# Graphene hybrid materials for energy storage and high performance polymer-graphene nanocomposites

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Graphene has recently been the subject of much interest internationally because it has unique electronic and optical properties, and therefore is being considered for applications in electronics, electrochromic devices and transparent conducting electrodes. The thermal conductivity of graphene is very high, and therefore potential as thermal management materials. It is also one of the strongest materials known and is currently being explored for its possibility as a reinforcement in polymeric matrices to make super strong composite materials. However, in order to realize the full potential of this material, there needs to be a cultural change so that routes from the test tube to the industrial plant are considered. In the report, graphene hybrid materials for energy storage and high performance polymer-graphene nanocomposites are introduced.

## 1) Graphene-based hybrid materials for energy storage

Recently, energy storage becomes a significant research domain in both civil and martial applications. Environmental friendly, portable, cheap, safe and high efficient storage is more preponderant than conventional ones. Graphene has emerged as an alternative energy storage material with superior properties, such as low weight, chemically, inert and low price. The surface area of graphene is about 2630 $m^2/g$, which is hugely favourable for energy storage applications. A graphene hybrid material has been developed as energy storage materials. It was found that the square resistance reduced to $10^{-4}$ $Vsq^{-1}$ when the percentage of graphene reached ca. 40 wt % in a graphene hybrid thin film [1]. The maximal specific capacitance was observed to be 114 F/g in a graphene/carbon nanotube (CNT) hybrid film. Figures 1 shows the specific capacitance of the hybrid graphene/CNT hybrid film. A theory [2] has been developed on geometrically enhanced extraordinary magnetoresistance in hybrids. According to the theory, it was noted such nanostructured graphene/CNT thin film [1] could be suitable for development of new structural materials with extraordinary magneto-resistance. The hybrid film as magnetic sensors is being developed. Current statue: Fabrication of graphene hybrid devices

## 2) High performance polymer-graphene nanocomposites

High potential of functionalized graphene (FG) for reinforcing polymers has been recognized. The incorporation of graphene can toughen polymers such as nylon [3] and epoxy (Figure 2), reduce the permeation of water and gas (Figures 3 and 4) and increase the surface scratch resistance [4] significantly. In order to realize the development of high performance graphene-polymer nanocomposites, the dispersion of graphene in polymer matrices is extremely important. With good dispersion, some excellent properties of graphene can be transferred to the matrix. Figure 5 shows the dispersion of graphene in nylon 12 with melt-processing without addition of any chemical and surfactant.

**References**

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[2] F.V.Kusmartsev, M.B.Sobnack and Geim A. K., CMT, 16, 325 (2001)
[3] R Rafig, D Cai, J Jin and M Song, Carbon, 48, 4309 (2010)
[4] D Cai, C Yusof and M Song, Nanotechnology, 20, 085712 (2009)

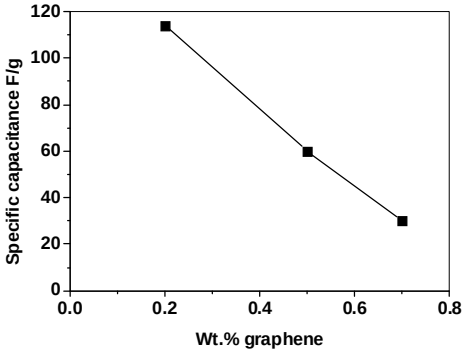


Figure 1: Capacitance with wt% graphene

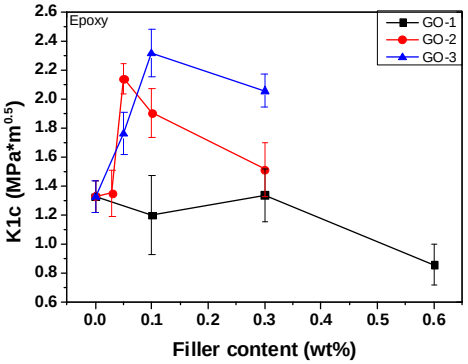


Figure 2: K1c with wt% FG

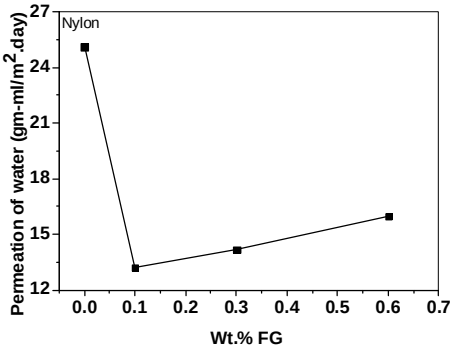


Figure 3: Permeation of water with wt% FG

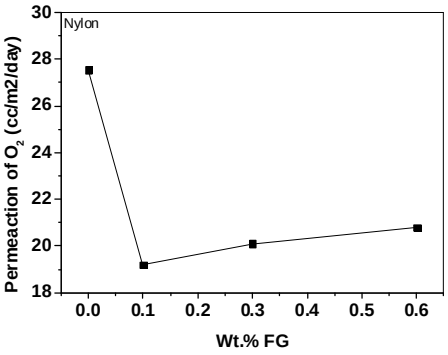


Figure 4: Permeation of oxygen with wt% FG

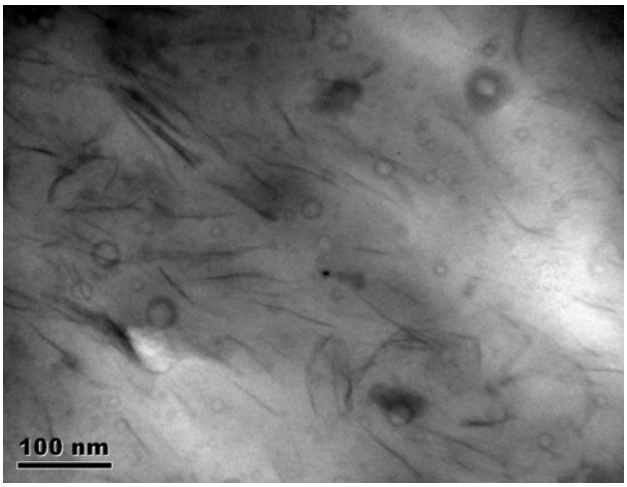


Figure 5: SEM images of graphene dispersed in a nylon 12 matrix