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Compositional Dependence of Hydroxylated Indium-Oxide on the Reaction Rate of CO2/H2 Reduction

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Abstract : A major goal in the emerging field of solar fuels is to realize an 'artificial leaf' – a material that converts light energy in the form of solar photons into chemical energy – using CO2 as a feedstock to generate useful chemical species. Enabling this technology will allow the greenhouse gas, CO2, emitted from energy and manufacturing production exhaust streams to be converted into valuable solar fuels or chemical products. Indium Oxide (In2O3) with surface hydroxyl (OH) groups have been shown to reduce CO2 in the presence of H2 to CO with a reaction rate of 15 μmol gcat−1 h−1. The likely mechanism is via a Frustrated Lewis Pair sites heterolytically splitting H2 to be absorbed and form protonic and hydric sites that can dissociate CO2. In this study, we investigate the dependence of oxygen composition of In2O3 on the CO2 reduction rate. In2O3-x films on quartz fiber paper were DC sputtered with an Indium target and varying O2/Ar plasma mixture. OH surface groups were then introduced by immersing the In2O3-x samples in KOH. We show that hydroxylated In2O3-x reduces more CO2 than non-hydroxylated groups and that a hydroxylated and higher O2/Ar ratio sputtered In2O3-x has a higher reaction rate of 45 μmol gcat-1 h-1. We show by electrical resistivity-temperature curves that H2 is adsorbed onto the surface of In2O3 whereas CO2 itself does not affect the indium oxide surface. We also present activation and ionization energy levels of the hydroxylated In2O3-x under vacuum, CO2 and H2 atmosphere conditions.

Keywords : solar fuels, photocatalysis, indium oxide nanoparticles, carbon dioxide
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