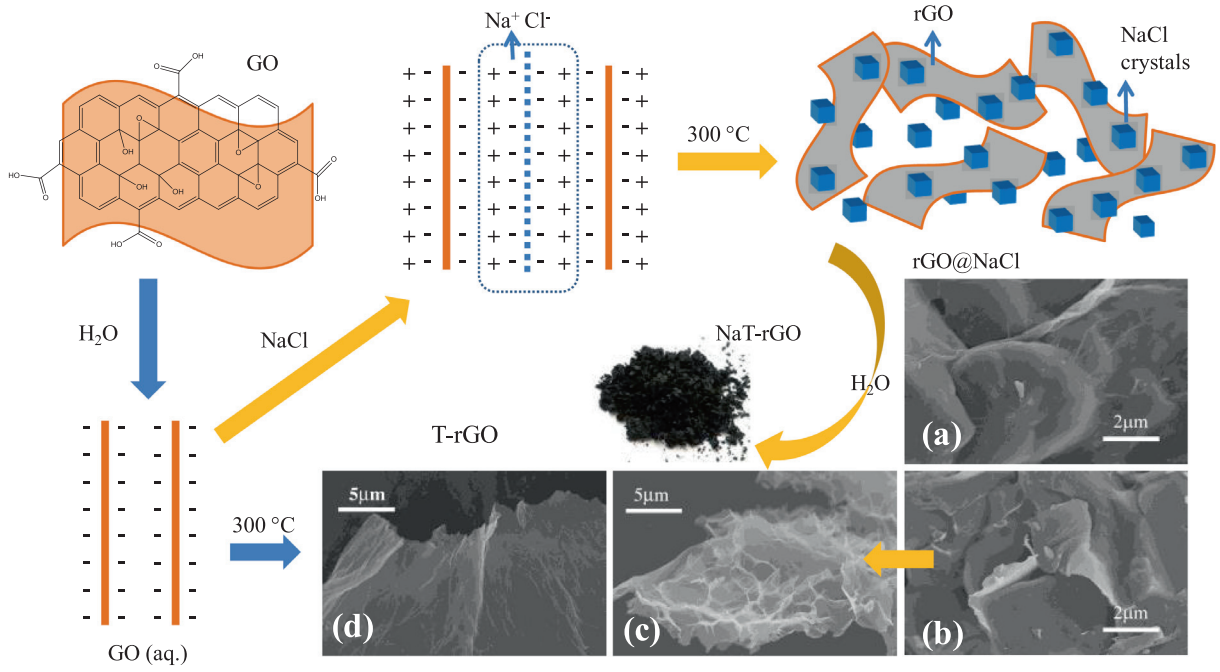

Fig. 1. Preparation scheme and SEM images of (a, b) rGO@NaCl, (c) NaT-rGO and (d) T-rGO.

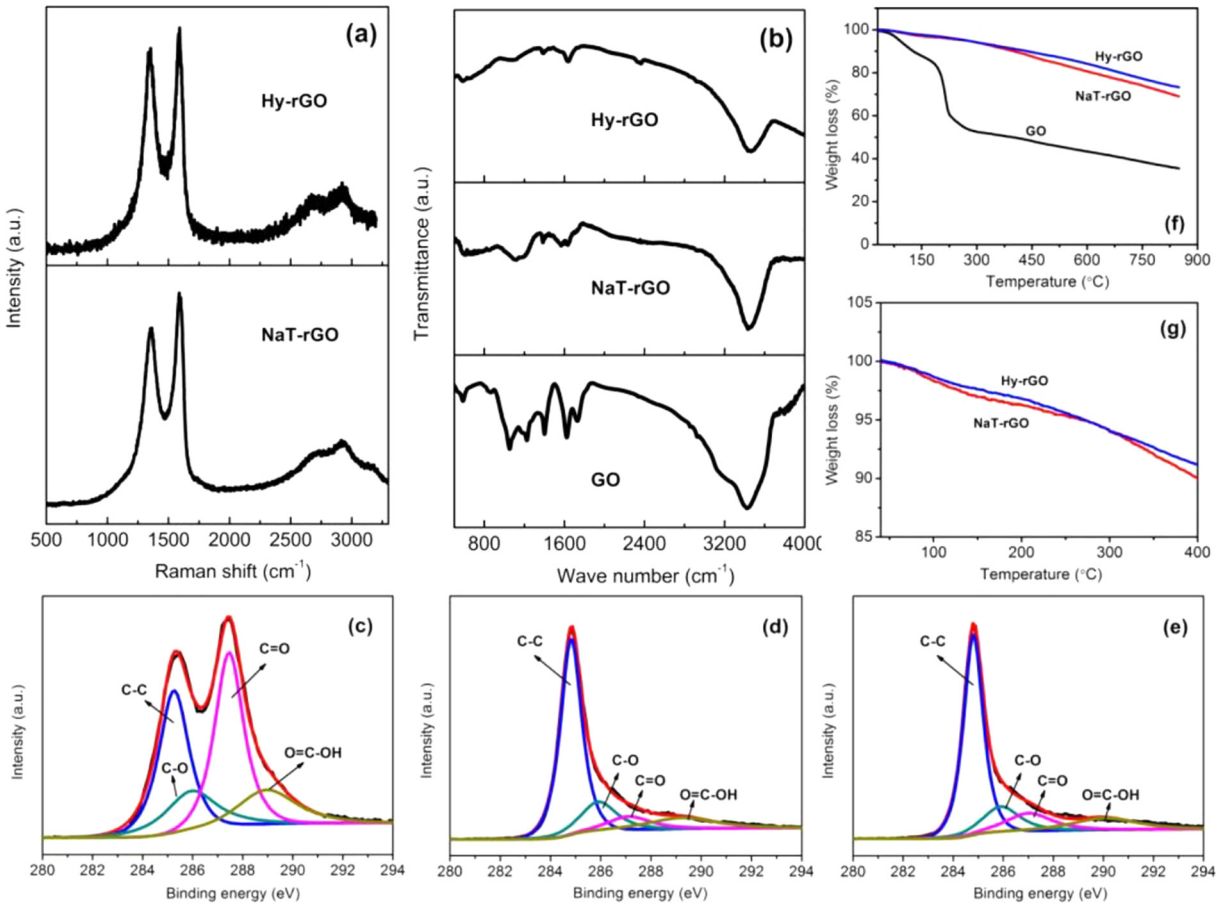

Fig. 2. (a) Raman spectra and (b) FTIR spectra for the samples; the deconvoluted C1s spectra for (c) GO, (d) NaT-rGO and (e) Hy-rGO; TGA curves for the samples: (f) 30–800 °C, (g) 30–400 °C.