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# Fine-tuning of Fullerene Self-Assembly toward Supramolecular Soft-Materials and Beyond

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Versatile morphology and controlled dimensionality of carbon-rich nano-materials has been recently received considerable attention because bulk properties of such carbon materials, *e.g.* fullerene $C_{60}$, can be enhanced by fine-tuning of the intermolecular interactions based on chemical modifications. Recently we developed supramolecular fullerene nano- and micro-architectures (polymorphism) utilizing the two different intermolecular forces introduced by $C_{60}$ ($\pi$-$\pi$) and alkyl chins (van der Waals).[1] By varying solvent system, a fullerene derivative bearing three hexadecyloxy chains, self-organized into vesicles, fibers, disks, cones,[1] and flowers[2] (Fig. a) based on interdigitated bilayers as a fundamental subunit. The finding suggests possible synthetic methodologies towards novel dimension-controllable supramolecular materials.

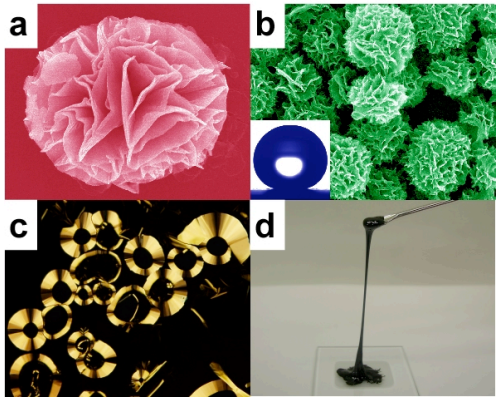


**Fig.** Images of hierarchically organized supramolecular fullerenes. SEM images of (a) a flower-shaped assembly, (b) micro-sized particles and the superhydrophobicity. (c) POM image of a mesomorphic fullerene and (d) photograph of a room temperature liquid fullerene.

Similar fullerene derivatives to be assembled into micro-sized particles with wrinkled flake-like outer surface morphology has been recently developed.[3,4] The particles have a fractal surface reminiscent of Lotus leaves and features significantly improve water-repellent superhydrophobicity (Fig. b). Importantly the fractal morphology can be transcribed to nano-flaked "metal" structures, which show an excellent surface enhanced Raman scattering (SERS) effect of a $10^5$ magnitude.[5]

Those derivatives also show mesomorphic behavior (Fig. c) together with electron transport and electrochemical propersies.[6] In addition, the derivatives epitaxially adsorbed on the highly-oriented pyrolytic graphite forming well-ordered 1D lamellar structure (perfectly straight $C_{60}$ nanowires in nanometer scale).[7] In the course of the series of studies, we also discovered "room temperature liquid fullerenes" in bulk scale as nanocarbon fluid materials (Fig. d).[8]

**References:**

[1] *Chem. Commun.* **2005**, 5982. [2] *Small* **2007**, *3*, 2019. [3] *Adv. Mater.* **2008**, *20*, 443. [4] *Angew. Chem. Int. Ed.* **2009**, *48*, 2166. [5] *Chem. Eur. J.* **2009**, *15*, 2763. [6] *J. Am. Chem. Soc.* **2008**, *130*, 9236. [7] *J. Am. Chem. Soc.* **2006**, *128*, 6328. [8] *J. Am. Chem. Soc.* **2006**, *128*, 10384.