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High performance supercapacitor electrodes based on eco-friendly glucose-derived nitrogen-doped graphene-like derivatives

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KEYWORDS

Electrochemical energy storage, N-doped graphene, Supercapacitors, Graphitic structure-property relationship

SHORT SUMMARY

The potential use of several ecofriendly Nitrogen-doped graphene-like derivatives (NGCDs) of various graphitic structure features, as supercapacitor electrode materials, has been explored. NGCDs have been synthesized via a novel facile, economic and eco-friendly technique. The synthesis technique is simply a single-step hydrothermal treatment of glucose, using traces of CTAB and Ammonia as structure-directing agents. The graphitic structure characteristics are controlled by manipulating the hydrothermal process temperature and CTAB dose. The electrochemical energy storage performance is strongly dependent on the oxidation level, doped N content and configurations, exfoliation degree of nanosheets, density of graphitic surface capping by CTAB and crystalline structural order of NGCDs. Interestingly, such graphitic structure parameters influence the energy storage capacitive performance in a competitive manner. The NGCD sample of the best energy storage capacitive performance out of the study, with specific capacitance of 553 F/g, energy density of 84.5 Wh/g and power density of 550.2 W/g, is regarded promising ecofriendly supercapacitor electrode material.

EXTENDED ABSTRACT

Today, graphene and its derivatives, with their unique properties, are leading candidate materials in many technological applications. Therefore, the worldwide interest towards green/clean production of graphene have recently been extensively grown, for clean environment and human health safety concerns [1, 2]. The challenges are to produce graphene derivatives via clean eco-friendly technology with high productivity, distinctive structural quality and consequently outstanding functional properties. The present study explores the potential use of eco-friendly Nitrogen-doped graphene-like derivatives, derived from glucose employing a novel chemical synthesis technique, as supercapacitor electrode materials. The novel synthesis strategy is simply a single-step hydrothermal treatment of glucose, using CTAB and Ammonia as structure-directing agents [3]. Herein, several N-doped graphitic carbonaceous derivatives (NGCDs) of various graphitic structure characters have been produced by manipulating the hydrothermal temperature (HT) and CTAB dose (CD) [4]. The investigated HT and CD values and the codes of the corresponding produced graphitic carbon samples are indicated Table 1. Understanding of how the graphitic structure features of NGCDs, control their electrochemical performance as supercapacitor electrodes (Figure 1) is a focal point of interest throughout the research work. Results reveal competitive effects of the graphitic structural parameters. Thus, although of worse graphitic nanosheets' exfoliation and higher oxidation state, NGCD-NCD250 and NGCD-LCD250 exhibit superior capacitive performance than NGCD-HCD250, due to increased doped-N content and lower density of capping CTAB. NGCD-HCD270 shows the highest capacitive performance with remarkable specific capacitance of 553 F/g, energy density of 84.5 Wh/g and power density of 550.2 W/g. Mainly because, it possesses the most promising microstructural features towards pure N-doped graphene, including lowest residual Oxygen content and capping CTAB density, presence of

graphitic doped-N configuration and well exfoliated large nanosheets architecture. Moreover, the cycling stability experiment shows that NGCD-HCD270 kept 93.5% of its specific capacitance over 1000 charge-discharge cycles (Figure 2). Overall, the study highlights the crucial role of graphitic structure character in tuning the electrochemical performance of NGCDs and provides N-doped Graphene-like derivative (NGCD-HCD270) as advanced supercapacitor electrode material, employing facile, economical and eco-friendly production method, which benefits the substantial development of electrical energy storage industry at competitive costs.

Tables and Figures

Table 1 Applied synthesis conditions and produced graphitic samples' codes

Hydrothermal synthesis conditions		Graphitic sample code
CTAB/Glucose molar ratio (CD)	HT (°C)	
0	250	NGCD-NCD250
1/9		NGCD-LCD250
1/6		NGCD-HCD250
1/6	270	NGCD-HCD270

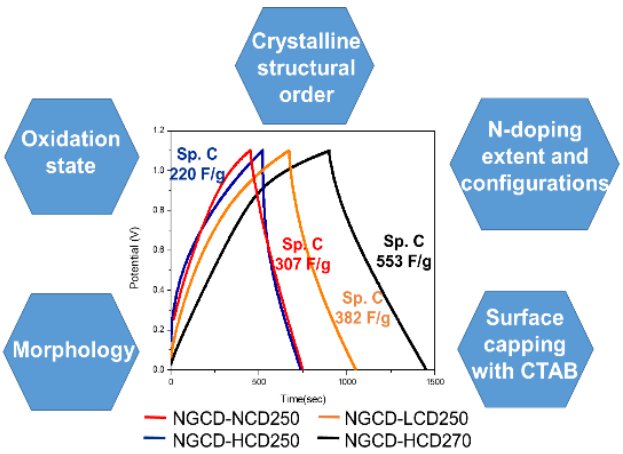

Figure 1 capacitive charge-dischrage performances of NGCDs as function of their graphitic structure characteristics

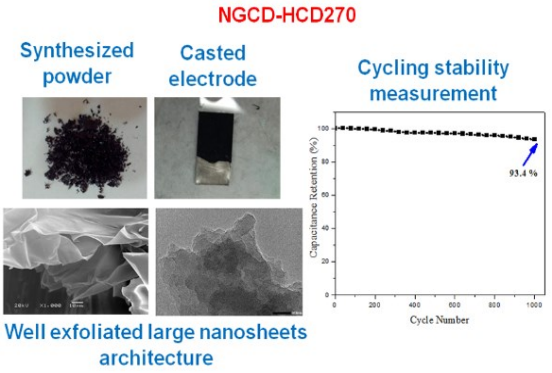

Figure2. Photos, morphological architecture and electrochemical performance of the optimum N-doped graphene derivative as supercapacitor electrode material (NGCD-HCD270)

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