Bio-Inspired, Smart, Multiscale Interfacial Materials

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Bio-inspired smart materials should be a "live" material with various functions like organism in Nature, they must have three essential elements as sense, drive and control. The studies on lotus and rice leaves reveal that a super-hydrophobic surface with both a large CA and small sliding angle needs the cooperation of micro- and nanostructures. Considering the arrangement of the micro- and nanostructures, the surface structures of the water-strider's legs were studied in detail. Accordingly, super-hydrophobic surfaces of aligned carbon nanotube films, aligned polymer nanofibers and differently patterned aligned carbon nanotube films have been fabricated. Many methods had been applied in making superhydrophobic films with multi-functional properties, such as structural colored, transparent and/or conductive superhydrophobic films. Under certain circumstances, a surface wettability can switch between superhydrophilicity and superhydrophobicity, just like in Chinese ancient Taiji philosophy that "Yin" and "Yang", the two opposing fundamental properties of nature, are switchable. The cooperation between surface micro- and nanostructures and surface modification of poly (N-isopropylacrylamide) gave reversible switching. By grafting the copolymer of temperature-sensitive and pH-sensitive components, a dual-responsive surface can be controlled by either or both of temperature and pH was fabricated. Besides organic surfaces, a series of inorganic switchers were also made. UV light stimulated transition between superhydrophobic and superhydrophilic by aligned ZnO, TiO_2, and SnO_2 films are successfully prepared respectively. Most recently, we developed a superoleophobic and controllable adhesive water/solid interface which opens up a new strategy to control self-cleaning properties in water. To expand the "switching" concept of the smart 2D surface, we also did a lot of interesting work in 1D system. For example, we discovered the water collection ability of capture silk of the cribellate spider Uloborus walckenaerius and then prepared artificial spider silk which will have great applications in water collection. In addition, we developed the novel biomimetic ion channel systems with a variety of intelligent properties (pH responsive, temperature responsive, potassium responsive, zinc activated, and dual-responsive single nanochannels), which were controlled by our designed biomolecules or smart polymers responding to the single external stimulus, provided an artificial counterpart of switchable protein-made nanochannels (highlight by Nature, and Nature China). These intelligent nanochannels could be used in energy-conversion system, such as photoelectric conversion system inspired by rhodopsin from retina or bR, and concentration-gradient-driven nanofluidic power source that mimic the function of the electric eels.

Keywords: Bio-inspired; Smart; Multiscale; Interface

Reference:
1. X. Hou, W. Guo, and L. Jiang, Chem. Soc. Rev.2011, 40, 2385-2401.
2. Y.M. Zheng, H. Bai, Z.B. Huang, X.L. Tian, F.Q. Nie, Y. Zhao, J. Zhai and L. Jiang, Nature, 2010, 463, 640-643;
3. M.J. Liu, Y.M. Zheng, J. Zhai and L. Jiang, Acc. Chem. Res., 2010, 43, 357-367;
4. L.P. Wen, X. Hou, Y. Tian, F.-Q. Nie, Y.L. Song, J. Zhai and L. Jiang, Adv. Mater., 2010, 22, 1021–1024;
5. W. Guo; L. X. Cao; J. C. Xia; F. Q. Nie; W. Ma; J. M. Xue; Y. L. Song; D. B. Zhu; Y. G. Wang; L. Jiang, , Adv. Funct. Mater. 2010, 20, 1339-1344.
6. F. Xia and L. Jiang, Adv. Mater., 2008, 20, 2842-2858;
7. X.J. Feng and L. Jiang, Adv. Mater., 2006, 18, 3063-3078;
8. S.T. Sun, L. Feng, X.F. Gao, and L. Jiang, Acc. Chem. Res., 2005, 38, 644-652;
9. X.F. Gao and L. Jiang, Nature, 2004, 432, 36;
10. L. Feng, S.H. Li, Y.S. Li, H.J. Li, L.J. Zhang, J. Zhai, Y.L. Song, B.Q. Liu, L. Jiang, and D.B. Zhu, Adv. Mater., 2002, 14(24), 1857-1860.