Catalysis Chemistry of the Nano-Confined Systems

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It’s well recognized now that the structural confinement causing within the nano-structured systems, will certainly lead a variation of electron characters, which, essentially, would conduce the modifications of the catalysis property in some systems. Such the “nano- effect” opens a new way for precisely tuning catalysis characters without, as conventional, by adding the certain additives into the catalyst systems. In this presentation, we will focus on the fundament and application of the nano-related science and technology in the fields of catalysis, with an emphasis on the electron confinement. The structure tuning effects of two systems concerning respectively the “quantum well states” of 2D thin films of metal on silicon and the “synergetic confinement” of the metallic nanoparticle encapsulated 1D CNTs will be illustrated: (1) The effect of electron quantum confinement on the catalytic activities of 2D ultra-thin metal films is explored by comparing the work function change and the initial reaction rate of atomically flat films of different thickness on silicon surfaces, using complementary microscopy and spectroscopy techniques. The obvious oscillations of the oxidation rate of lead films are observed, which are attributed to be a manifestation of the Fabry-Perot interference modes of electron de Broglie waves (quantum well states) in the films. (2) Carbon nanotubes (CNTs) have well defined hollow interiors and exhibit unusual mechanical and thermal stability as well as electron conductivity. This opens intriguing possibilities to introduce other matter into the cavities, which may lead to nanocomposite materials with interesting properties or behavior different from the bulk. The unique properties concerning the redox and catalysis of the CNT-encapsulated metals and metal oxides have been recognized. The auto-reduction of the encapsulated Fe₃O₄ is significantly facilitated inside CNTs with respect to the outside nanoparticle, and it becomes more facile with decreasing CNT channel diameter as evidenced by temperature programmed reaction. A striking enhancement of the catalytic activity of Rh particles confined inside nanotubes for the conversion of CO and H₂ to ethanol has been found. These unique behaviors of transition metal nanoparticles inside CNTs have been attributed to a particular electronic interaction of encapsulates with the interior CNT surface.

References
3. Experimental observation of quantum oscillation of surface chemical reactivities, Xucun Ma, Peng Jiang, Yun Qi, Jinfeng Jia, Yu Yang, Wenhui Duan, Wei-Xue Li, Xinhe Bao, S. B. Zhang and Qi-Kun Xue, P NATL ACAD SCI USA (PNAS), 104(2007)(22)9204-9208