# Graphene nanoplatelets (gnps)

Graphene is known as a two-dimensional material, which obtains sp2-hybridized carbon atoms bonded in a honeycomb structure. While a graphene sheet is referred to material performed by a plane of unique hexagonal atoms, graphene nanoplatelets, one of the graphene-based materials, is defined as particles with a nanoscale thickness between 3 and 100 nm with varied sizes up to 50 µm and have a bulk density between 0. 03 to 0. 1 g/cm3. The oxygen content in GNPs is less than 1%, carbon content shows more than 99. 5 wt% and a residual acid content presents less than 0. 5 wt%[28, 29]. It is possible to add the desired species such as covalent or hydrogen bonding capability over functionalization at the sites on the edges of the GNPs during the exfoliation process as shown in Fig. 2.

Graphene nanoplatelets or GNPs are new type of particles made from graphite. This type of nanoparticles consists of small stacks of platelet-shaped graphene sheets which are similar to those found in the carbon nanotubes' walls but laid in a planar form. GNPs normally are offered as black granules and have thickness around 5 to 10 nm with varied sizes up to 50 µm and have a bulk density between 0. 03 to 0. 1 g/cm3. Their oxygen content is less than 1%, carbon content shows more than 99. 5 wt% and a residual acid content presents less than 0. 5 wt% [28]. It is possible to add the desired species such as covalent or hydrogen bonding capability over functionalization at the sites on the edges of the GNPs during the exfoliation process as shown in Fig. 2.

Figure 2 Graphene Nanoplatelets/ Functionalization at sites on the edges [28]

Graphene nanoplatelets (GNPs) have unique nanoscale size, shape and composition of materials. Thus, it is expected that GNPs can be applied as reinforcing filler to improve on the important properties such as mechanical and thermal properties, the thermal and electrical conductivity of a broad range of polymeric materials, along with thermoset and thermoplastic composites, natural or synthesis rubber, thermoplastic elastomers. The specific properties of GNPs in both parallel and perpendicular to a surface are demonstrated in Table 1 and it is clear to understand that the properties of fillers in the longitudinal direction to the surface are much better than in the perpendicular direction to the surface [10, 28]. Another benefit of GNPs as the 2D nanoplatelet is the rise of the gas permeation resistance of the polymeric CMs[30].

Table 1 Graphene Nanoplatelets Properties [10, 28, 31]

Parallel to surface Perpendicular to surface

Density 2. 2 g/cm3 2. 2 g/cm3

Thermal Conductivity 3, 000 watts/m-K 6 watts/m-K

Thermal Expansion 4-6 x10-6 m/m/dg-K 0. 5-1×106 m/m/dg-K

Tensile Modulus 1, 000 GPa N/A

Tensile Strength 5 GPa N/A

Electrical Conductivity 107 S/m 102 S/m

Studies have shown that a small number of GNP added into polymers can enhance the overall physical and mechanical properties without decreasing the valuable attributes of the polymers[32]. For instance, Ahmadi-Moghadam et al. and Shen et al. [33, 34] found that adding GNPs to polymeric materials or resin could increase the thermal conductivity and stability, electrical conductivity, improve barrier properties such as reducing gas permeability, while simultaneously improve mechanical properties such as stiffness, strength and toughness (impact strength) of the materials. Moreover, GNPs can improve appearance, including scratch and mar resistance and expand flame retardance of matrix materials.

Shen et al. [28] stated that GNPs are highly conductive and can produce an effective conducting network at low loading levels in most polymers. Adding 2-3 wt% of GNPs in thermosetting resins or 5-7 wt% of GNPs in thermoplastic materials can reach Electrostatic discharge (ESD) and Electromagnetic interference/ radio-frequency interference (EMI/RFI) shielding capabilities as shown in Fig. 3. Moreover, unlike other conductive materials GNPs do not have negatively affects the mechanical and aesthetic properties of the base matrix materials, nor are GNPs abrasive to tooling as metal flakes and fibres can make.

Figure 3 Electrical Resistivity in a control epoxy composite [28]

According to these, GPNs are currently used to replace both conventional and nanoscale additives/fillers such as carbon fibre, carbon black, carbon nanotubes, nano-clays, or other compounds in many composite applications while increasing the range of properties which are being modified.