Data Article

Data on flexibility and thermal stability of Polypyrrole-based ternary nanocomposite films

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A B S T R A C T

Carbon materials, such as multi-walled carbon nanotube (MWCNT), single-walled carbon nanotubes (SWCNT), and graphene sheets (GNS), filling into polymer substrates can effectively improve performance of composite materials [1,2]. The data presented here in this article illustrates the different impacts of GNS and MWCNT on the mechanical properties of polypyrrole (PPy)-based composites systems. PPy/GNS and PPy/MWCNT binary composites were added into poly(3,4-ethylenedioxythiophene): poly (styrene sulfonate) (PEDOT: PSS) matrix. Changing the ratio of PPy/GNS and PPy/MWCNT to PEDOT: PSS, a series of PEDOT: PSS-PPy/GNS (abbreviated as PGNS) and PEDOT: PSS-PPy/MWCNT (abbreviated as PMWCNT) ternary composites films were obtained. The synthesis process of PGNS and PMWCNT films are based on Wang et al [3].

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Specifications Table

| Subject area       | Materials Science: Chemistry |
|--------------------|------------------------------|
| More specific subject area | Flexibility and thermal stability of inorganic-organic ternary composite materials |
| Type of data       | Cross-sectional SEM images, digital photos, TGA curves |
| How data was acquired | The morphologies of the samples were examined by scanning electron microscopy (Nova Nano SEM450, USA). The thermal stability were measured by Thermogravimetric analysis (TG209F1, NETZSCH, Germany). |
| Data format        | Raw and Analyzed |
| Parameters for data collection | PPy/GNS and PPy/MWCNT filling ratio to PEDOT: PSS are changed. |
| Description of data collection | The flexibility and thermal stability of PGNS and PMWCNT films with different PPy/GNS and PPy/MWCNT filling content were investigated. |
| Data source location | Chengdu, China |
| Data accessibility | Data is with this article. |
| Related research article | Y. H. Wang, S. Q. Wu, Q. J. Yin, B. Jiang, S. T. Mo, Poly (3,4-ethylenedioxythiophene)/ Polypyrrole/ Carbon Nanoparticle Ternary Nanocomposite Films with Enhanced Thermoelectric Properties, 10.1016/j.polymer.2020.123131. |

Value of the Data

- The cross-sectional SEM images of PGNS and PMWCNT films can help understand the dispersion status of PPy/GNS and PPy/MWCNT in PEDOT: PSS matrix.
- This following data helps to understand the different impacts on mechanical properties of PPy/GNS and PPy/MWCNT filled composite films.
- The comparison with various PPy/GNS or PPy/MWCNT ratio to polymer matrix can help in understanding the role of inorganic fillers on the mechanical properties of inorganic-organic composite materials.

1. Data Description

Film thickness have been recorded by cross-sectional SEM images of PGNS and PMWCNT films as Fig. 1 and Fig. 2, which are the same as the ones provided in Ref. [3] but with large scale. After adding PPy/GNS into PEDOT: PSS aqueous solution, the mixed solution was filtered on PVDF membrane to obtain PGNS composite films. As shown in Fig. 1, the boundary of sample layers and porous PVDF membrane are marked with dashed line. The thickness of D-PEDOT: PSS is 5.8 μm, and rises with increasing the PPy/GNS filling content in PGNS nanocomposite films. PGNS-70% films possess the largest thickness of 46.7 μm. Despite the solid content of PPy/GNS exceeds PEDOT: PSS, PGNS-70% films remain a layered structure. In Fig. 2, the thickness of PMWCNT composite films is also measured. With tangled PPy/MWCNT, the layer-stacked structures of PMWCNT-70% films are destroyed, which lead to the disordered shape of PMWCNT-70% films. Therefore, PGNS films (Fig. 1B-1F) present more uniform thickness and surface than PMWCNT films (Fig. 2B-2F).

The flexibility of PGNS and PMWCNT nanocomposite films relies on basement membrane. As presented in Fig. 3A-1, 3B-1 and 3C-1, PGNS and PMWCNT films filtering on PVDF membrane keep good flexibility with increasing the PPy/GNS and PPy/MWCNT filling content. When depositing PEDOT: PSS-PPy/GNS and PEDOT: PSS-PPy/MWCNT aqueous solution (1 mL) onto Cu plate (~12.5 mm of diameter), the obtained PGNS and PMWCNT films can be peeled off (Fig. 3A-2, 3B-2 and 3C-2) at 40 °C. PGNS-5% films (Fig. 3A-3) show good flexibility, while PGNS-70% films (Fig. 3B-3) break into two pieces after bending. Thickness of PGNS films enlarge as the content of PPy/GNS increase. Larger amount of PPy/GNS powders are filled into PGNS-70% films than PGNS-5% films, which is major reason of decreasing the flexibility of PGNS-70% films.
PMWCNT-70% films (Fig. 3C-2) become twisted after separating from Cu plate, and are easily crushed (Fig. 3C-3). This phenomenon is consistent with the cross-sectional SEM images of PMWCNT-70% in Fig. 2F, where the uneven surface and disordered structure of PMWCNT-70% are observed.

TGA curves of PGNS and PMWCNT ternary nanocomposite films are shown in Fig. 4. In Fig. 4A, the initial weight loss up to 150 °C is attributed to the removal of absorbed water or some volatile impurities [4]. PGNS-5% and PGNS-10% present a similar degradation procedure. The weight loss at a temperature around 200 °C, which is close to the boiling point of DMSO, is due to the significant loss of DMSO. The weight loss noticeably at around 320 °C and 420 °C correspond to the thermal degradation of PSS and PEDOT polymeric chains, respectively [5]. By adding PPy/GNS, the onset point of PGNS-30% and PGNS-50% films was delayed, and the thermal stability was enhanced. In PGNS-70% composite films, the weight loss at 600 °C is about 28%, which benefits from the good thermal stability of GNS. In Fig. 4B, PMWCNT ternary
Fig. 3. Digital photos of (A-1, B-1 and C-1) PGNS-5%, PGNS-70% and PMWCNT-70% films filtering on PVDF membrane, (A-2, B-2 and C-2) PGNS-5%, PGNS-70% and PMWCNT-70% films peeling off from Cu plate, and (A-3, B-3 and C-3) toughness test of PGNS-5%, PGNS-70% and PMWCNT-70% films.

Fig. 4. TGA curves of (A) PGNS and (B) PMWCNT ternary nanocomposite films.

nanocomposite films had a similar thermal decomposition curve to PGNS films in the same temperature range. And PGNS-70% show better thermal stability than PMWCNT-70% films. This result indicates that the present of PPy/GNS or PPy/MWCNT fillers in PEDOT: PSS matrix facilitate the thermal stability of PGNS and PMWCNT ternary nanocomposite films. The raw data of TGA data for PGNS and PMWCNT films have been provided in an open access format.

2. Experimental Design, Materials and Methods

2.1. Synthesis of PPy/GNS and PPy/MWCNT

GNS were well-dispersed into 100 ml 50 vol% ethanol solution with ultrasonic agitation for 2 h. Then pyrrole monomer (0.3 mol) was added at 5 °C and stirred for 30 min. The mass ratio
of pyrrole monomer to GNS was 1:0.4. Afterward, 0.6 mol FeCl$_3$·6H$_2$O in 50 mL H$_2$O was slowly dropped into the above solution. After polymerization, the resulting composites were filtered and washed with ethanol and deionized water in sequence for several times. The final products were dried under vacuum at 60 °C overnight and named as PPy/GNS. PPy/MWCNT were prepared under the same procedure.

2.2. Synthesis of PGNS and PMWCNT films

Designed amount of PPy/GNS and PPy/MWCNT composite were added into 2 mL PEDOT: PSS aqueous solution under vigorous stirring and sonicating. The mixed solution (1 mL) was then filtered on PVDF membrane (0.22 μm), and treated with 100 μL (5vol%) DMSO. The mass ratio of PPy/GNS to PEDOT: PSS was 5%, 10%, 30%, 50%, and 70%, and the composite films were labeled as PGNS-5%, PGNS-10%, PGNS-30%, PGNS-50% and PGNS-70%. For PMWCNT, they are PMWCNT-5%, PMWCNT-10%, PMWCNT-30%, PMWCNT-50% and PMWCNT-70%. The PEDOT: PSS film only treated with DMSO, labeled as D-PEDOT: PSS, was also prepared in the same procedure.

2.3. Methods

The morphologies of the samples were examined by scanning electron microscopy (Nova Nano SEM450, USA). Thermogravimetric analysis (TG209F1, NETZSCH, Germany) was applied to investigate the thermal stability of the PGNS and PMWCNT ternary nanocomposite films under nitrogen flow from 30 °C to 600 °C at a heating rate of 10 °C min$^{-1}$.

CRediT Author Statement

Yihan Wang: Writing-Original draft preparation, Methodology, Software; Siqi Wu: Data curation; Qinjian Yin: Supervision, Reviewing and Editing; Bo Jiang: Visualization, Investigation; Site Mo: Software, Validation.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.106754.
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