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The Highly Dispersed WO3-x Photocatalyst over the Confinement Effect of Mesoporous SBA-15 Molecular Sieves for Photocatalytic Nitrogen Reduction

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Abstract : As one of the largest industrial synthetic chemicals in the world, ammonia has the advantages of high energy density, easy liquefaction, and easy transportation, which is widely used in agriculture, chemical industry, energy storage, and other fields. The industrial Haber-Bosch method process for ammonia synthesis is generally conducted under severe conditions. It is essential to develop a green, sustainable strategy for ammonia production to meet the growing demand. In this direction, photocatalytic nitrogen reduction has huge advantages over the traditional, well-established Haber-Bosch process, such as the utilization of natural sun light as the energy source and significantly lower pressure and temperature to affect the reaction process. However, the high activation energy of nitrogen and the low efficiency of photo-generated electron-hole separation in the photocatalyst result in low ammonia production yield. Many researchers focus on improving the catalyst. In addition to modifying the catalyst, improving the dispersion of the catalyst and making full use of active sites are also means to improve the overall catalytic activity. Few studies have been carried out on this, which is the aim of this work. In this work, by making full use of the nitrogen activation ability of WO3-x with defective sites, small size WO3-x photocatalyst with high dispersibility was constructed, while the growth of WO3-x was restricted by using a high specific surface area mesoporous SBA-15 molecular sieve with the regular pore structure as a template. The morphology of pure SBA-15 and WO3-x/SBA-15 was characterized byscanning electron microscopy (SEM). Compared with pure SBA-15, some small particles can be found in the WO3-x/SBA-15 material, which means that WO3-x grows into small particles under the limitation of SBA-15, which is conducive to the exposure of catalytically active sites. To elucidate the chemical nature of the material, the X-ray diffraction (XRD) analysis was conducted. The observed diffraction pattern inWO3-xis in good agreement with that of the JCPDS file no.71-2450. Compared with WO3-x, no new peaks appeared in WO3-x/SBA-15.It can be concluded that WO3-x/SBA-15 was synthesized successfully. In order to provide more active sites, the mass content of WO3-x was optimized. Then the photocatalytic nitrogen reduction performances of above samples were performed with methanol as a hole scavenger. The results show that the overall ammonia production performance of WO3-x/SBA-15 is improved than pure bulk WO3-x. The above results prove that making full use of active sites is also a means to improve overall catalytic activity.This work provides material basis for the design of high-efficiency photocatalytic nitrogen reduction catalysts.

Keywords : ammonia, photocatalytic, nitrogen reduction, WO3-x, high dispersibility
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