



## Wood plastic composite using graphene nanoplatelets

Shabnam Sheshmani<sup>a</sup>, Alireza Ashori<sup>b,\*</sup>, Marzieh Arab Fashapoyeh<sup>a</sup>

<sup>a</sup> Department of Chemistry, Shahr-e-Rey Branch, Islamic Azad University, Tehran, Iran

<sup>b</sup> Department of Chemical Technologies, Iranian Research Organization for Science and Technology (IROST), Tehran, Iran

### ARTICLE INFO

#### Article history:

Received 12 February 2013

Received in revised form 18 March 2013

Accepted 19 March 2013

Available online 26 March 2013

#### Keywords:

Graphene  
Mechanical properties  
Wood plastic composite  
Nanoplatelets  
Coupling agent

### ABSTRACT

This article presents the preparation and characterization of wood flour/polypropylene (PP) composites filled with graphene nanoplatelets (GNPs). The effects of GNPs, as reinforcing agent, on the mechanical and physical properties were also investigated. In order to increase the interphase adhesion, maleic anhydride grafted polypropylene (MAPP) was added as a coupling agent to all the composites studied. The morphology of the specimens was characterized using scanning electron microscopy (SEM) technique. The results of strength measurements indicated that when 0.8 wt.% GNPs were added, tensile and flexural properties reached their maximum values. At high levels of GNPs loading (3–5 wt.%), increased population of GNPs leads to agglomeration and stress transfer gets blocked. The addition of GNPs filler moderately increased the impact strength of composites. Addition of GNPs decreased the average water uptake and thickness swelling by 35% and 30%, respectively, compared to the control sample (without GNPs). It was observed that the composites filled with GNPs decomposed at higher temperatures compared to the pure PP and control. In all cases, the degradation temperatures shifted to higher values after the addition of GNPs. The improvement of physical and mechanical properties of composites confirmed that GNPs have good reinforcement and the optimum effect of GNPs was achieved at 0.8 wt.%.

© 2013 Elsevier B.V. All rights reserved.

### 1. Introduction

Now-a-days, the use of wood polymer composites (WPCs) has tremendously increased due to their various advantages. They are used in different outdoor and indoor applications such as decking, railing, fencing, docks, landscaping timbers, and in a number of automobile industries [1]. The lignocellulosic fibers offer a combination of attractive properties such as low density, renewability, biodegradability, wide availability, and low cost, which make them alternatives to traditional synthetic fibers in many applications. However, WPCs exhibit lower physical (higher water absorption and thickness swelling), mechanical (less flexural and tensile strength) as well as thermal properties compared with traditional synthetic composites [2]. There are two major approaches to enhance physical and mechanical properties of WPCs through the use of fillers: by treating them with coupling agents, and by changing their particle size [1]. Chemical coupling agents are substances, typically polymers, which are used in small quantities to treat a surface so that bonding occurs between the treated surface and other surfaces, e.g. wood and thermoplastics [3]. The incorporation of nanoparticles as reinforcing fillers is another method for improving the overall properties of WPCs. The nanoparticles are

certainly one of the most promising reinforcements that are being studied by many scientists all over the world. This is mainly due to their high surface area, low density and high Young's modulus, among other properties that can be transferred to the polymeric matrix if a good dispersion of the filler is ensured in the polymer [4]. A nano-scale filler offers larger effective surface area than a micro-scale filler. As a result, there is more interphase region in a nanocomposite than in a microcomposite. Therefore, the properties of the polymer in the inter-phase region dominate the overall properties of the bulk nanocomposite. In other words, nanofillers can alter the properties of a large volume fraction of the polymer resulting in a significant change in properties at low loading [5].

Carbon is a unique and very versatile element which is capable of forming different architectures at the nano-scale. In this era of nanocomposites research, new members of the carbon nano-scale family have arisen, and more are going to come [6]. Until recently, carbon nanotubes (CNTs) were dominant nanosized carbon fillers for polymer composites [4,7]. However, effective utilization of CNT is hindered by the complexity of their dispersion in polymer matrix and high cost. One of the alternatives is graphene, the material which has become one of the hottest topics in physics and materials science [8–12]. As a matter of fact, from a geometric perspective (Fig. 1), carbon nanostructures like CNTs can be obtained by the coiling up of the covalent graphene building units resulting in a three dimensional structure [13].

\* Corresponding author. Tel.: +98 228 2276637; fax: +98 228 2276265.  
E-mail address: [ashori@irost.org](mailto:ashori@irost.org) (A. Ashori).

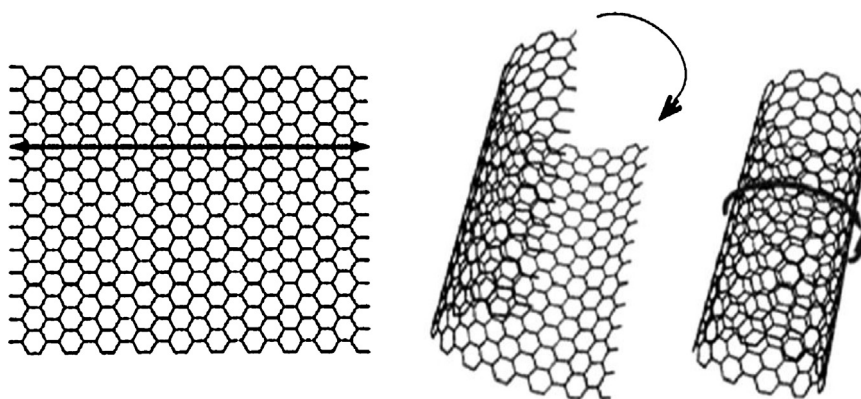


Fig. 1. Rolling up of graphene sheet to form carbon nanotubes.

Graphene has attracted tremendous attention from the experimental and theoretical scientific communities in recent years due to its unique mechanical and physical properties [14–17]. It is two-dimensional allotrope of carbon, formed by single layer of carbon atoms, bonded by  $sp^2$  orbitals into hexagonal two-dimensional crystal lattice. Besides these ideal structures, controlled reduction of graphite oxide yields reduced graphene oxide sheets, which contain a few layers of graphene. The structures with several layers of carbon atoms are also named graphene nanoplatelets (GNP). They are much easier to produce, compared with CNTs and controlled reduction allows preparing nanoplatelets with different oxidation levels and different electronic properties [18]. Graphene, with its unique physical properties is a multifunctional nanofiller that can improve electrical, thermal, mechanical, or gas barrier properties of composites at extremely small loadings. The superior properties of graphene compared to polymers are also reflected in polymer/graphene nanocomposites. Polymer/graphene nanocomposites show superior mechanical, thermal, gas barrier, electrical, and flame retardant properties compared to the neat polymer [19,20]. It was also reported that the improvements in mechanical and electrical properties of graphene based polymer nanocomposites are much better in comparison to that of clay or other carbon filler-based polymer nanocomposites [12,21,22]. Liang et al. [23] demonstrated a solution-processed poly(vinyl alcohol) (PVA)–graphene oxide (GO) nanocomposites and a 76% increase in tensile strength and 62% improvement of Young's modulus were achieved at only 0.7 wt.% of GO. Rafiee et al. [24] compared reinforcement efficiency of graphene with single- or multi-walled carbon nanotube (CNT) and the superiority of graphene platelets over CNT was fully exemplified at a nanofiller weight fraction of 0.1–0.002%.

As mentioned earlier, previous studies have examined the application of GNPs in polymers. However, no published reports are available in the open-access literatures which evaluate the use of GNPs in WPCs. The main objective of this work was to study the effects of GNP as a reinforcing agent on the physico-mechanical properties of WPCs.

**Table 1**  
Physical and mechanical properties of used PP and MAPP.

Typical properties	Test method (ASTM)	Unit	Value	
			PP	MAPP
MFI @ 230 °C	D1238	g/10 min	18	10
Density	D1505	g/cm <sup>3</sup>	0.92	0.90
Vicat softening point, 10 N	D1525	°C	154	147
Flexural modulus	D790	MPa	1550	880
Tensile strength	D638	MPa	33	22
Elongation at yield	D638	%	12	12

## 2. Materials and methods

### 2.1. Materials

Poplar (*Populus deltoides*) flour (PF) was collected from a local sawmill in Karaj, Iran. The PF was initially washed with 1% NaOH solution, followed by washing with cold water. The treated PF was milled down to particle size of 60 mesh and then dried at  $105 \pm 5$  °C till the attainment of constant weight. The sieved wood flour was kept in a container for subsequent use.

Polypropylene (PP), with trade name V30S, obtained from Arak Petrochemical Co. (Iran), was used as the polymer matrix. The coupling agent used in the preparation of composites was Maleic anhydride grafted polypropylene (MAPP), which was supplied by Arkema (France). Both PP and MAPP were in the form of pellets. Table 1 shows the typical properties of PP and MAPP.

The GNP powder (grade AO-4) was obtained from the Graphene Supermarket Co., USA. The specific surface area was  $<15$  m<sup>2</sup>/g, and the purity was 99.2%. The average thickness and lateral size of GNPs were about 12 nm and 4.5 μm, respectively. Electronic microphotographs of GNPs (Fig. 2) were taken with scanning electronic microscope (MIRAI TESCAN).

### 2.2. Compounding of materials

Table 2 shows the blend design for compounding of materials. Totally 9 sets of blends and composite samples were fabricated. Compounding of PF, PP, MAPP, and GNPs was performed in a Brabender compounder (CW Brabender Instrument Inc.) with an internal mixer. The mixing was carried out at 185 °C with a rotation speed of 40 rpm and a blending time of 5 min. For each batch, the total starting mass of materials was 45 g. The fiber volume fraction was kept constant at 20 wt.% for all the composites. Following compounding, all the blends were cooled to room temperature and ground into 10-mesh powder with a Thomas-Wiley mill.

Download English Version:

<https://daneshyari.com/en/article/8333423>

Download Persian Version:

<https://daneshyari.com/article/8333423>

[Daneshyari.com](https://daneshyari.com)