Flow Synthesis of Plasmonic Nanoshells using a Microreactor

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Silica@gold core-shell nanoparticles consist of silica cores and gold nanoshells. Because of their plasmon resonance absorbance of near-infrared rays, they can find applications in a wide range of fields such as medical imaging and photothermal therapy. The absorption peak depends on the ratio of shell thickness to core size. Controlling the structure of silica@gold core-shell nanoparticles is of crucial importance. A widely-used preparation method of Au nanoshells is the seed-mediated growth, which is composed of three steps as follows: the surface modification of silica cores to increase affinity with Au, producing the formation of core-shell clusters (CSCs), in which silica cores are decorated with Au nanoparticle seeds, and the shell growth by reducing Au ions on the Au seeds.[1] This method allows high coverage of gold seeds and good control in the shell thickness, although it is typically operated in a batch type process which takes about 1 week to complete the procedure. Hence, it is required to establish a facile and versatile method.

Here we developed a flow process using a microreactor to synthesize CSCs and silica@Au core-shell nanoparticles. The microreactor we applied is central collision type, which realizes quick and homogeneous mixing by intensively bombarding two inlet fluids.[2] In the process to synthesize CSCs, we mixed a surface-modified silica suspension containing Au ions with a strong reducing agent, $NaBH_4$, in the microreactor to in-situ reduce Au ions on core silica surfaces. Fig.1a shows a typical TEM image of resultant particles, in which core silica particles are uniformly decorated with monodispersed Au particles. Because a batch synthesis with the same procedure resulted in nonuniform decoration of polydispersed Au particles and also produced unattached Au nanoprticles, high mixing performance provided by the microreactor enabled one-step synthesis of CSCs. The microreactor is effective to produce Au nanoshells as well. We successfully synthesized uniform Au nanoshells by mixing CSCs containing Au ions with a mild reducing agent, ascorbic acid, as shown in Fig.1b. By taking advantages of the microreactor, we established the flow process to synthesize CSCs and silica@Au core-shell nanoparticles, which dramatically shorten the synthetic period compared to batch processes.[3]

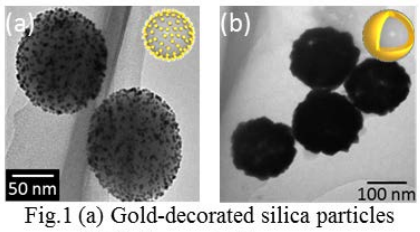

Fig.1 (a) Gold-decorated silica particles (b) Gold nanoshells

As an application of this process, we examined silica@Pt core-shell nanoparticles. Because the wide use of Pt as a catalyst is prevented because of its preciousness, producing Pt nanoshells can reduce the cost and promote the utility. We applied the above-mentioned procedure and synthesized silica@Pt core-shell nanoparticles with the shell thickness of 15 ~ 20 nm.

References

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