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Photoelectrocatalytic Production of Solar Fuels from Water and CO_2

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Abstract

There is renewed interest in the photocatalytic and photoelectrochemical conversion of CO_2 into value-added chemicals using various semiconductor particles and electrodes. Common CO_2 reduction products are C1 chemicals (CO, HCOOH, CH_3OH, and CH_4) in aqueous media, while the production of C2-C4 hydrocarbons (e.g., C_2H_6 and C_3H_8) has also been reported. A number of solar-active materials have been reported, but they still suffer from low selectivity, poor energy efficiency, and instability, while failing to drive simultaneous water oxidation. In this regard, p-type $CuMO_2$ (where M = Al^{3+} and Fe^{3+}) is highly promising because of its unique structure; suitable bandgap energies; high conduction band level, which is sufficient for H_2 production and CO_2 reduction; and relative stability in aqueous solution. Unfortunately, the typical synthetic route for $CuMO_2$ is annealing a Cu(I) and M(III) salt mixture at high temperature, which inevitably results in irregular, coarse particles of several micrometers. Furthermore, the as-synthesized particles are difficult to fabricate into durable films on transparent conducting oxide (TCO) substrates because of the absence of particle-to-particle interaction. Even if they are fabricated, the films have less intimate and looser interparticle connections undergoing a significant charge recombination at the solid/solid interface. This difficulty in synthesizing $CuMO_2$ films has caused this material to be less studied despite its potential as a promising photocathode. With this in mind, we have attempted to synthesize high-efficiency $CuMO_2$ films on TCO substrates via electrochemical deposition. This talk presents our recent studies on the solar CO_2 conversion to value-added chemicals while using water as an electron donor in various photo-systems [1-11].

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