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Study on Photocatalytic of Composite Semiconductor For Different Structure

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Abstract : Photocatalytic materials have the advantages of low cost, high efficiency, energy saving and no secondary pollution, and have broad application prospects. The single semiconductor photocatalyst has some catalytic activity, but because of the narrow range of light absorption and higher recombination rate of photogenerated electrons and holes, the active hydroxyl radicals are reduced, which affects the photocatalytic efficiency. Semiconductor recombination can effectively reduce the recombination rate of photogenerated electrons and holes, and prolong the lifetime of the electron hole, which is one of the effective methods to improve the photocatalytic efficiency.
Keywords*:*Compound semiconductor, Photo-generated electron, Photo-generated hole, Photocatalyst

I. INTRODUCTION

A single semiconductor photocatalyst has certain catalytic activity, have some ability to degrade organic pollutants, due to the narrow range of light absorption and photo electron and hole high recombination rate, which becomes the key factor that influence the photocatalytic efficiency so as to improve the light efficiency, quantum efficiency, light stability and reaction activity[1]. On a single semiconductor photocatalyst for the modification the semiconductor composite can achieve the purpose of effectively improving the photocatalytic efficiency. Compound semiconductor is two or more than two kinds of semiconductor to form a composite system with a micro structure. With the semiconductor compound, through reasonable complementary different conduction band and valence band of the semiconductor of effective charge separation, the separation of photogenerated electrons and holes are achieved and transfered to inhibit the recombination rate of photogenerated electrons and holes that is one of the effective methods to improve the photocatalytic efficiency[2].

II. PHOTOCATALYTIC PROPERTIES OF COMPOSITE SEMICONDUCTORS

Characteristics of compound semiconductor photocatalysis is: its chemical properties are very stable, completely unaffected by strong oxidizing substances, no selectivity of the reactants, mineralization ability; effective on degradation of organic pollutants, no two pollution, environmentally friendly; compound semiconductor after the photogenerated electrons can effectively improve with the separation of photogenerated holes, light excitation energy range of system expansion, overcomes the weakness of single semiconductor photocatalyst; make full use of the sun light, full range of efficient, energy saving, low cost.

Composite semiconductor is a semiconductor to form a composite system with a micro structure, usually by a wide bandgap semiconductor conduction band is low and a high conduction position narrow gap semiconductor composites. Usually the narrow gap semiconductor has a wide light response, the first is excited, because of its high charge conduction band potential, which will be injected into the conduction band of wide bandgap semiconductor, the electron hole separation, and the electronic excitation

transition can occur in smaller light, expand the scope of wide spectral response band gap semiconductor in order to improve the photocatalytic performance. Such as: compound TiO_2 and CdS is the most typical example[3-4], in CdS/TiO_2 composite system, the narrow band gap semiconductor CdS and broadband semiconductor TiO_2 composite semiconductor $CdS\text{-}TiO_2$ formation system, although not visible light excitation in the $CdS\text{-}TiO_2$ system of TiO_2 photocatalytic reaction, but it can stimulate the CdS, makes the conduction electron transition to TiO_2, photogenerated holes in CdS valence band, to achieve the separation of the photogenerated carriers and improve the photocatalytic ability.

III. COMPOSITE SEMICONDUCTOR PHOTOCATALYSTS WITH DIFFERENT STRUCTURES

Composite semiconductor materials can be divided into mixed, laminated, core-shell, coaxial cable type, parallel type, surface dispersion type from the structure. This paper focuses on the study of typical composite semiconductor photocatalysts.

3.1 Hybrid composite semiconductor

A mixing system mainly consisting of two or more powder materials, including nanoscale materials. Chen[5] by ball milling method of nanometer SnO_2/TiO_2 composite powder was prepared, the light red shift of excitation wavelength of 20 nm, the light absorption was strengthened, improving the photocatalytic activity is mainly because the charge separation efficiency and broaden the excitation light wavelength range. Wang Yunfang[6] successfully prepared by stearic acid method $CuO/SnO_2/TiO_2$ composite photocatalyst was prepared, using TiO_2/SnO_2 composite semiconductor to promote effective separation of photogenerated carrier transport and transport, with the help of CuO doping, the charge separation efficiency increased, so that the catalyst has excellent photocatalytic activity.

3.2 Laminated composite semiconductor

Laminated film structure is called layered structure, is composed of a compound semiconductor with different component superposition of each component, arranged orderly in the two-dimensional direction, at least one component layer thickness at the nanometer scale, many semiconductor composite films belong to this class. Yining Hua et al.[7] using electrospinning method and hydrothermal treatment combined with the SnO_2/TiO_2 nano composite film electrode has a photoelectric conversion performance and excellent photocatalytic properties were prepared. The quality of the film in equal conditions, the degradation rate ofrhodamine B reached 95%, compared to 56% for TiO_2, 58% for SnO_2. The chemical deposition of CdS/TiO_2 composite photocatalyst layer by S Qian et al.[8], CdS thin films were deposited on the TiO_2 plane, forming a layered structure, increase the surface area, the electron transfer rate, can efficiently absorb pollutants.

3.3 Core shell composite semiconductor

The core shell structure is a structure formed by a semiconductor coating on the other half of the conductor particles. If the particle size is controlled effectively and the surface area is increased, the photocatalytic activity can be improved; or the diameter of the nucleus and the thickness of the shell can be effectively adjusted, which may be beneficial to solve the problem of light corrosion to the semiconductor. A composite catalyst $Fe/ZnO\text{-}TiO_2$ with a diameter of 12~48 nm was prepared by citrate sol self combustion method, and the efficiency of photocatalytic degradation of methyl orange was more than 95% by Li Cuixia et al[9]. Ma Dong and others[10] synthesized $Cu_2O@TiO_2$ spherical particles with core-shell structure by solvothermal method. The photocatalytic degradation performance of methyl

orange was obviously higher than that of Cu_2O and TiO_2, and the main reason could be attributed to the formation of p-n heterojunction.

3.4 Coaxial cable type composite semiconductor

Coaxial cable type refers to the diameter of the nano cable core, usually the inner conductor or semiconductor, nano fiber shell coated for heterogeneous conductor, semiconductor or insulator consisting of the core and the outer coaxial. Chen Yingsheng et al.[11] by coaxial electrospinning of NiO-TiO_2 coaxial nanofibers with core-shell structure were prepared by composite n type semiconductor TiO_2 and P type semiconductor NiO, reduces the recombination rate of photogenerated electrons and holes, the photocatalytic performance is better than that of TiO_2 powder and nano TiO_2 nano fiber, Ni-TiO_2 fiber, and the decomposition of methylene blue the rate is about 85%, after 3 times of the catalytic cycle can still maintain the catalytic ability of 80%, good repeatability and stability. Xu Shuzhi et al.[12] by TiO_2@SiO_2 coaxial coaxial electrospinning technology for preparation of double walled submicrotubes, cable equivalent hollow, Si - O-Ti bond formation so that the formation of surface defects of TiO_2, conducive to the separation of electron hole pairs and hydrophilic SiO_2, enhanced the adsorption capacity of the catalyst, effectively improve the photocatalytic performance.

3.5 Side-by-side compound semiconductor

Juxtaposition refers to a composite longitudinal nanofiber bundle composed of adjacent semiconductors. Liu et al.[13] by parallel double spinneret was prepared by a novel SnO_2/TiO_2 structure parallel double nano fiber semiconductor photocatalyst by electrospinning technique, SnO_2, TiO_2 was neither covered nor mixed, with all exposed surfaces, this special heterojunction in the photocatalytic process, promote the separation of photogenerated electrons and holes, fully play the role of photogenerated electrons and holes, the rhodamine B showed higher photocatalytic activity than pure TiO_2 nanofibers, 45 minutes, the degradation rate reached 100%, compared with the pure TiO_2 nano fiber to improve the catalytic efficiency of nearly 50%.

3.6 Surface dispersed composite semiconductor

Surface dispersion refers to the structure of heterogeneous particles loaded on the surface of a particle or on the surface of a fiber. Li Yuejun et al.[14] by means of electrospinning technique and hydrothermal treatment combined with TiO_2, nano fiber as a template in the uniform growth of SnO_2 nanoparticles of TiO_2 nanofibers, SnO_2/TiO_2 nanofibers with different structure were prepared, played TiO_2 with high specific surface and a large number of reactive sites and other advantages, the photocatalytic activity compared with the pure TiO_2 nanofibers were improved. By electrospinning, pure ZnO nanofibers were prepared, the NiO particles were uniformly loaded onto ZnO nanofibers by solvothermal method, NiO/ZnO composite nanofibers, the photocatalytic activity was significantly increased compared with pure ZnO nanofibers, and easy separation, recovery and reuse. Du Huan[15] used twelve thiol legal nano CdS was to combine the CdS particles of CoO particles were prepared by reaction of p-CoO/n-CdS composite photocatalyst for the photodegradation of methyl orange, its excellent performance is about 2.2 times of the photocatalytic activity of CdS.

IV. CONCLUSIONS

Composite photocatalytic materials from semiconductor material structure will be good together, greatly improving the photogenerated electron hole separation degree of the carrier, to stimulate and transfer on

the interface of composite materials and composite, showed the highest catalytic activity of single semiconductor photocatalyst, has become one of the effective methods to improve the photocatalytic efficiency. With the continuous deepening of the research, the design and development of novel and efficient composite semiconductor photocatalytic materials with different structures will play a positive role in improving the photocatalytic activity.

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