Single anomalously large spherical assembly of polymer microparticles formed by optical trapping at solution surface

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We are studying the "optically evolved assembly formation" in laser trapping for nanoparticles (NPs) and microparticles (MPs) at solution surface, in which optical potential can expand out to a few tens of micrometer from the focus by the light scattering and propagation of the trapping laser [1-2]. For polystyrene (PS) MPs, various large 2-dimensional (2-D) assembly structures are formed at solution interfaces, including hexagonal and necklace-like arrangements [3-4]. With 20 μm PS MPs, they form a sub-millimeter order huge 2-D assembly [4]. In this work, we use together two kinds of PS MPs with different size of 1 μm and 20 μm as trapping targets, and report that an enormous 3-dimensional (3-D) light scattering sphere is prepared at the solution surface by long time laser irradiation.

We irradiated 1064 nm continuous-wave (CW) laser on a 20 μm PS MP, which was trapped at the solution surface of D_2O. The laser light was propagating with whispering gallery modes (WGMs) at the 20 μm surface. The evanescent wave due to WGMs at 20 μm MP's surface trapped many 1 μm PS MPs and the 1 μm PS MPs formed the necklace structure (Fig. 1B). With an increase of irradiation time, 1 μm PS MPs further formed outer packing structure. At 25-30 min after turning on the laser, the assembly grew more than 40 μm of size, and formed an enormous 3-D ball shaped assembly at the solution surface (Fig. 1C). By capturing back scattering light image of the assembly, we clearly observed light scattering surrounding the "big-ball" assembly (Fig. 1D). The surrounding 1 μm PS MP located at the outer packing structure started to disperse after trapping laser was switched off. Thus, we consider this spherical assembly formation is induced by optical force generated by the trapping laser irradiation. The evanescent wave of WGMs captures 1 μm PS MPs at the surface of a 20 μm PS MP, and the trapped 1 μm PS MPs scatter the laser and further gather the small PS MPs. As the laser intensity is high enough, scattering and gathering processes can be repeated growing the scattering ball. In this study, we have successfully extend our optically evolved assembly formation from 2-D to 3-D and will discuss dynamics and mechanism of this new optical trapping phenomenon.

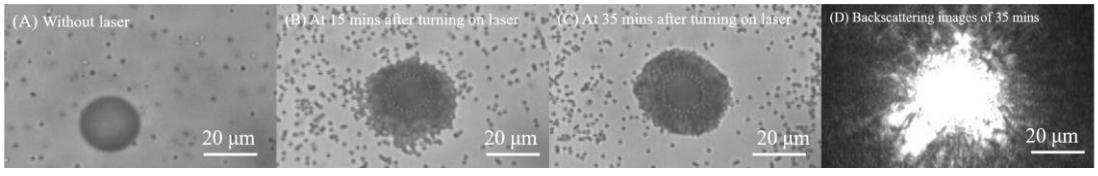

Fig. 1 (A-C) A series of transmission images showing a spherical assembly formation of large and small MPs are 20 μm and 1 μm PS MPs. Laser power is 1 W. (D) A back scattering image of the spherical assembly showing the scattering of the 1064 nm trapping laser.

[1] S.-F. Wang *et al.*, *Langmuir*, **2016**, *32*, 12488. [2] T. Kudo *et al.*, *Nano Lett.* **2016**, *16*, 3058. [3] J.-S. Lu *et al.*, *J. Phys. Chem. C*, **2020**, *124*, 27107. [4] J.-S. Lu *et al.*, *J. Phys. Chem. Lett.*, **2020**, *11,* 6057.