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Preparation and Characterization of CuFe2O4/TiO2 Photocatalyst for the Conversion of CO2 into Methanol under Visible Light

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Abstract : A systematic study was conducted to explore the photocatalytic reduction of carbon dioxide (CO₂) into methanol on TiO₂ loaded copper ferrite (CuFe₂O₄) photocatalyst under visible light irradiation. The phases and crystallite size of the photocatalysts were characterized by X-ray diffraction (XRD) and it indicates CuFe₂O₄ as tetragonal phase incorporation with anatase TiO₂ in CuFe₂O₄/TiO₂ hetero-structure. The XRD results confirmed the formation of spinel type tetragonal CuFe₂O₄phases along with predominantly anatase phase of TiO₂ in the CuFe₂O₄/TiO₂ hetero-structure. UV-Vis absorption spectrum suggested the formation of the hetero-junction with relatively lower band gap than that of TiO₂. Photoluminescence (PL) technique was used to study the electron–hole (e[−]/h⁺) recombination process. PL spectra analysis confirmed the slow-down of the recombination of electron–hole (e[−]/h⁺) pairs in the CuFe₂O₄/TiO₂ hetero-structure. The photocatalytic performance of CuFe₂O₄/TiO₂ was evaluated based on the methanol yield with varying amount of TiO₂over CuFe₂O₄ (0.5:1, 1:1, and 2:1) and changing light intensity. The mechanism of the photocatalysis was proposed based on the fact that the predominant species of CO₂ in aqueous phase were dissolved CO₂and HCO₃⁻at pH ~5.9. It was evident that the CuFe₂O₄ could harvest the electrons under visible light irradiation, which could further be injected to the conduction band of TiO₂ to increase the life time of the electron and facilitating the reactions of CO₂ to methanol. The developed catalyst showed good recycle ability up to four cycles where the loss of activity was ~25%. Methanol was observed as the main product over CuFe₂O₄, but loading with TiO₂ remarkably increased the methanol yield. Methanol yield over CuFe₂O₄/TiO₂ was found to be about three times higher (651 μmol/g_{cat}L) than that of CuFe₂O₄photocatalyst. This occurs because the energy of the band excited electrons lies above the redox potentials of the reaction products CO₂/CH₃OH.

Keywords : photocatalysis, CuFe2O4/TiO2, band-gap energy, methanol
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