UniSysCat - Special Lecture

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Carbon Dots Functional Materials

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Carbon-based nanostructures have received much attention due to their unique physicochemical properties and diverse applications. Compared to other carbon nanostructures, carbon dots (C-Dots) exhibit abundant photoluminescence (PL) and photoelectrochemical properties. C-Dots can be defined as spherical-like carbon particles (graphitic fragments) with sizes less than 10 nm. In 2010, we developed a facile electrochemical approach for the large-scale fabrication of high-quality C-Dots with high purity, using graphite rods and pure water as the starting materials. These well crystalline C-Dots show size-dependent photoluminescence and rich photoelectrocatalytic properties. Further, C-Dots with definite chemical structures and controlled morphology are being pursued, such as chiral C-Dots and crystalline C_3N C-Dots. We demonstrated C-Dots have many unique properties, such as tunable PL, dispersibility, low toxicity, biocompatibility, bio-degradation, abundant raw materials and low cost. Those features thus bode well for the wide applications of C-Dots in bioimaging, optoelectronic devices, catalysis and functional materials. The relationships between the structure, surface composition and photoelectrochemical properties of C-Dots were clarified. Especially, we have proposed a simple semi-empirical equation for determining the conduction bands and valence bands of the C-Dots calculated from their band gaps. In such semi-empirical model, a linear relationship between CB (VB) and band gap is observed. A series of carbon-based, highly efficient photocatalytic, electrocatalytic and photoelectrocatalytic systems for energy and environmental applications were designed and prepared. C-Dots show high catalytic activities for many reactions, C-Dots also act as functional components for the high-performance photocatalyst and electrocatalyst design. We proposed a new design concept of a cheap composite EC catalyst for a tunable, stable, selective and efficient production of syngas, made

of three components: a HER catalyst, a CO_2 reduction catalyst towards CO and a catalyst which stabilizes the active hydrogen (H•) necessary to trigger both HER and the CO_2 reduction reactions. In which, C-Dots are the generation site of H• needed to trigger both the reduction of CO_2 to CO and the HER. A new method to analyze the electron transfer number of photocatalysis by forced kinetic process under steady-state photoexcitation was proposed for the first time, and then demonstrated a new mechanism of "two-step two-electron pathway" for efficient overall water photo-splitting. We also proposed a new in-situ and transient photoelectrochemical analysis system, by which we found a new photoelectrochemical property of C-Dots, namely, salt-enhanced electron sink effects. The ions in seawater ionize the functional groups of CDs, which enhances the electron sink effect of CDs, making the photocatalytic activity in seawater better than that in the pure water. C-Dots promise highly efficient new photoelectrocatalysts towards clean and new energy catalysis and the conversion from solar energy to chemical energy.

Dr. Prashanth Wilfried Menezes

Organizer