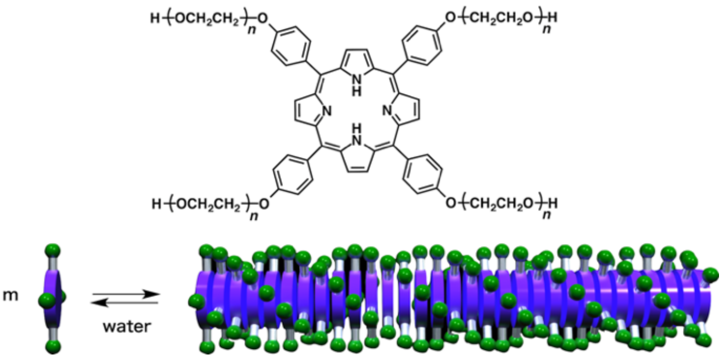
Supramolecular Polymerization: Its Significance and Applications

Takuzo Aida [a, b]
[a] *RIKEN CEMS, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan.*
[b] *The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-8656, Japan.*
aida@macro.t.u-tokyo.ac.jp



About a century ago, Dr. Hermann Staudinger substantiated the existence of ultralong molecules and won the long-term debate against the colloidal theory to establish polymer science. Needless to say, polymer science has made tremendous contributions to the progress of human society, although it coincidentally brought about a critical environmental issue to tackle. In this lecture, I would like to present the significance and applications of supramolecular polymerization, a modernized version of the colloidal approach to polymeric materials. Supramolecular polymers attract attention not only because they are 100% recyclable but also they can be designed to be environmentally friendly, self-healable, responsive, and/or adaptive [1–4]. In 1988, we reported the first prototype of supramolecular polymerization, featuring the formation of a 1D polymeric assembly using an amphiphilic porphyrin with water-soluble oligoether side chains as the monomer and have made fundamental contributions to this field [5]. Representative examples include (1) nanotubular supramolecular polymerization, (2) chain-growth supramolecular polymerization, (3) supramolecular block copolymerization, (4) stereoselective supramolecular polymerization, and (5) thermally bisignate supramolecular polymerization. These contributions are integral elements of conventional polymer science, filling in the critical gap between supramolecular and conventional polymerizations. Furthermore, we have expanded the basic concept of supramolecular polymerization into the noncovalent design of innovative soft materials. Successful examples include the developments of (i) bucky gels, (ii) aquamaterials, (iii) mechanically robust self-healable materials, (iv) supramolecular polymers of biomolecular machines, (v) ferroelectric columnar liquid crystals, (vi) reorganizable and adaptive core-shell columnar liquid crystals, (vii) an elastic MOF with a densely catenated backbone, (viii) solvent-free autocatalytic supramolecular polymerization, and (ix) fluorous nanochannels for ultrafast desalination by supramolecular polymerization. I will highlight some of these examples to show the significance of supramolecular polymerization for realizing sustainable society [6–10].

[1] Aida, Meijer, Stupp, *Science* **2012**, *335*, 813–817. [2] Aida, Meijer, *Israel J. Chem.* **2020**, *60*, 33–47. [3] Aida, *Adv. Matter.* Essay, **2020**, 1908140. [4] Meijer, Aida *et al.*, *Prog. Polym. Sci.* **2020**, 101250. [5] Aida *et al. Chem. Commun.* **1988**, 391–393. [6] Yanagisawa, Aida et al,, *Science* **2018**, *359*, 72–76. [7] Fujisawa, Aida *et al.*, *J. Am. Chem. Soc.* **2021**, *143*, 37. 15279–15285. [8] Meng, Aida, Sato *et al.*, *Nature* **2021**, *598*, 298–303. [9] Chen, Aida *et al.*, *Nature Mat.* **2022**, *21*, 253. [10] Itoh, Chen, Aoki, Aida *et al.*, *Science* **2022**, 367, 738–743.