Materials Letters 152 (2015) 192–195

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

Nitrogen doped activated carbon/graphene with high nitrogen level: Green synthesis and thermo-electrical properties of its nanofluid

Seyed Farid Seyed Shirazi, Samira Gharehkhani *, Hooman Yarmand *, Ahmad Badarudin, Hendrik Simon Cornelis Metselaar, Salim Newaz Kazi

Department of Mechanical Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia

ARTICLE INFO

Article history:
Received 17 February 2015
Accepted 23 March 2015
Available online 1 April 2015

Keywords:
Carbon materials
Thermal properties
Electrical properties
Nanofluid

ABSTRACT

We have synthesized a nitrogen doped activated hybrid material containing carbon derived from empty fruit bunch (EFB) pulp as a waste material, and graphene oxide (GO) by using KOH and urea via one step thermal treatment at 800 °C. The results show an excellent attachment of GO to the carbon matrix with a spongy-like structure of final product (NACG), possessing the high surface area (2261.2 m^2/g) and high nitrogen content (11.53%). A significant enhancement in thermal conductivity (10.16%) as well as in electrical conductivity (11433%) of dispersed NACG in the ethylene glycol (EG) confirms its potential application towards nanofluids.

1. Introduction

The carbon-based materials with different structures such as carbon nanotube (CNT), activated carbon (AC) and graphene have received a broad attentions in various fields of electrochemical, water treatment, biomaterial and nanofluid [1–3]. AC as an amorphous sp^2 carbon with high surface area, can be produced from the agricultural waste materials and non-wood pulps [4]. An approach to reach the further properties, the AC can be composited with other carbonic materials e.g. graphene. Another strategy is doping the heteroatoms such as nitrogen, boron, sulfur and fluorine into the carbon structure [5]. Among the dopants, nitrogen as the well known element, can be doped by different methods e.g. chemical vapor deposition, nitrogen plasma process and thermal treatments. From the previous reports, it can be realized that N-doping process requires the complicated equipment and costly materials. Moreover, the applications of nitrogen doped carbon-based materials have been considered mostly for electrochemistry and water treatment units, so it seems that introducing the new applications with low cost processes can open the new windows to extend the usage of these types of materials. Since doping the carbon structure with N atoms improves the electrical conductivity properties [12], the study on the thermo-electrical properties of nanofluids containing N-doped hybrid of carbon structures is of interest from the applied perspective.

The study on Ag-CNT/hydrogen exfoliated graphene hybrid dispersed in EG showed an enhancement of 8% in thermal conductivity [1]. In another report, the values of thermal and electrical conductivities of GO/CNT composite dispersed in EG were significantly improved with increasing the concentration of dispersed materials [2].

However, various studies conducted on the thermal and electrical conductivity of composite material suspensions, no investigation has yet performed on the nanofluids containing N-doped activated hybrid of carbon materials. In the present study, the nitrogen doped activated carbon/graphene (NACG) hybrid with high nitrogen content was successfully synthesized by using the carbon derived from EFB pulp, and GO. Thermo-electrical behavior of the NACG nanofluid was examined to extend the application of this material for nanofluid.

2. Materials and methods

Synthesis of material: The GO was prepared from the graphite flakes using a simplified Hummers' method [6]. The carbon prepared via pyrolysis of EFB fiber at 500 °C with 10 °C/min for 2 h in N_2 atmosphere. The prepared carbon (1 g) was added to the 100 ml aqueous solution containing 4 g of KOH and 5 g of urea. The mass ratio of KOH/carbon and urea/carbon was 4:1 and 5:1. Similar mass ratios were used to prepare the GO (3 wt% of carbon) sample. Carbon sample and GO sample were stirred at 500 rpm for 2 h. Then were mixed together and stirred for 3 h and dried at 50 °C. The dried mixture was heated to 430 °C at rate of 5 °C in N_2 flow and maintained for 30 min, then heated up to 800 °C and maintained for 75 min. The obtained sample was then thoroughly washed with 0.1 M HCl (37%) and deionized water and was dried overnight at 60 °C.

* Corresponding authors. Tel.: +60182890460; fax: +60379675317.
E-mail addresses: s_gharahkhani_248@yahoo.com (S. Gharehkhani), hooman_yarmand@yahoo.com (H. Yarmand).

http://dx.doi.org/10.1016/j.matlet.2015.03.110
0167-577X/

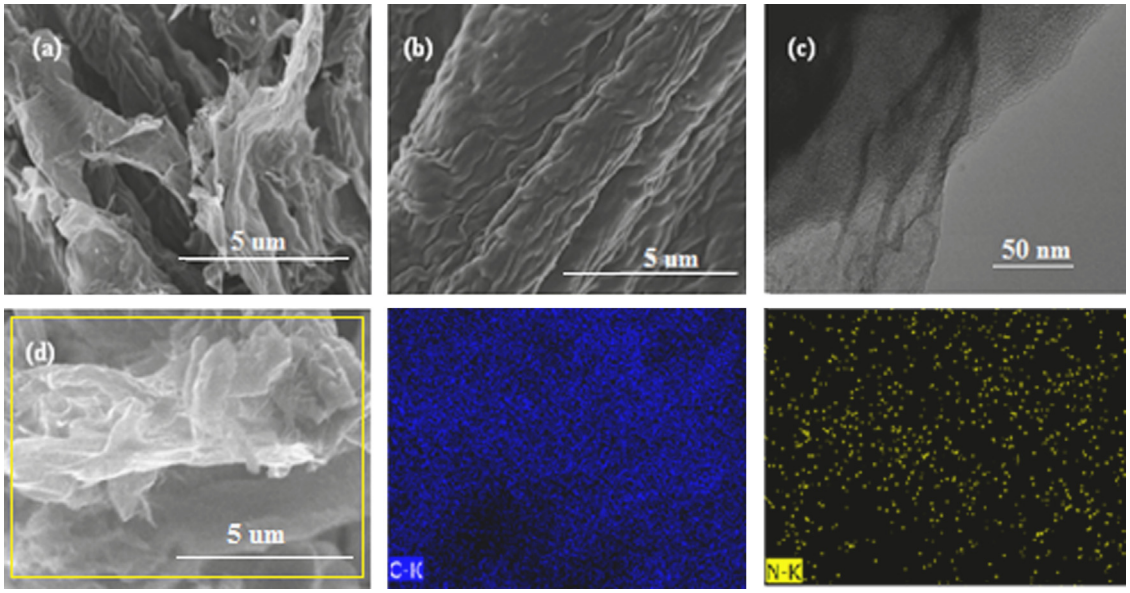

Fig. 1. (a) The FESEM images of NACG and (b) pure AC, (c) TEM image and (d) Elemental mapping of NACG.

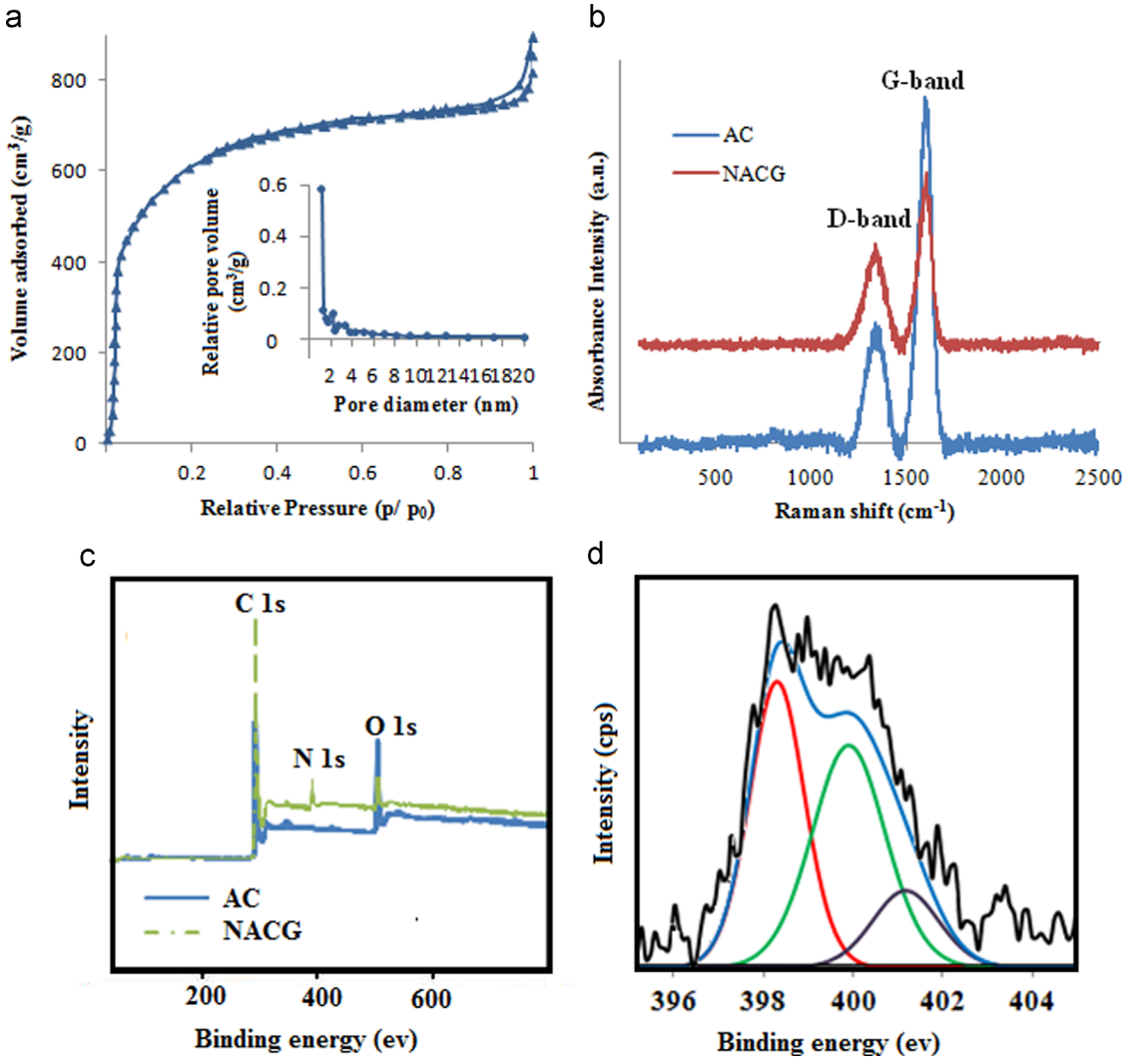

Fig. 2. (a) N_2 adsorption and desorption isotherms and pore size distribution of NACG, (b) the Raman spectra, (c) XPS spectra of AC and NACG and (d) high-resolution N 1s spectra of NACG.