Water-Soluble Graphene through Polyglycerol Grafting

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For applications of nanocarbons in biology and medicine, such as imaging probe and drug carrier, they have to be well solubilized in a physiological environment. In this context, surface chemical functionalization has been extensively investigated to impart strong hydrophilicity to nanocarbons. We found recently that polyglycerol (PG) grafting on the surface of nanodiamond (ND) made ND highly soluble in phosphate buffer [1]. The aqueous solution is very stable for months and the solubility of the PG-functionalized ND (PG-ND) is as high as 16 mg/mL in phosphate buffer saline (PBS), which is 400 times larger than that of the PEG-functionalized ND [2].

In this paper, we will present our recent result of PG grafting at the periphery of exfoliated graphene through ring-opening polymerization of glycidol to prepare PG-functionalized graphene (PG-G) soluble in PBS (Scheme 1). We carried out the PG-functionalization of exfoliated graphene under similar reaction conditions to those of the PG-ND [1], but used graphene prepared through wet-process of graphite exfoliation as a starting material.

The strong Tyndall effects were observed in the aqueous solutions as shown in Fig. 1, suggesting that PG-G is solubilized both in the water and PBS. The existence of PG-G in these solutions was confirmed by UV and Raman spectroscopies (Figs. 2 and 3). Aqueous solutions have UV absorption around 270 nm. Since it is well known that graphene exhibits absorption at similar wavelength, we conclude that the solutions contain graphene. The Raman spectra shown in Fig. 3 support the above conclusion; both G and G' bands are detected in the dried samples from water and PBS solutions. From the ratio of G' / G and the symmetrical shape of G' band, a few-layer graphene is considered to be dominant in the PG-G. In addition, the intensity of the D band is very low, indicating that the PG-G does not have number of defects and that the process to prepare PG-G causes little damage to graphene.

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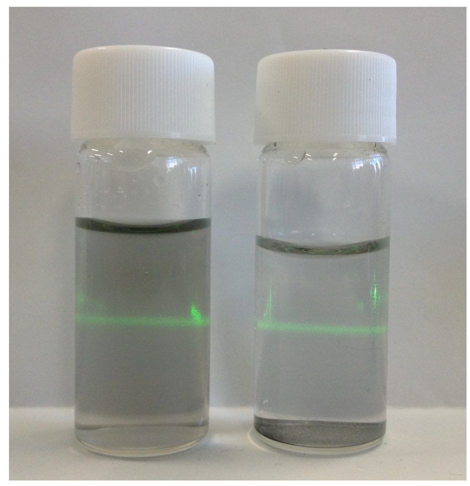
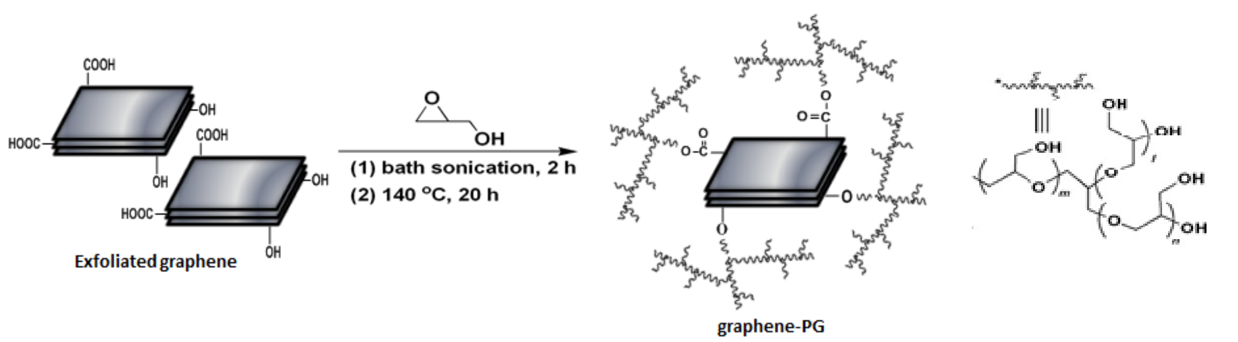


Fig.1 Aqueous solutions of polyglycerol - functionalized graphene in water (left) and PBS (right).



Scheme.1 Synthesis of graphene functionalized with hyperbranched polyglycerol through the ring - opening polymerization of glycidol.

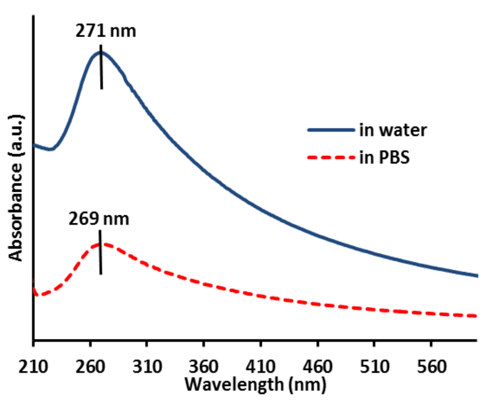


Fig.2 UV spectra of polyglycerol - functionalized graphene

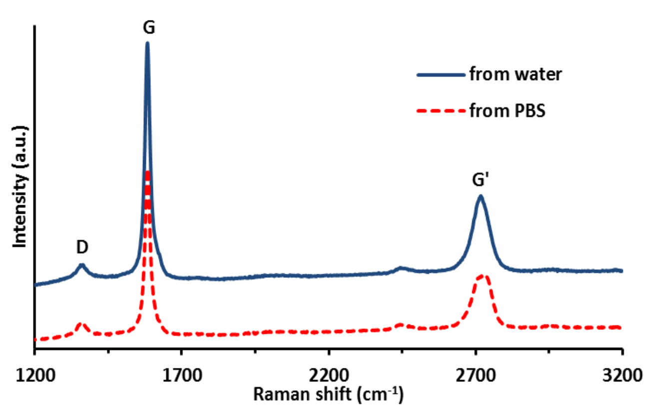


Fig.3 Raman spectra of polyglycerol - functionalized graphene