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Synthesis and Fabrication of CNTs/Fe_3O_4@Pdop@Au Nanocables by a Facile Approach

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Experimental Section

Chemicals

Multiwalled CNTs (MWCNTs) with a mean diameter of 60–80 nm were provided by the Shenzhen Nanotech Port Co. Ltd.Iron(III) acetylacetonate ($Fe(acac)_3$, 99%) was purchased from Acros. Triethylene glycol (TREG, 99%) was from Aldrich. Dopamine hydrochloride, tetrachloroaurate hydrate($HAucl_4$), sodium borohydride($NaBH_4$) was purchured from aladdin, Deionized water and ehanol was used for all experiments. Other chemical reagent were purchased from shanghai chemical reagent company.

Synthesis of CNTs/Fe_3O_4 composites

CNTs/Fe_3O_4 nanocomposites were fabricated according to the literature with minor modification. In a typical procedure, 400 mg $Fe(acac)_3$ and 100 mg MWCTs were added to 60 mL TREG and ultrasonicated for 10 min. The resulting mixture was then heated to 278 °C under argon protection and kept at reflux for 30 min. After cooling to room temperature, the obtained composites were magnetically separated by a magnet and washed with ethanol for several times and dried at 60 °C in vacuum.

Synthesis of CNTs/Fe_3O_4@Pdop core–shell composites

Typically, 100 mg of **CNTs/Fe_3O_4** was firstly dispersed in a mixed solution of ethanol (20 mL) and water (15 mL) under sonication. Then, 150 mg of dopamine was added with mechanical stirring. After stirring for 10 minutes, 10 mL of aqueous solution with dissolved tris-base (300 mg) was added as the catalyst, and the resultant solution was gently stirred for 24 h at room temperature.The product was collected by a magnet and washed with deionized water and ethanol three times respectively, and finally dried in vacuum at 60°overnight.

Synthesis of CNTs/Fe_3O_4@Pdop@Au composites

40 mg of the CNTs/Fe_3O_4@Pdop composite solution was added to 30 mL water by sonication to form a stable dispersion, then, 8 mL $HAuCl_4$(1mg/ml) was added into the flask and stirred vigorously for 12 h at room temperature. The product was collected and washed by water and ethanol several times and dried for further use.

Synthesis of CNTs/Fe_3O_4@Pdop@Au composites（by adding $NaBH_4$）

40 mg of the CNTs/Fe_3O_4@Pdop composite solution was added to 30 mL water by sonication to form a stable dispersion, then, 8 mL $HAuCl_4$(1 mg/ml) was added into the flask. Meanwhile, a 2 mL $NaBH_4$ in aqueous solution(10 mg/ml) was added rapidly with vigorous stirring and the reaction mixture was stirred for an additional 30 minutes. The product was collected and washed by water and ethanol several times and dried for further use.

Catalytic Properties of the CNTs/Fe_3O_4@Pdop@Au composites

The reduction of MB by $NaBH_4$ was chosen as a model reaction for the efficiency testing of the Au-immobilized nanoparticle. A given amount of the magnetic catalysts were added into the mixture of $NaBH_4$ and MB (100mg/L) .The colour of the mixture gradually vanished, indicating the reduction of the MB dye. Changes in the concentration of MB were monitored by examining the variations in the maximal UV-Vis absorption at 665 nm. After the catalytic reaction was completed, the nanocatalysts were separated by externally applied magnetic field and then repeated for the catalytic reaction. The recyclability of the nanoparticle catalysis was determined by measuring the maximal UV-Vis absorption of MB at the end of each catalytic degradation reaction.

Measurements and characterizations

The SEM images were obtained by a SS-550 scanning electron microscope (Shimadzu, Japan). Fourier transform infrared (FT-IR) spectra (4000-400 cm^{-1}) in KBr were recorded using the AVATAR 360 FT-IR spectrophotometer (Nicolet, Waltham, USA). The data of UV-vis adsorption were obtained by using UV-2450 spectrophotometer (Shimadzu, Japan). The crystal structure of nanoparticles was determined by X-ray diffractometer (XRD). The XRD pattern of each sample was recorded with a Shimadzu (Japan) D/Max-2500 diffractometer, using a monochromatized X-ray beam with nickel-filtered Cu Kα radiation. The XRD patterns were collected in the range

of 5°<2θ<80° with a dwelling time of 2s and a scan rate of 6.0°/min. The substance is automatically searched by using JCPDS-International Center for Diffraction Data.

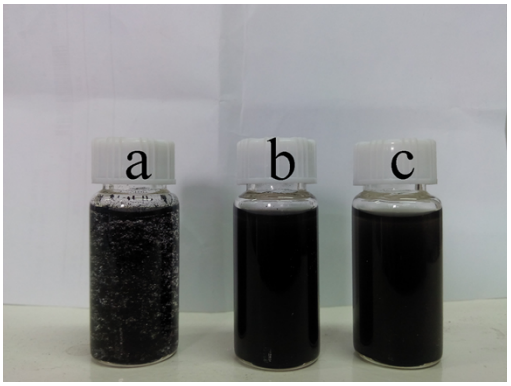

Fig. S1 the optical image of CNTs(a), CNTs/Fe_3O_4(b), CNTs/Fe_3O_4@Pdop(c) dispersed in water for 30 seconds

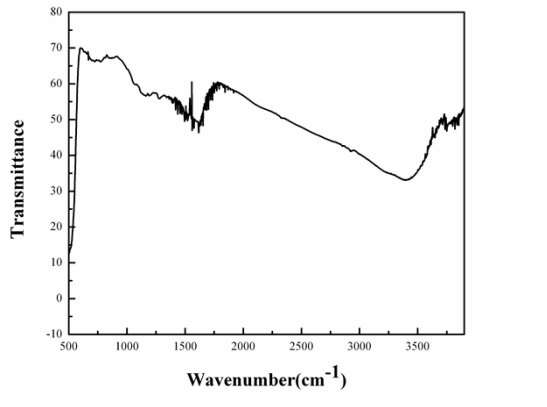

Fig S2 the FTIR of CNTs/Fe_3O_4@Pdop

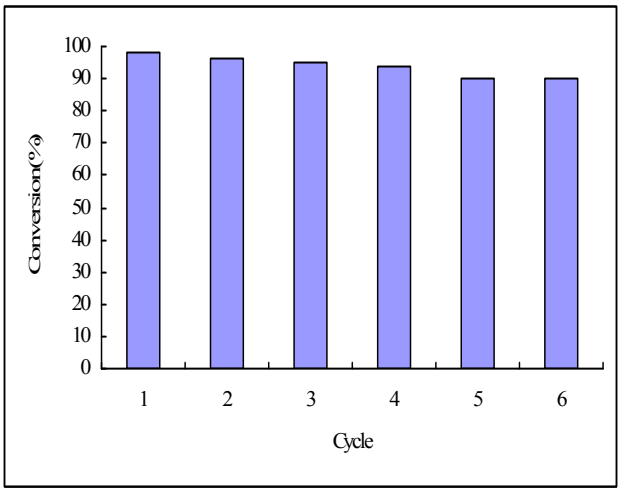

Fig. S3 The recyclability of the CNTs/Fe_3O_4@Pdop@Au as the catalyst for the reduction of MB with $NaBH_4$