Intellectual Property and Enterprise

Improved synthesis of graphene oxide and its application to nanocomposites

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We have developed a method for the rapid preparation of graphene oxide (GO)—a strategically important material for future technology (Fig.1).

The most common method for synthesizing GO is the Hummers' method (oxidation with $KMnO_4$ and $NaNO_3$ in concentrated H_2SO_4), which requires a long reaction time and large amounts of reagents. In our research found that the microwave irradiation of natural graphite flakes before the oxidation step improved the efficiency of the oxidation process. This facile method provides a greater amount of GO compared with the original Hummers' method. We expect our rapid synthesis method based on microwave irradiation to make a major contribution to the large-scale production of GO.

Patent information: Japanese patent No.5098064

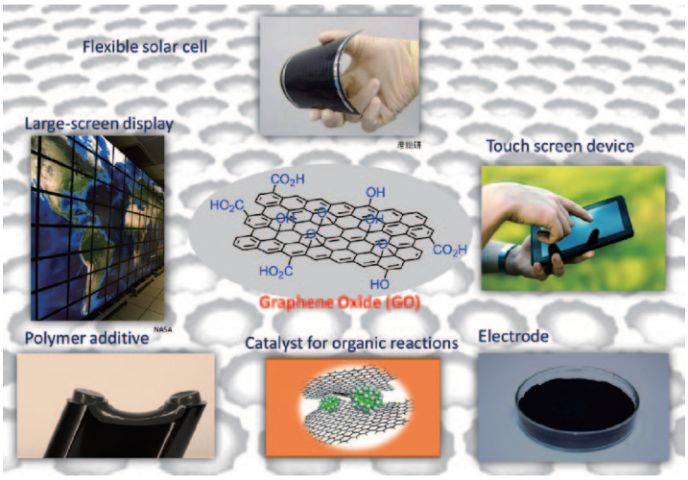

Fig. 1. Promising applications of graphene oxide

Graphene is a promising support material for Pt nanoparticles, which triggered much interest in metal/graphene composites. In some cases, however, graphene-supported metal species are not preferred, because the interaction between the metal particles and graphene is quite weak due to the graphene itself is being relatively chemically inert due to the strong sp^2 and π binding between carbon atoms in the graphene plane. Consequently, the metal nanoparticles are mobile on graphene, which leads to limited applications of metal/graphene composites. It has been proposed that defects or mechanical strain in graphene can significantly increase the chemical reactivity of graphene itself and also enhance the interaction between metal nanoparticles.

Therefore, GO offers significant advantages for the synthesis of composites with inorganic materials and organic polymers due to its large amounts of oxygen functionality. As an application of our GO, metal nanoparticles were supported on its surface. We succeeded to synthesize Pt, Pd, Rh, Ir, Cu, etc. nanoparticles on GO via solution processes (Fig. 2). Controlling the degree of oxidation of GO and the oxidation state of metal species will offer a wide range of applications of metal/GO composites such as electrodes, fuel cell catalysts, and catalysts for chemical synthesis. We showed that the Pd/GO composite exhibited superior catalytic activity in selective hydrogenation and cross coupling reactions (Fig.3).

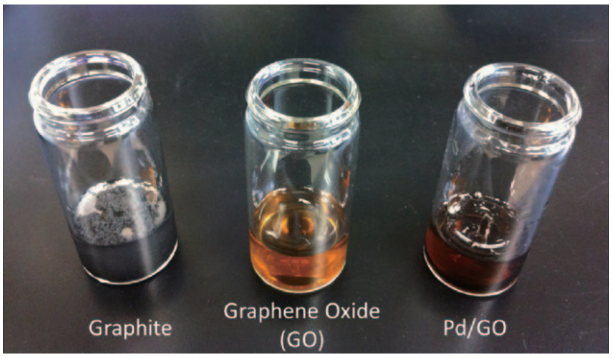

Fig. 2. Pictures of insoluble graphite (left), aqueous solution of GO (middle), and aqueous solution of Pd/GO composite.

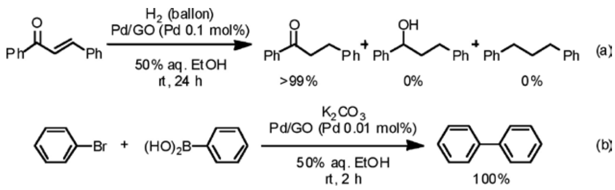

Fig. 3. Pd/GO-catalyzed (a) selective hydrogenation of a multi-functionalized organic compound and (b) Suzuki-Miyaura cross coupling reaction.

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http://www.tt.vbl.okayama-u.ac.jp/en/