Editor's Choice
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Development strategies in transition metal carbide for hydrogen evolution reaction: A review

Jun HW, Kim SB, Lee JW

Abstract - Economically viable hydrogen production by water electrolysis requires an inexpensive and efficient electrocatalyst. Transition metal carbides (TMCs) have many merits such as low price, platinum-like catalytic activity, high physical stability, and electrical conductivity. This review presents strategies for improving the catalytic activity of TMCs. It highlights synthesis using nanostructuring by inorganic-organic complexes and carbon supports to increase the number of active sites and to facilitate mass transport, and modification of electronic configuration by heteroatom doping, heterostructure, and phase control to increase intrinsic activity. The review concludes with an outlook on challenges to achieving practical TMC catalysts for the hydrogen evolution reaction.

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Photocatalytic water splitting using hygroscopic MgO modified TiO2/WO3 dual-layer photocatalysts

Huang CW, Liao CH, Wu JCS

Abstract - MgO modified TiO_2/WO_3 dual-layer photocatalysts (DLP) was synthesized by radio-frequency magnetron sputtering (RFMS). The influences of MgO on the properties and the performance of the prepared DLP were investigated. MgO modified TiO2 thin films were characterized by instrumental analysis such as XRD, AFM, SEM-EDS, and UV-visible absorption spectrometry. Their photoactivity was assessed by conducting photovoltammetry followed by splitting water in a twin-cell reactor, where hydrogen gas and oxygen gas were produced separately. The yield of H_2 and O_2 in the twin-cell reactor corresponded to the photovoltammetry results, indicating that MgO can significantly improve the photoactivity of DLP. The improvement is attributed primarily to the hygroscopic Nature of MgO, which can increase the amount of H_2O molecules on the surface of TiO_2 for carrying out the photoreaction. In addition, the incorporated MgO layer can also act as an insulator to suppress the electron leakage that occurred at the TiO_2-water interface.

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Hydrogen storage into monobenzyltoluene over Ru catalyst supported on SiO_2-ZrO_2 mixed oxides with different Si/Zr ratios

Kim TW, Kim CS, Jeong HR, Shin CH, Suh YW

Abstract - Supported Ru catalysts have been often employed for hydrogen charge into liquid organic hydrogen carrier molecules (monobenzyltoluene in this work), and their catalytic performance largely depends upon physicochemical properties of the support materials. We prepared supported Ru catalysts on SiO_2-ZrO_2 with different Si/(Si+Zr) ratios ranging from 0 to 30mol% by loading Ru3(CO)12 onto Si,Zr-mixed metal hydroxide and subsequent thermolysis. The textural properties, Ru particle size, and hydrogenation activity of Ru/SiO_2-ZrO_2 catalysts show a volcanoshaped dependence on the content of Si added, where the maximum is achieved at the Si/(Si+Zr) ratio of 5mol%. Up to this Si content the incorporation of Si into ZrO_2 improves thermal stability and decreases the particle size of tetragonal ZrO_2, resulting in a positive contribution to hydrogen storage efficiency. However, the further addition of Si increases surface heterogeneity and charge imbalance, and hence induces a decrease in the density of surface OH group reacting with Ru3(CO)12, which explains the lowered activity. Therefore, the addition of up to 5mol% Si into ZrO_2 is effective in enhancing the hydrogenation performance of Ru/ZrO_2 owing to the improved textural properties and smaller Ru particles.

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Modified blue TiO2 nanostructures for efficient photo-oxidative removal of harmful NOx gases

Nguyen HH, Gyawali G, Martinez-Oviedo A, Nguyen HP, Lee SW

Abstract - Blue TiO_2 nanostructures were produced via Lithium/ethylenediamine (Li/EDA) reduction method and applied for photo-oxidative removal of harmful NOx gases under simulated solar light irradiation. Blue TiO_2 possesses some unique physicochemical properties such as enhanced visible-light absorption, superficial defects or oxygen vacancies, and the evolution of Ti^{3+} species. Moreover, the photoluminescence spectra (PL) revealed the efficient separation of photoinduced electron-hole pairs in the modified blue TiO_2 nanostructures, enhancing their photocatalytic activities. The results indicated that the blue TiO_2 nanostructures exhibited the highest performance towards photo-oxidation of NOx gases, with an efficiency of 72.6% under simulated solar light irradiation.

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Improvement in separation performance of PEI-based nanofiltration membranes by using L-cysteine functionalized POSS-TiO_2 composite nanoparticles for removal of heavy metal ion

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Abstract - L-cysteine as an amino acid was used for the modification of glycidyl POSS in the synthesis of L-cysteine functionalized POSS, including carboxyl, hydroxyl, and diamine groups. Then, the synthesized nanoparticles were applied to fabrication of L-cysteine POSS-TiO_2 composite nanoparticles. NF membranes were prepared from the incorporation of different concentrations of the synthesized composite nanoparticles into the polyether-imide (PEI) as the membrane matrix. The prepared membranes were characterized by Fourier transform infrared spectroscopy (FTIR), Field emission scanning electron microscopy (FESEM) and atomic force microscope (AFM). Moreover, the separation performance of the NF membranes was examined by pure water flux (PWF) and the separation of Na2SO4, $Pb(NO_3)_2$, $Cr(NO_3)_2$ and $Cu(NO_3)_2$ aqueous solutions. The results showed the increase of pure water flux due to present hydrophilic groups on the membrane surface. The highest pure water flux obtained was 22.03 L/m2h in 1 wt% of nanoparticles. Furthermore, the rejection of Na_2SO_4 and $Pb(NO_3)_2$, $CrSO_4$, and $Cu(NO_3)_2$ improved to 78%, 64%, 67% and 66% that increased 11%, 33%, and 22%, and 39% compared with the pristine PEI membrane, respectively. Finally, the best FRR% (81%) was obtained for 0.1 wt% of the composite nanoparticles (M3).

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Multi-functional NiO/g-C_3N_4 hybrid nanostructures for energy storage and sensor applications

Ngo YLT, Chung JS, Hur SH

Abstract - A multi-functional NiO/g-C_3N_4 (NC) hybrid nanostructure was synthesized by a hydrothermal process using melamine and $Ni(OH)_2$ as precursors followed by thermal treatment. The optimal conditions were determined by studying the process conditions, such as the $Ni(OH)_2$ to melamine ratio and thermal treatment temperature. The NC prepared in this study exhibited both excellent glucose sensing properties and supercapacitor properties. A very high glucose sensitivity, as high as 5,387.1 μA $mM^{-1}cm^{-2}$, and excellent energy density of 49.6Wh kg^{-1} at a power density of 1,064.2W kg^{-1} were obtained when NC was used as the electrode material for glucose sensing and symmetric supercapacitor, respectively. A flexible glucose sensing device using a flexible substrate and self-powered glucose sensor system that used the same material (NC) for the both power supply and sensing devices were also demonstrated.