Metal Nanoparticles for Energy Conversion

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Much attention has been paid to metal nanoparticle (NPs) as one of important building block for nanotechnology. They are applied to various fields [1] such as catalysis [2], sensing, electronics, magnetism, and medicals. On the other hand, health and energy are two biggest issues for human beings recently. Here the applications of metal nanoparticles to energy conversion are discussed by focusing on electrocatalysts for polymer electrolyte fuel cells [3-5] and additives of organic-inorganic hybrids materials for thermoelectric energy conversion [6-10]. Although energy conversion of chemical energy to electrical energy is usually carried out at power station, the efficiency is less than 50%. Fuel cells are theoretically expected to reveal the higher efficiency than the power station because of the direct energy conversion from chemicals to electricity. However, one of the biggest issues for fuel cells is that fuel cells require a lot amount of platinum as the electrocatalyst. Usually Pt supported on carbon is used as the catalysts for polyelectrolyte fuel cells. In order to minimize the consumption of Pt, we directly used Nafion® as the protective polymer for Pt-containing NPs without carbon supports. The Pt NPs with nano-networks were prepared by the reduction of Pt(IV) ions by NaBH₄ in the presence of Nafion® [3]. The Au/Pt and Pd/Pt bimetallic NPs with a core/shell structure were constructed by the successive reduction, and the structures with a Au or Pd core and a Pt shell were confirmed by TEM with EDS [4,5].

Another example of energy conversion is concerned with thermoelectric materials, which can convert thermal energy (temperature difference) to electricity. Usually, inorganic semiconductors are used as the thermoelectric materials. Practically used thermoelectric materials is bismuth(III) telluride Bi₂Te₃, which is often applied to Peltier cooling as silent coolers and temperature controller at low temperature. We have applied the conducting polymer to organic thermoelectric materials, which is flexible and can be produced at low cost [6-9]. However, the organic thermoelectric materials have the problem that their thermoelectric performance is less than that of inorganic materials. In order to improve the thermoelectric performance of organic thermoelectric materials, we introduced inorganic NPs, especially metal NPs to the organic conducting polymers to produce organic-inorganic hybrid thermoelectric materials. Hybrids of polyaniline or poly(3,4-ethylenedioxythiophene) with metal NPs were prepared and applied to the thermoelectrics. Hybridization can improve the thermoelectric performance about twice of those of the pristine conducting polymers [10]. This technique may be applicable to a variety of small power sources in our lives.

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References