210d Production of H_2 by Hydrolysis of Zn Aerosol Freshly Made by Evaporation and Condensation

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The production of solar hydrogen via the Zn/ZnO water-splitting thermochemical cycle consists of a 1st step solar endothermic dissociation of ZnO and a 2nd step non-solar exothermic hydrolysis of Zn. We report on a novel combined process for the efficient execution of the second step that encompasses the formation of Zn nanoparticles followed by their in-situ hydrolysis for H_2 generation. The advantages of using Zn nanoparticles are three-fold: 1) their inherent high specific surface area augments the reaction kinetics, heat transfer, and mass transfer; 2) their large surface to volume ratio favors complete or nearly complete oxidation; and 3) their entrainment in a gas flow allows for simple, continuous, and controllable feeding of reactants and removal of products. This combined process is experimentally demonstrated using a tubular aerosol flow reactor featuring Zn-evaporation, steam-quenching, and Zn/H_2O-reaction zones. When the latter zone was operated continuously at just below the Zn(g) saturation temperature, Zn particles of 69 nm BET equivalent crystallite size were formed and hydrolyzed up to a 83% degree of chemical conversion, while the H_2 yield reached up to 70% after a single pass of H_2O of 0.85 s residence time and for a set Zn-evaporator furnace temperature of 1023 K.