

Synthesis of Gold / Poly (methyl methacrylate) Hybrid Nanocomposites

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Fabrication of metallic nanoparticles has become an extreme interest topic in the field of material science, due to the wide range of optical and electronic properties that are accessible in the nanometer-size regime. The unique properties of nanoparticles come from quantum-confinement or surface effects, which become operative.¹ Under certain conditions, nanoparticles of metals could be induced to undergo self-organization into three-dimensional superlattices.² Such nanoparticle assemblies open the door to "tunable" materials, in which optical and electronic properties are dependent on both initial cluster sizes and the manner in which clusters organize to form larger structures.

Recently, polymer protected nanoparticles have been successfully synthesized.³ Polymer protected, nano-sized metals are receiving increased attention because they provide high potential for many technological applications such as the controlled drug release, catalysis, and electron or energy storage.⁴ Polymer-protected metal colloids are usually prepared from suitable metal precursors by presents of protective polymers. By the choice reaction conditions and concentrations of protective polymer, it is possible to control the growth of nanoparticles with different size distribution.⁵

When the reduction of 0.83 mM HAuCl₄ / 35 mM PMMA mixed solution is carried out in the presence of 0.5 mM NaBH₄ reduction reagent, the color of solution is changed from yellow to brownish red. The TEM image shown in Figure 1(a) reveals dark particles dispersion around the gray background of the ball shaped polymer matrix. Dark particles dispersed in the aggregates are believed to be gold nanoparticles in the cores of assembled PMMA polymers. This is supported by energy dispersion spectroscopy (EDS).

After washing with ethanol to remove most of the free PMMA polymer, gold nanoparticles were isolated from alcohol solutions by centrifugation. To verify the PMMA assembly around the outer surface of gold nanoparticles, Figure 1(b) compares Fourier transfer infrared (FT-IR) spectra of gold nanoparticles and free PMMA isolated. The vibration band of carbonyl (nC=O) at 1780 cm⁻¹ is characteristic of PMMA branches. With comparison of gold-coated PMMA spectrum to the free PMMA spectrum, Figure 1(b) clearly demonstrates that there presents an appreciable quantity of PMMA around gold nanoparticles.

Figure 2(a)-(b) shows the glass transition temperature (T_g) of nanocomposites that determined by differential scanning calorimetry (DSC) is decreased dramatically about 25% (at about 90°C) as compared with bulk PMMA polymer (at about 120°C). The result demonstrates that nanocomposites system has a particular opportunity to advance our understanding of engineering polymers at lower treatment temperature. After 90°C of thermal treatment (approximate the T_g of nanocomposites), the morphology of nanocomposites shown in Figure 2(c) can be driven into Figure 2(d). The figure demonstrates that the gold nanoparticles can be linked by PMMA polymer in the form of nano-network structure. Herein, Figure 2(d) demonstrates all of the gold nanoparticles are fully surrounded by PMMA polymer as the thermal treatment temperature rise up to 90°C.

The formation of inorganic nanoparticles-polymer matrices hybrid materials with unique morphologies yields composite materials with various properties.⁴ Therefore, how to fabricate novel geometric structures is current interest and under investigation. This novel synthesis of organic-inorganic hybrid nanocomposites might be able to apply to other nanoparticulate objects.

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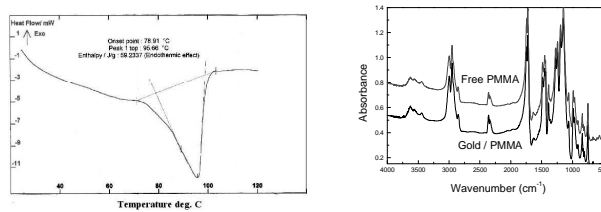
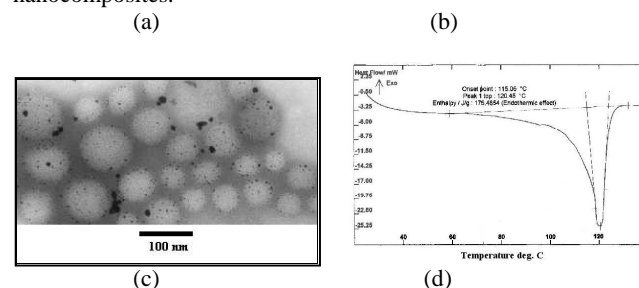


Figure 1. (a) TEM image; (b) FT-IR spectra of gold / PMMA nanocomposites.

Figure 2. (a) T_g of gold/PMMA nanocomposites; (b) T_g of bulk PMMA; (c) TEM morphology of nanocomposites at room temperature; (d) TEM morphology of nanocomposites at 90°C heating treatment.**References**

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