Densely Packed UV-Visible Light Responsive Photocatalytic Pairs in Hexagonally Arrayed Silicate Nanochannels for Hydrogen Production

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The use of UV-visible light responsive catalysts in hydrogen production is of high interest owing to reduced energy and environment resources. Here, we present a highly efficient system for photocatalytic hydrogen production, comprising ordered silicate nanochannels embedded with novel visible-light-responsive catalytic phosphotungstic acids (PTA) along the silicate channel walls and arrayed co-catalytic platinum nanoparticles within the channels. The UV-visible-light-responsive PTA catalyst is synthesized by replacing a corner WO^{4+} of PTA with Ni for Ni-ℓPTA, and then embedded onto the walls of hexagonally packed silicate channels during synthesis at an air-liquid interface. In situ grazing incidence small-angle X-ray scattering on the air-liquid interface [1-2] evidence multi-step formation processes of the ordered and oriented silicatropic template PMS and the subsequent formation of Pt NP arrays in the PMS template. Suggested by the X-ray results, the latter process involves anion exchange of the Pt-metal precursors, and the surfactant micelles of the silicate PMS channels, upon UV-visible light irradiation. The hence formed composite Pt-NP@Ni-ℓPMS, with closely packed catalytic pairs of Pt-NP and PTA, demonstrates a high hydrogen production rate upon light illumination, due presumably to efficient generation and transport of photoelectrons. The efficiency of H_2-production surpasses greatly that of PMS or Ni-ℓPMS with or without randomly disperse Pt nanoparticles.

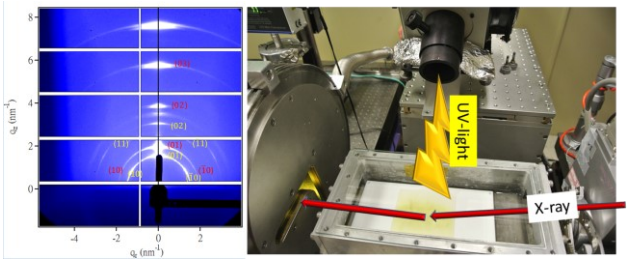

Figure 1. A typical GISAXS pattern of the in situ synthesized Pt-NPs-PTA@silica composite measured at the air-water interface with the instrument setup shown.

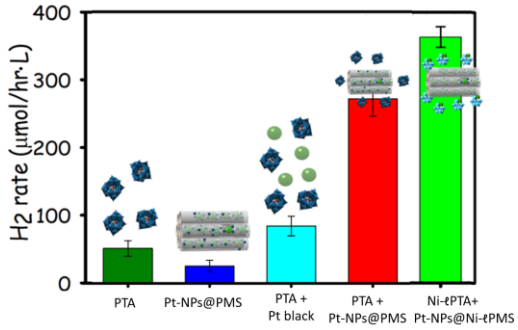

Figure 2. Comparison of the H_2 production rates with the five conditions indicated, showing the synergistic effect of Pt−NPs@Ni-ℓPMS in the solution of Ni-ℓPTA for a best performance.

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[2] Y. H. Lai, S. W. Chen, M. Hayashi, Y. J. Shiu, C. C. Huang, W. T. Chuang, C. J. Su, H. C. Jeng, J. W. Chang, Y. C. Lee, Advanced Functional Materials 2014, 24, 2544-2552.

Keywords: UV-Visible-Light-Responsive PTA, Arrayed Pt nanoparticles, Photocatalytic hydrogen production, meso-ordered silicatropic template, grazing incidence small-angle X-ray scattering