Fabrication and Applications of Graphene in Loughborough University

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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 order to achieve this challenge, an integrated research approach following graphene from its production to processing and applications has being carried out in Loughborough University. The being carried out research includes the following parts.

1) Fabrication of graphene and functionalized graphene

Graphene and functionalized graphene were fabricated from graphite based on top down routes for applications as energy storage, surface coatings, thermal management and composites. For realization of these applications, massive mass graphene and functionalized graphene are needed. Although lots of researches on graphene based electrodes have been done, up to now there are not viable methods to produce graphene based material for electrode with controlled quality in large scale and in massive quantity. New production methods for production of graphene in massive quantity must be developed. With the aid of dispersion agents and ultrasonication, a new physical method for fabrication of graphene and a new chemical method for production of functionalized graphene from graphite have been developed in our laboratory. Figures 1 and 2 show the TEM images of graphene and functionalized graphene produced based on the two methods, respectively.

2) 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 3 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 develop.

3) Graphene/polymer composites for aerospace, automotive, construction and packing applications

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 4), reduce the permeation of water and gas (Figures 5 and 6) and increase the surface scratch resistance [4] significantly.

In the communication, about research progress will be introduced in details

References

[1] D Cai, M Song and C Xu. Advanced Materials, 20, 1706 (2008)
[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)

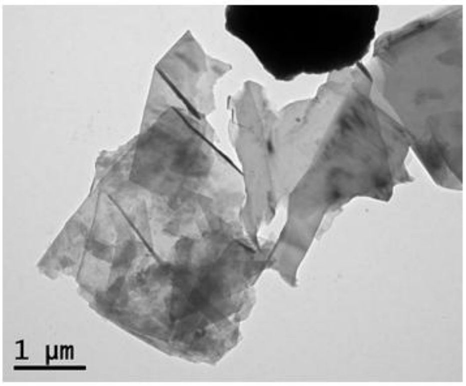

Figure 1:TEM images of graphene made by the physical method

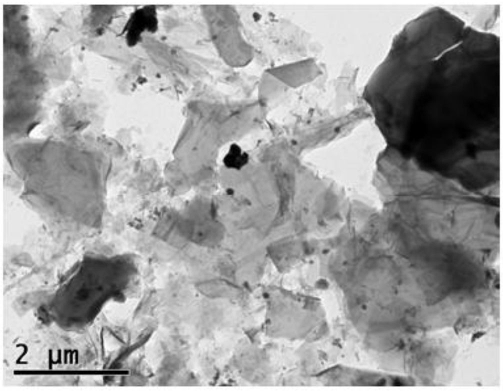

Figure 2: by the chemical method

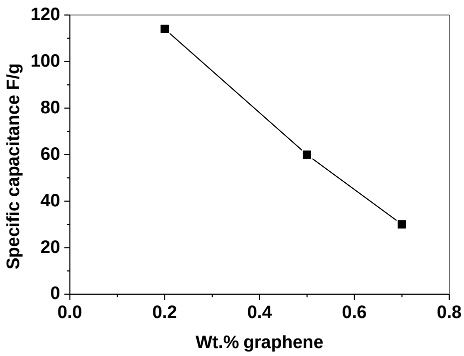

Figure 3: Capacitance with wt% graphene

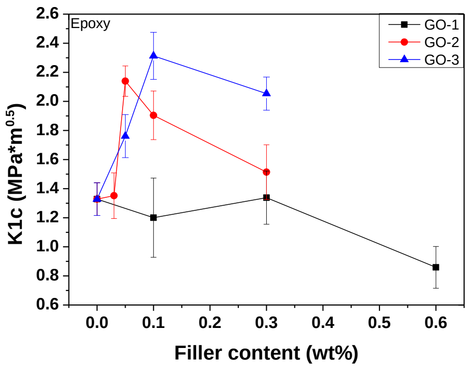

Figure 4: K1c with wt% FG

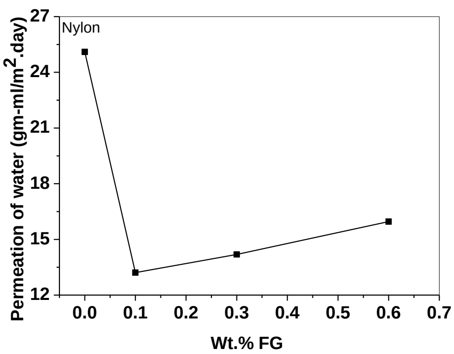

Figure 5: Permeation of water with wt% FG

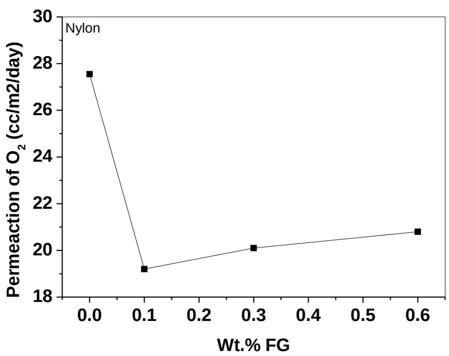

Figure 6: Permeation of oxygen with wt% FG