Self-Organization of Colloidal Particles in Confining Aqueous Droplets for Photonic Balls

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Self-assembly, which is a governing principle how materials form in nature, has attracted great attention in materials chemistry and soft condensed-matter physics. Fundamental building blocks (for instance, atoms, molecules, macromolecules, and colloidal particles) are organized spontaneously into bulk thermodynamic phases. However, most of self-assembled structures have always contained undesired defects and the overall orientation of their arrangement or packing structure is hard to control.

Recently, we developed the emulsion-based route to creating spherical shaped colloidal crystals or polyhedra. In this case, emulsion droplets provided the geometrical confinement for the self-assembly of colloidal particles. Specifically, colloidal particles in confining droplets are self-organized into colloidal clusters as the droplets are shrunk by slow evaporation of the liquid in droplets. When the number of colloidal particles in a droplet is large, they form a spherical colloidal crystal[1-3] (or photonic ball) which exhibits an optical stop band for the normal incident light independently of the position all over the spherical surface.

In this study, we made emulsion with micropipette apparatus for narrow size distribution. After generation of emulsion, they treated by increased temperature and consolidated to spherical aggregations. Figure 1 showed schematic diagram of emulsion consolidation process. Fabricated spherical colloidal crystals have several layered structure from surface to core and this layered structure make a constructive bragg's reflection for specific wavelength. Therefore their photonic characteristics response on several physical properties such as particle size, refractive index mismatch and angle of incident beam. To make better photonic properties, inverse structure is fabricated by colloidal crystal templating method.

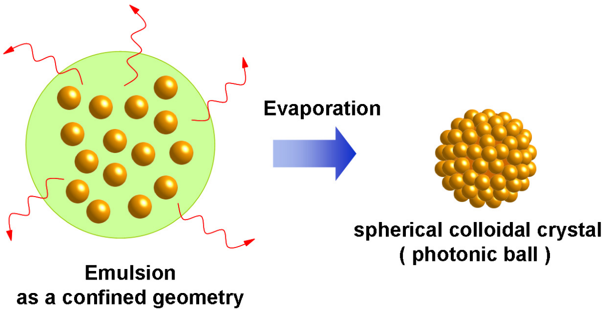

Figure 1 Schematic diagram of emulsion consolidation process

The fabricated photonic ball is shown in Figure 2. As you can see the SEM image, photonic balls have a quite smooth surface that is composed of hexagonal packed lattice. Unlike usual colloidal crystal, photonic ball has isotropic optical characteristics because of these structural characteristics.[3] Figure (b) is image of photonic ball dispersed in hexadecane and they showed reflective color depending on angle between incident beam(usual flashlight) and view. This color can be easily expected by Bragg's law and the reflectance of photonic balls was responding readily and precisely to any change in physical properties including size of the colloidal particles, refractive index mismatch.

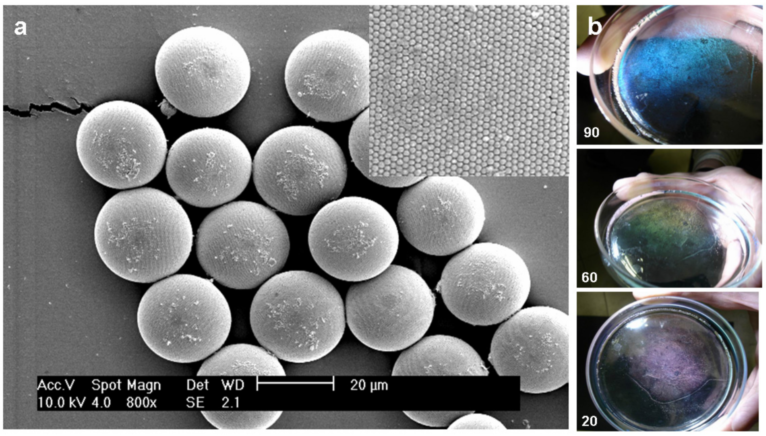

Figure 2 (a) SEM image of spherical colloidal crystals and (b) their reflective color depending on the angle between incident beam and view.

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