Solar-to-electric Conversion: Improved Performance of C N codoped TiO₂ in Dye-sensitized Solar Cells

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TiO₂ has been proven to be a non-toxic, stable and efficient photoanode material in dye-sensitized solar cells (DSSC) since 1991. Meanwhile, TiO₂ usages in DSSC are greatly restricted due to its narrow light-response range and low separation probability of the photoinduced electron-hole pairs in the semiconductor. Doping can play a significant role to remedy those limitations. While non-precious metal dopants usually appear as charge carrier recombination centers and thus impair photoelectrochemistry and photocatalysis activities, non-metal dopants have been intensively investigated since Asahi et al. reported nitrogen-doped TiO₂ with high photocatalytic reactivity under visible light in 2001.

Numerous efforts were made in doping to improve TiO₂ performance in both photoelectrochemistry and photocatalysis. Different kinds of codoped methods were also constantly introduced to enhance TiO₂ performance besides single element like C, N, S, B, F, etc. Chu et al. demonstrated a method to prepare C doped nanostructured TiO₂ films simply and cheaply. C doped into substitutional sites of TiO₂ has proven to be indispensable for band gap narrowing and photovoltaic effect. The C doped TiO₂ films exhibited an overall conversion efficiency (η) up to 4.42 %. Tian et al. synthesized N B codoped TiO₂ by a facile modified sol–gel method, which was successfully applied to an enhanced device for DSSC with an open-circuit photovoltage of 0.823 V and yielding a high overall η of 8.4 %. These results suggested the substantial potential of TiO₂ nanocrystals with controlled doping in DSSC applications.

We have been working on C N codoped TiO₂ since 2009, when C N codoped TiO₂ nanoparticles were synthesized by calcining TiCN powders in air. Stronger light absorption in both the UV and visible light region were observed and a highest photocatalytic activity with 41.1 µmol/h hydrogen evolution rate was obtained in a calcined temperature at 550 °C. Recently, we reported a rapid and clean approach to synthesize N doped and C N codoped TiO₂ with enhanced photocatalytic and photovoltaic performance by calcining TiN nanoparticles under air and CO atmosphere respectively. The C N codoped TiO₂ nanoparticles were synthesized by urea powders. The experimental results indicated that the photocurrent of C N codoped TiO₂ nanotubes under UV-vis light raised up to 2.7 times than the pristine TiO₂ (Fig. 1), while the η of the C N codoped TiO₂ showed enhanced degradation rate of 1.26 % compared to 1.05 % for TiO₂ DSSC (Fig. 2).

Fig. 1. The photocurrent-time curves of TiO₂ (a) and C N codoped TiO₂ (b) under UV-vis light

Fig. 2. The J-V curves of DSSC fabricated by TiO₂ (a) and C N codoped TiO₂ (b) photoanodes

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References: