Chemical Engineering Master's Defense

CO_2 Photocatalytic Reduction to Fuels

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abstract

A new photocatalytic material was synthesized to investigate its performance for the photoreduction of carbon dioxide (CO_2) in the presence of water vapor (H_2O) to valuable products such as carbon monoxide (CO) and methane (CH_4). The performance was studied using a gas chromatograph (GC) with a flame ionization detector (FID) and a thermal conductivity detector (TCD). The new photocatalytic material was an ionic liquid functionalized reduced graphite oxide (IL-RGO (high conductive surface))-TiO_2 (photocatalyst) nanocomposite. Brunauer-Emmett-Teller (BET), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, and UV-vis absorption spectroscopy techniques were employed to characterize the new catalyst. In the series of experiments performed, the nanocomposite material was confined in a UV-quartz batch reactor, exposed to CO_2 and H_2O and illuminated by UV light. The primary product formed was CO with a maximum production ranging from 0.18-1.02 μmol(gcatalyst-hour)$^{-1}$ for TiO_2 and 0.41-1.41 μmol(gcatalyst-hour)$^{-1}$ for IL-RGO-TiO_2. A trace amount of CH_4 was also formed with its maximum ranging from 0.009-0.01 μmol(gcatalyst-hour)$^{-1}$ for TiO_2 and 0.01-0.04 μmol(gcatalyst-hour)$^{-1}$ for IL-RGO-TiO_2. A series of background experiments were performed and results showed that; (a) the use of a ionic liquid functionalized reduced graphite oxide -TiO_2 produced more products as compared to commercial TiO_2, (b) the addition of methanol as a hole scavenger boosted the production of CO but not CH_4, (c) a higher and lower reduction time of IL-RGO as compared to the usual 24 hours of reduction presented basically the same production of CO and methane, (d) the positive effect of having an ionic liquid was demonstrated by the double production of CO obtained for IL-RGO-TiO_2 as compared to RGO-TiO_2 and (e) a change in the amount of IL-RGO in the IL-RGO-TiO_2 represented a small difference in the CO production but not in the CH_4 production. This work ultimately demonstrated the huge potential of the utility of a UV-responsive ionic liquid functionalized reduced graphite oxide-TiO_2 nano-composite for the reduction of carbon dioxide in the presence of water vapor for the production of fuels.

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