Supramolecular Materials & Hand-Operating Nanotechnology for Novel Functions

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Supramolecular materials have been wisely constructed via bottom-up approaches as seen in preparation of molecular complexes and organized nanostructures. Functional materials have been wisely constructed via bottom-up approaches as seen in preparation of molecular patterns and complexes [1-3], organized nanostructures [4-7], and function materials [8]. These materials are used for various functions such as one-pot materials separation, selective sensing, auto-modulated drug release, and photo-energy conversions as reported in our recent researches. For example, a novel hierarchic nanostructure based on layer-by-layer (LbL) assembly and mesoporous technology, so-called mesoporous silica nanocompartment film, was reported [9]. The resulting mesoporous nanocompartment films possess special molecular encapsulation and release capabilities so that stimuli-free auto-modulated stepwise release of water or drug molecules was achieved. We also demonstrated the LbL assembly of mesoporous carbon capsules on a QCM plate and the use of the resulting structure for selective adsorption of gaseous substances [10]. The related LbL structures of mesoporous carbons were demonstrated for in situ sensor use based on highly cooperative nanopore-filling adsorption in the liquid phase [11]. Recently, we have developed preparation of zebra-type nanowires through supramolecular assembly of block copolymers (Figure 1) [6]. The obtained nanowires displayed reversible photo-current responses as photo-energy conversion capability.

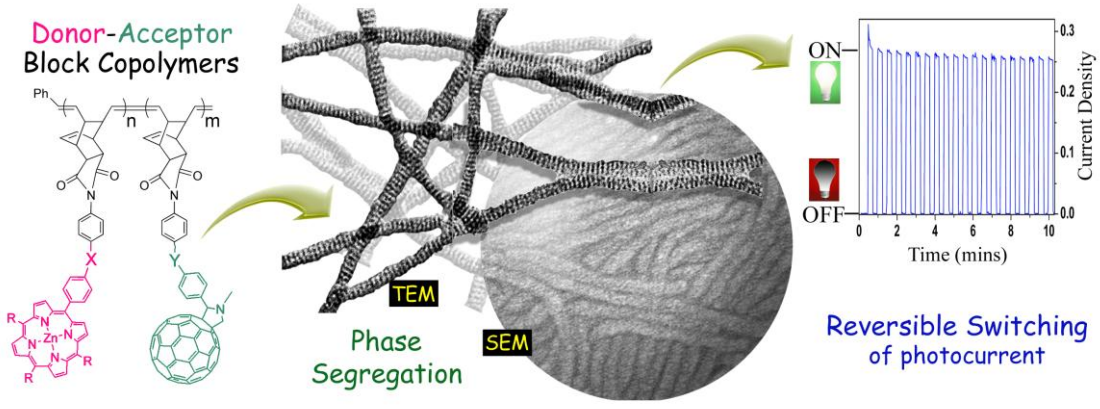

Figure 1. Zebra Nanowire for Photo-Current Switching

Not limited to material developments, novel concepts to bridge nano (molecular) structures and bulk systems now becomes crucial in order to control real nano and molecular functions from our visible worlds. Recently, we propose a novel methodology “hand-operating nanotechnology” where molecular orientation, organization and even functions in nanometer-scale can be operated by our bulk (hand) operation. As shown in the following Figure 2, this concept can be realized at dynamic two-dimensional medium, the air-water interface because this medium possess both features of bulk and molecular dimension. For example, we successfully manipulated molecules at the air-water interface upon bulk (10-100 cm size) motion of the entire monolayer and realized “capture and release” of aqueous guest molecules using molecular machine, steroid cyclophane [12]. In addition, mechanically controlled chiral recognition by the armed cyclen monolayer was successfully demonstrated [13].

References

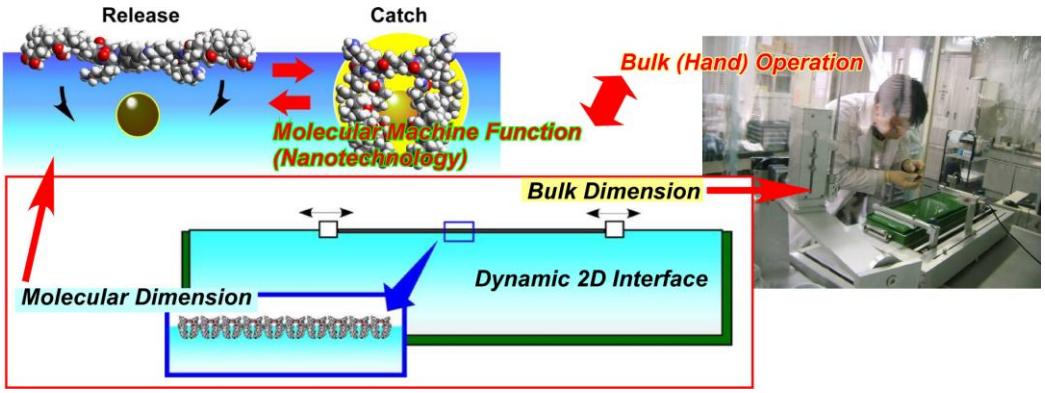

Figure 2. Hand-operating nanotechnology

[1] A. Shundo *et al.*, *J. Am. Chem. Soc.* **131**, 9494-9495 (2009). (Highlighted in *Nature Chemistry*).
[2] S. Acharya *et al.*, *J. Am. Chem. Soc.* **131**, 11282-11283 (2009).
[3] F. D'Souza *et al.*, *J. Am. Chem. Soc.* **131**, 16138-16146 (2009).
[4] S. Acharya *et al.*, *J. Am. Chem. Soc.* **130**, 4594-4595 (2008).
[5] M. Sathish *et al.*, *J. Am. Chem. Soc.* **131**, 6372-6373 (2009).
[6] R. Charvet *et al.*, *J. Am. Chem. Soc.* **131**, 18030-18031 (2009).
[7] N. Pradhan *et al.*, *J. Am. Chem. Soc.* **132,** 1212-1213 (2010).
[8] K. Ariga *et al.*, *J. Am. Chem. Soc.* **129**, 11022-11023 (2007).
[9] Q. Ji *et al.*, *J. Am. Chem. Soc.*, **130**, 2376-2377 (2008). (Highlighted in *Nature Materials*).
[10] Q. Ji *et al.*, *J. Am. Chem. Soc.* **131**, 4220-4221 (2009).
[11] K. Ariga *et al.*, *Angew. Chem. Int. Ed.* **47**, 7254-7257 (2008).
[12] K. Ariga *et al.*, *J. Am. Chem. Soc.* **122**, 7835-7836 (2000).
[13] T. Michinobu *et al.*, *J. Am. Chem. Soc*. **128**, 14478-14479 (2006).