Carbon coated Au/TiO₂ mesoporous microspheres: a novel selective photocatalyst

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ABSTRACT Photocatalysts with desirable selectivity to transformation and purification of targeted pollutants are of great importance in water purification. Here, we demonstrate that selective photocatalysis can be realized by the assistance of gold-enhanced selective adsorption onto carbon-coated Au/TiO₂ mesoporous microspheres (Au/TiO₂@C-MM), which were prepared via a surfactant-assisted two-step method that involved the assembly of oleic acid-stabilized titania and gold nanoparticles into colloidal spheres in an emulsion using sodium dodecyl sulfate as a surfactant and the conversion of the surfactants into carbon under annealing in Ar. Due to the negatively charged amorphous carbon, the mesoporous structure, and the surface plasmon resonance absorption of the Au components, the Au/TiO₂@C-MM shows enhanced charge- and size-selective adsorption properties, which enables the materials to have high selectivity in the photocatalytic process.

Keywords: Au/TiO₂, carbon, mesoporous microsphere, selective adsorption, photocatalysis

INTRODUCTION

Heterogeneous photocatalysis has great potential to solve worldwide environmental and energy-related issues [1,2]. Titania (TiO₂) has been regarded as one of the most efficient photocatalysts since the first report by Fujishima and Honda [3–6], because of its high catalytic activity, good stability and low toxicity. After that, huge progress towards improving the photocatalytic efficiency of TiO₂ has been made [7], such as band-tailoring by element doping [8,9], constructing mesoporous and/or array structures [10–13], and plasmonic sensitizing [14,15]. Nevertheless, TiO₂ is generally regarded as non-selective because the degradation of organic compounds on TiO₂ is enabled by non-selective oxidizing agents (e.g., OH radical) [16]. In most

cases, the contaminated system contains a large variety of organic pollutants, nonselective oxidizing agents will generally degrade pollutants with high-level, leading to the low degradation efficiency of target pollutants. Therefore, developing photocatalysts with desirable selectivity to transformation and purification of targeted pollutants is of great importance in water purification [17–20]. Recently, several researchers have shown that selective photocatalysis can be approached by modifying the surface of the photocatalysts with specific molecules [16,21–23]. Therefore, a shell with molecular selectivity around TiO₂, which combines the merits of the high photocatalytic activity of TiO₂ and the photocatalytic selectivity of the surface modifiers, would be used as a highly selective photocatalyst. For example, Chen and co-workers [24] synthesized mesoporous TiO₂@SiO₂ nanofibers for the selective photocatalytic decomposition of organic dyes, which was due to the size selectivity of the SiO₂ shell. Choi and co-workers [25] reported that the incorporation of titania within FAU-type zeolites produced a catalyst with size and charge selectivity for the photocatalytic degradation of charged pollutants.

Integrating photo-inactive carbon as a co-adsorbent was also reported to increase the photocatalytic activities of TiO₂ due to the synergistic effect of the high adsorption capacity of carbon and the photocatalytic activity of TiO₂ [26,27]. Therefore, photocatalytic selectivity can be achieved when carbon materials with selective adsorptive properties are introduced into TiO₂/carbon composites. However, few research concerning the photocatalytic selectivity of TiO₂/carbon composites has been reported to date.

Herein, we report a facile approach to prepare Au/TiO₂@carbon mesoporous microspheres (Au/TiO₂@C-

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MMs) and investigate their selective photocatalytic properties. Au/TiO₂@C-MMs were prepared via a surfactant-assisted two-step method that involved the assembly of oleic acid (OA)-stabilized titania and gold nanoparticles (NPs) into colloidal spheres in an emulsion using sodium dodecyl sulfate (SDS) as a surfactant and the conversion of the surfactants into carbon under annealing in Ar. The as-prepared Au/TiO₂@C-MMs display multiple advantages: 1) the negatively charged carbon imparts to the composites excellent selective adsorption of positively charged organic compounds; 2) the mesopores in the composite enable size selectivity in the adsorption-photocatalytic process; 3) the enhanced adsorption and photocatalytic activities are due to the mesoporous structure and surface plasmon resonance (SPR) of the metallic Au components that are stably confined in the hybrid microspheres. Such a selective photocatalytic degradation of water pollutants may provide a useful strategy for the development of an economical photocatalytic process by targeting only the most recalcitrant pollutants.

EXPERIMENTAL SECTION

Chemicals

All chemicals are analytical grade and used as received without further purification.

Synthesis of TiO₂ NPs

TiO₂ NPs were prepared by a solvothermal method using cyclohexane as the dispersant, as described elsewhere [28]. In a typical synthesis, 7 mL of OA and 20 mL of cyclohexane were mixed in a dried teflon autoclave and stirred for 10 min at room temperature. Then, 1 mL of titanium tert-butoxide (TBOB) and 5 mL of triethylamine were added to the mixed solution. The autoclave was then sealed and heated at 180°C for 24 h. After cooling to room temperature, the resulting suspension was precipitated by ethanol and separated via centrifugation. After three successive wash cycles of dispersion in cyclohexane, precipitation with ethanol, and centrifugation, the TiO₂ NPs were re-dispersed in 10 mL of cyclohexane.

Synthesis of Au NPs

Au NPs were prepared by the OA-assisted solution method [29]. Typically, a 30 mL aqueous solution containing 0.01 g of HAuCl₄·3H₂O, 0.1 g of NaOH, 1.6 mL of OA, and 12 mL of ethanol was mixed at room temperature under vigorous agitation. Injection of an aqueous solution of vitamin C (Vc) (0.05 mol L⁻¹, 0.5 mL) led to the gradual formation

of a purple solution, indicating the formation of the gold sol. Then, 30 mL of cyclohexane was added immediately. The solution was continuously stirred for approximately 1 h and remained stable for 24 h. The gold colloids were extracted into the cyclohexane phase. After three successive wash cycles of dispersion in cyclohexane, precipitation with ethanol, and centrifugation, the Au NPs were re-dispersed in 2 mL of cyclohexane.

Synthesis of Au/TiO₂@C-MMs

To prepare mesoporous microspheres, water-dispersed Au/TiO₂ colloidal spheres were first synthesized by the microemulsion-based, bottom-up self-assembly (EBS) method [30]. In a typical synthesis, 0.3 g of SDS was dissolved in deionized water (100 mL) to form a clear solution. Then, 10 mL of a cyclohexane solution containing TiO₂ NPs and different amounts of Au NPs (0.25, 0.5 and 1 mL of 0.2, 0.5 and 0.9 wt.%, respectively) was added to the aqueous solution. The system was emulsified by ultrasonication with magnetic stirring and held at 70°C for 6 h with constant stirring to evaporate the cyclohexane and form condensed colloidal spheres. After the reaction was cooled to room temperature, the products were washed with water and then dried at 70°C. Au/TiO₂@C-MM was obtained by calcination of the products in Ar at 350°C for 6 h.

Characterization

The morphology of the as-synthesized samples was characterized by field-emission scanning electron microscopy (FE-SEM, Zeiss SUPRA 55, operated at 20 kV) and transmission electron microscopy (TEM, FEI Tecnai G² 20 S-Twin, operated at 200 kV). The structure and composition of the samples were characterized using a high-resolution TEM (HRTEM) system (JEOL 2100) equipped with an energy-dispersive X-ray spectrometer (EDS) operating at 200 kV. The Raman spectra of the samples were recorded on a LabRAM HR Raman microscope with a laser excitation wavelength of 632.8 nm. Powder X-ray diffraction (XRD) patterns were recorded on an X-ray diffractometer (Rigaku D/max 2500) at a scan rate of 5° per minute in the 2θ range from 10° to 70°. Thermogravimetric analyses (TGA) were performed on a Pyris Diamond TG instrument. X-ray photoelectron spectroscopy (XPS) was performed using a Thermo Electron ESCALAB 250 XPS spectrometer. Brunauer-Emmett-Teller (BET) specific surface areas and average pore sizes were obtained from the N₂ adsorption-desorption isotherms at 77 K (Autosorb-1, Quantachrome). Zeta potential measurements

were conducted with a Zetasizer Nano ZS (Malvern Instruments). Inductively coupled plasma (ICP) measurements were conducted on an inductively coupled plasma-atomic emission spectrometer (ICP-AES, Shimadzu ICPS-7500).

Adsorption and photocatalytic property tests

The selective adsorption and photocatalytic activities were evaluated in a homemade glass reactor with recycled water for the degradation of organic dyes (the molecular structures of the dyes are illustrated in Table S1) in aqueous solution. A 500 W Xe lamp (Shanghai Lansheng Electronics Co., Ltd.) was used as a simulated solar light source. At the given time intervals, the analytical samples were taken from the mixture and immediately centrifuged to remove the photocatalysts. The clear supernatants were analyzed by recording variations of the absorption in the UV-vis spectra of dyes using a UNICO UV-2802PC UV/visible scanning spectrophotometer.

RESULTS AND DISCUSSION

Preparation and characterization of Au/TiO₂@C-MM

The fabrication process of the Au/TiO₂@C-MMs is illustrated in Fig. 1 and it involves the assembly of OA-capped NPs into colloidal spheres [30], followed by a subsequent pyrolysis treatment in Ar to achieve carbon-coated mesoporous microspheres. Typically, a stable oil/water (O/W) microemulsion was first obtained by ultrasonic treatment of the mixture of an aqueous SDS solution and a cyclohexane dispersion containing the OA-capped TiO₂ (approximately 3 nm in diameter and 20 nm in length, Fig. S1a) and the Au NPs (approximately 10 nm in diameter, Fig. S1b) (Fig. 1a). After evaporating the cyclohexane from

the microemulsion system, the NPs in the droplets became concentrated and assembled into well-packed colloidal spheres (Fig. S1b). Subsequently, these colloidal spheres were annealed at 350°C for 6 h under Ar atmosphere to form mesoporous microspheres (Au/TiO₂@C-MMs, Fig. 1c). In this process, the surfactants were converted into amorphous carbon and coated on the surface of Au and TiO₂ NPs among the mesoporous microspheres.

As shown in Fig. 2a, the Au/TiO₂ colloidal spheres of about 300 nm in diameter were obtained by the assembly of TiO₂ and Au NPs via EBS method. After calcination, the Au/TiO₂@C-MMs with a sphere size of approximately 150–400 nm in diameter were obtained, and the spherical morphology of which was almost intact (Fig. 2b). Further analysis by HRTEM shows clear evidence that the NPs are embedded in the amorphous carbon matrix (Fig. 2c). Distinct lattice fringes of 0.23 and 0.35 nm are observed on the NPs, which correspond to the (111) planes of Au and the (101) planes of the anatase phase of TiO₂, respectively. The EDS of the Au/TiO₂@C-MMs shown in Fig. 2d reveals that the main elements of the product are C, O, Au and Ti, which further confirms the presence of the Au and TiO₂ components inside the carbon matrix. The phase of the as-synthesized product was characterized by XRD. As shown in Fig. 2e, all the peaks can be indexed to anatase TiO₂ (space group *I*4₁/*amd* (141), JCPDS No. 21-1272). Characteristic peaks of Au NPs and carbon are absent in the XRD pattern because of the low content of Au and the amorphous structure of carbon. Raman spectroscopy was used to further study the graphitization of the carbon component. The Raman signatures of the G band (~1590 cm⁻¹) and D band (~1355 cm⁻¹) of the Au/TiO₂@C-MMs confirm the existence of carbon, which is poorly crystallized and similar to

Figure 1 Schematic illustration of the fabrication procedure for the Au/TiO₂@C-MMs.

Figure 2 (a) TEM image of the Au/TiO₂ colloid spheres; (b–f) morphological and chemical composition characterizations of the Au/TiO₂@C-MMs: (b) SEM, (c) HRTEM images, (d) EDS spectrum, (e) XRD pattern and (f) Raman spectrum.

the carbon formed by the carbonization of organic surfactants (Fig. 2f) [31,32].

More detailed information regarding the chemical and bonding environment of the Au/TiO₂@C-MMs was ascertained using XPS. As shown in Fig. 3a, the peak observed at a binding energy of 83.3 eV was ascribed to the metallic Au 4f_{7/2}, thus confirming that the Au species exists as metallic Au⁰ in the Au/TiO₂@C-MMs. Compared to bulk Au⁰ 4f_{7/2} at 84.0 eV, the peak of the Au/TiO₂@C-MMs exhibits a negative shift of 0.7 eV, indicating strong interactions between Au and carbon [33,34]. The binding energy of Ti 2p_{3/2} is 458.6 eV, which is virtually identical to that of anatase TiO₂ (Fig. 3b) [35]. The C 1s spectra of the Au/TiO₂@C-MMs in Fig. 3c could be fitted into four peaks

located at ~284.5, ~285.4, ~286.5 and ~288.7 eV, which are assigned to C–C, C–O–C, C=O, and COOH, respectively [36]. This result suggests the existence of large numbers of O-containing groups bonded to the carbon, which endow the Au/TiO₂@C-MMs with a negatively charged surface on the Au and TiO₂ NPs. The carbon content of the composite was determined by TGA. As shown in Fig. 3d, besides a weight loss attributed to the evaporation of the adsorbed moisture or gas molecules below 150°C, a major weight loss of 9.1 wt.% attributed to the combustion of the carbonaceous components occurs between 200 and 450°C, corresponding to the carbon content of the sample. The mesoporous structure of the obtained Au/TiO₂@C-MMs composites was investigated through N₂ adsorption-desorption

Figure 3 (a–c) High-resolution XPS spectra of Au/TiO₂@C-MMs: (a) Au 4f, (b) Ti 2p, and (c) C 1s. (d) TGA profile of the Au/TiO₂@C-MMs heated in air from room temperature to 550°C. (e) N₂ adsorption-desorption isotherm curve and (f) pore size distribution of the Au/TiO₂@C-MMs. The inset TEM image in (e) shows the porous structure.

measurements, and the isotherm curve is shown in Fig. 3e. A type IV isotherm with a hysteresis loop of type H3 is observed, which confirms the existence of a porous structure in the materials. The inset TEM image in Fig. 3e also confirms the mesoporous structure of the sample. The pore size distribution curve, which was obtained from the desorption curve, indicates that the Au/TiO₂@C-MMs possess pores with sizes of approximately 3 nm (Fig. 3f). The specific surface area of the composites is 321 m² g^{−1}, much larger than that of P25 (50 m² g^{−1}). For comparison, TiO₂ NPs coated with C (TiO₂@C NPs) via calcination of the

OA-capped TiO₂ under Ar flow and TiO₂ mesoporous microspheres (denoted as TiO₂-MMs) prepared via calcination of TiO₂ colloidal spheres at 350°C in air to remove carbonaceous components were prepared, and their morphology and phase characterization are shown in Fig. S2 and Table S2.

Selective adsorption and photodegradation properties of the Au/TiO₂@C-MMs

The adsorption of substrates on the catalyst is a key factor that affects the photocatalytic activity. Therefore, selective

photocatalysis can be realized by combining selective adsorption with the non-selective photocatalytic process. The existence of O-rich groups on the carbon endows the Au/TiO₂@C-MMs with a negatively charged surface and favors the charge-selective adsorption and degradation of charged dyes. The adsorption behavior of the Au/TiO₂@C-MMs toward various organic compounds was first investigated and illustrated in Fig. 4a and Fig. S3. The adsorption selectivity of the Au/TiO₂@C-MMs was investigated by adding 30 mg of the Au/TiO₂@C-MMs to 100 mL of methyl orange (MO), acid orange 7 (AO7), rhodamine B (RB), and methylene blue (MB) solutions (3×10^{-5} mol L⁻¹), followed by stirring in the dark. The structures of these dyes are illustrated in Table S1. As shown in Fig. 4a and Fig. S3a, anionic substrates such as MO and AO7 are barely adsorbed onto the Au/TiO₂@C-MMs, whereas cationic substrates such as RB and MB are strongly adsorbed onto the Au/TiO₂@C-MMs. This phenomenon could be clearly explained by the electrostatic exclusion or attraction between the negatively charged Au/TiO₂@C-MMs

and the charged substrates. The surface charge of the Au/TiO₂@C-MMs was further investigated by zeta potential analysis, and the results are shown in Fig. 4b. Under near-neutral pH conditions, the Au/TiO₂@C-MMs was negatively charged, and thus the cationic substrates were selectively adsorbed. With decreasing pH, the negative charge decreased, and the mesoporous microspheres became positive when the pH was lower than the isoelectric point of approximately 5. Thus, reducing the pH to lower than 5 should reverse the adsorption behavior of the Au/TiO₂@C-MMs. As reflected in Fig. 4c and Fig. S3b, a reversed adsorption selectivity was observed at pH 3, with faster adsorption of the AO7 anionic dye compared with the cationic MB. This observation indicates the possibility of tuning the photocatalytic selectivity to target water pollutants by simply changing the pH of the system.

It is well known that Au NPs can significantly increase the photocatalytic activity of the composite due to the SPR of the Au NPs [15,37,38]. However, we demonstrated here that the incorporation of Au NPs can also increase the abil-

Figure 4 Charge-selective adsorption of the Au/TiO₂@C-MMs. (a) Comparison of the adsorption of anionic substrates (MO and AO7) and cationic substrates (RB and MB) with an initial concentration of 3×10^{-5} mol L⁻¹ (100 mL) by the Au/TiO₂@C-MMs (30 mg) under neutral conditions. (b) Zeta potential measurements of the Au/TiO₂@C-MMs at different pH values. (c) Comparison of the adsorption of anionic substrates (AO7) and cationic substrates (MB) with an initial concentration of 3×10^{-5} mol L⁻¹ (100 mL) by the Au/TiO₂@C-MMs (30 mg) at pH 3. (d) C_t/C_0 versus reaction time for the adsorption of MB (9×10^{-5} mol L⁻¹, 100 mL) over 30 mg of TiO₂@C NPs, TiO₂-MMs and Au/TiO₂@C-MMs with different Au loadings at pH 7.

ity of materials to adsorb dyes. As a proof-of-concept, the adsorption property of the nanocomposites with different amounts of gold loading (0.2, 0.5 and 0.9 wt.% Au/TiO₂@C-MMs, detected by ICP) was examined to investigate the optimum amount of Au loading using MB as the substrate. In a typical experiment, 100 mL of an aqueous solution of MB (9×10^{-5} mol L⁻¹) containing 30 mg of catalyst was stirred in the dark for 60 min to allow for adsorption. As shown in Fig. 4d, it can be observed that the TiO₂@C-MMs obtained from the self-assembly of TiO₂ NPs exhibit a higher adsorption capacity than those of TiO₂@C NPs and TiO₂-MMs, owing to the increased specific surface area and porous structure of the mesoporous microspheres (Table S2). For the loading with Au NPs, a significant improvement in the adsorption of MB was achieved. Specifically, 0.5 wt.% Au/TiO₂@C-MMs exhibit the highest adsorption capacity for MB, which is 2.6 times higher than that of TiO₂@C-MMs and 5.3 times that of TiO₂@C NPs at 60 min, respectively. The improvement might have been caused by the interaction of the Au NPs with the heteroatoms of the substrates and the synergistic effect between the Au NPs and the amorphous carbon [39,40]. However, the adsorption efficiency decreases when the Au content increased to 0.9 wt.%, which might have been attributed to the slight aggregation of Au NPs in the TiO₂ matrix, resulting in a decrease in the number of adsorptive sites of the composite. Thus, 0.5 wt.% Au/TiO₂@C-MMs was chosen as the sample for the following study.

To further investigate the photocatalytic selectivity of the Au/TiO₂@C-MMs, we examined the effect of carbon on the process of selective adsorption and photodegradation of anionic and cationic substrates compared with the Au/TiO₂-MMs without carbon, which was obtained using a similar procedure as for the Au/TiO₂@C-MMs,

except calcinating the colloidal spheres at 350°C under O₂ flow. The adsorption-photocatalytic properties were demonstrated by the degradation of two common dyes with different charges (MO and MB) under simulated solar irradiation. Typically, 30 mg of catalyst was added to the MO or MB solution (9×10^{-5} mol L⁻¹, 100 mL). The mixtures were stirred in the dark for 60 min, and then the light was turned on for the photocatalytic test. As shown in Fig. 5a and Fig. S4a, the Au/TiO₂@C-MMs showed obviously different behavior for the adsorption and photodegradation of MO and MB. Nearly 70% of cationic MB was adsorbed in 60 min, and cationic MB degraded completely within 4 h. Only 12% of anionic MO was adsorbed in 60 min, and 20% was degraded in 4 h. In addition, the first-order rate constant (*k*) of MB was much higher than that of MO, also demonstrated that the photodegradation process of MB was much faster than that of MO. In contrast, the Au/TiO₂-MMs with the same amount of gold loading exhibited almost equal adsorption and photocatalytic activity of these two dyes (Fig. 5b and Fig. S4b). These results indicate that the selective adsorption and photocatalytic property are rendered by the negatively charged carbon on the surface of the catalyst.

In addition, the molecular size selectivity of the Au/TiO₂@C-MMs was also observed in the adsorption of various substrates in Fig. 4a. The adsorption efficiency of the cationic substrates (RB and MB) was consistent with the size order of the molecules. Specifically, the Au/TiO₂@C-MMs showed much faster adsorption of the dye with a smaller molecular size (MB, 0.66 nm × 1.38 nm) than the larger dye (RB, 1.03 nm × 1.59 nm). Therefore, the adsorption behavior of the Au/TiO₂@C-MMs of various dyes with similar structures but different sizes (Thionin acetate (TA), new methylene blue (NB) and MB) was fur-

Figure 5 Comparison of the charge-selective adsorption and photocatalytic degradation of MB and MO with an initial concentration of 9×10^{-5} mol L⁻¹ (100 mL) by 30 mg of the Au/TiO₂@C-MMs (a) and Au/TiO₂-MMs (b) under neutral condition.

Figure 6 (a) Molecular structures of TA, MB, NB and RB. (b) Adsorption curves of TA, MB and NB ($6 \times 10^{-5} \text{ mol L}^{-1}$, 100 mL, respectively) with similar structures but different molecular sizes over 30 mg of the Au/TiO₂@C-MMs under neutral condition. (c) Adsorption and photocatalytic degradation of the mixture dyes with different sizes ($6 \times 10^{-5} \text{ mol L}^{-1}$ MB and $6 \times 10^{-5} \text{ mol L}^{-1}$ RB, 100 mL) by 30 mg of the Au/TiO₂@C-MMs under neutral condition. The inset of (c) shows a digital photograph of the degradation process.

ther assessed to confirm its size-selectivity (molecular structures and sizes are illustrated in Fig. 6a which were used as model substrates). As shown in Fig. 6b, the adsorption rate of the dyes on the Au/TiO₂@C-MMs decreased, as expected, as the molecular size of these substrates gradually increased, demonstrating the size selectivity of the Au/TiO₂@C-MMs. The adsorption selectivity enables the preferential selective photodegradation of a targeted pollutant in water. Here, a mixture of dyes with different sizes (100 mL, $6 \times 10^{-5} \text{ mol L}^{-1}$ MB and $6 \times 10^{-5} \text{ mol L}^{-1}$ RB) was used to demonstrate the selective photodegradation. The Au/TiO₂@C-MMs show much faster adsorption and degradation of the dye with a smaller molecular size (MB, 0.66 nm × 1.38 nm) than the larger dye (RB, 1.03 nm × 1.59 nm) (Fig. 6c and Fig. S5), because the preferential adsorption of MB inhibits the adsorption of RB in the mixed solution, thus leading to the preferential photodegradation of MB. The selective adsorption-degradation process can also be seen intuitively from the digital photograph (inset of Fig. 6c). The mixture of MB and RB is indigo, and after

the addition of the Au/TiO₂@C-MMs, the color of the mixture turns shallow scarlet, which is close to the color of RB, indicating the preferential adsorption and degradation of MB.

Finally, the recyclability of the Au/TiO₂@C-MMs was evaluated through the adsorption and photodegradation of MB ($3 \times 10^{-5} \text{ mol L}^{-1}$, 100 mL) in successive cycles. Each cycle consisted of 1 h of adsorption and 3 h of illumination under simulated solar light. The recycled Au/TiO₂@C-MMs was centrifuged and washed repeatedly with deionized water three times before reuse in the next cycle. As shown in Fig. 7, the adsorption capacity of the Au/TiO₂@C-MMs decreased in the second cycle [12], and after that, the adsorption capacity and photocatalytic activity remained almost unchanged (91% after 6 cycles). This suggests that the Au/TiO₂@C-MMs are quite stable during the adsorption and photocatalytic process.

CONCLUSIONS

In summary, the negatively charged amorphous carbon-

Figure 7 Reusability of the Au/TiO₂@C-MMs (30 mg) as the photocatalyst for the adsorption and degradation of MB (3×10^{-5} mol L⁻¹, 100 mL) under neutral condition.

coated Au/TiO₂ mesoporous microspheres (Au/TiO₂@C-MMs) were prepared via a facile surfactant-assisted, two-step method, in which OA and SDS were used as both a surfactant and carbon source. The Au/TiO₂@C-MMs display excellent charge- and size-selective adsorption-photocatalytic activity and stability, which is mainly attributed to 1) the negatively charged carbon coating on the NPs, which endows the material with charge selectivity; 2) the pore size of the mesoporous material, which provides the size selectivity of the composite; 3) the increased specific surface area of the composites and increased adsorption of organic substances on the photocatalyst surface, where they were oxidized, due to the mesoporous structure; and 4) the well-dispersed Au NPs in the TiO₂ matrix, which enhances the light absorption due to their SPR absorption. The strategy reported here for preparing charged carbon-coated mesoporous microspheres might open an avenue for developing highly selective and efficient photocatalysts for water treatment and environmental conservation.

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碳包覆Au/TiO₂介孔微球: 一种新型选择性光催化剂

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摘要 选择性光催化剂的开发对于污水处理等环境问题具有重要意义. 本文利用十二烷基硫酸钠作为表面活性剂, 油相Au和TiO₂纳米颗粒为前驱体, 经微乳液自组装-表面活性剂碳化两步法, 成功合成了碳包覆Au/TiO₂介孔微球 (Au/TiO₂@C-MM) 复合光催化剂材料. 得益于负电荷无定形碳、介孔结构和Au表面等离子体共振特性, Au/TiO₂@C-MM在光催化过程中表现出优异的尺寸和电荷选择性.