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Limiting factors in Photovoltaic-Electrochemical cell development for syngas production

Abstract:
One of the ways to reduce the CO2 concentration in air is to convert it to any valuable product(s), such as fuels. This can be achieved by employing photo-electrochemical route. However, this is an energy intensive technique and almost 50% cost of fuel production goes into the applied electrical power. The success of this technique can be achieved if the applied power is derived from a source that is (1) cheap, (2) non-toxic (3) renewable and (4) up scalable. Wind and solar photovoltaics are good candidates to serve this purpose. With sharp decrease in the price of PV energy, especially record low auction values (0.027$/kWh!), it is a very attractive power source. We have looked into various types of catalysts Zn, porous Zn, Cu-In, and estimated the Faradaic efficiencies of the production of hydrogen (H2) and carbon-monoxide (CO) from CO2 splitting in a electrochemical cell. We made various types of solar PV power sources, i.e., modules made from a-Si/a-Si/nc-Si triple junction cells, a-Si/nc-Si tandem cells and silicon heterojunction solar cells. Comparing the current voltage characteristics of the electrochemical cells and PV modules, we estimated solar to fuel conversion efficiency of CO over 3% for Zn and porous Zn catalysts for CO2 splitting. We tried as a demonstration a PV wired electrochemical cell with Cu-In catalyst, which produced very small quantity of CO and the STF efficiency was below 1%. The coupling loss was observed with the wired connection which affects the product efficiency. The solution to this problem can be found by reducing the operational voltage and equi-balance current flows in these two devices.

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