Ambient Pressure X-ray photoemission spectroscopy study of the photocatalytic reduction of CO_2 on ZnO/Cu_2O nanoparticle heterojunction

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Abstract

In this research, we report a photocatalytic reduction study of carbon dioxide on type II semiconductor heterojunction. We prepared a series of samples such as ZnO(7%)/Cu_2O(cube), ZnO(7%)/Cu_2O(r.d.) and ZnO(40%)/Cu_2O(r.d.). Two cuprous oxide structures were selected for the anticipated difference in photocatalytic performance: the cubic structure terminated with (100) face, and the rhombic dodecahedron (r.d.) terminated with (110) face. Ambient pressure XPS (APXPS) was used to track the change of reaction species on the photocatalyst surfaces. The ZnO/Cu_2O(r.d.) is found to be more reactive than ZnO/Cu_2O(cube), as evidenced by a larger production of carbon intermediates such as formate, carbonyl, and methoxy on the surface by means of APXPS C 1s spectra. Further, more ZnO loading, 40% vs. 7%, on Cu_2O(r.d.) produces more methane instead of methanol. The energy diagram relevant to the performance of photocatalyst is also constructed by using APXPS data. The heterojunction of Cu_2O(cube)-ZnO has smaller valence and conduction band offsets than its counterpart of ZnO/Cu_2O(r.d.). Based on the band diagrams, ZnO(7%)/Cu_2O(r.d.) photocatalyst perform according to the so-called Z-scheme system.

Keywords – APXPS, CO_2 photoreduction catalyst, cuprous oxide/zinc oxide.