Towards sustainable production of hydrogen employing consolidated bioprocessing of lignocellulosic biomass

Hydrogen (H2) has the highest energy density of all biofuels known to date which exceeds more than three times that of gasoline. In contrast to gasoline, there are no greenhouse gas emissions, as H2 is a carbon-free fuel with water as the only product of combustion. However, currently about 95% of H2 is produced via steam reforming of fossil-based feedstocks such as methane that significantly contributes to pollution. A potentially viable alternative for sustainable production of H2 is presented through biological fermentation of renewable biomass sources. As current cost of lignocellulose conversion to bioenergy ($15-$25/GJ) exceeds the cost of fossil fuels ($3.31-$17.37/GJ), development of an economically-feasible, large-scale H2 production system would require the use of low-cost materials such as energy crops (switchgrass, SWG) and biomass waste (municipal solid waste, MSW). Furthermore, competitive large-scale production of bio-H2 is to be based on advanced biological process such as Consolidated Bioprocessing (CBP). CBP using thermophilic microorganismsoffers several techno-economic advantages, including increased conversion rates, substrate accessibility, solubility, etc. H2 production utilizing the CBP capabilities of the extreme thermophile Caldicellulosiruptorsaccharolyticus DSM 8903 were examined in dark fermentation of carbon sources such as glucose, cellulose, SWG and MSW. While H2 production from glucose reached the theoretical maximum for dark fermentation of 4 mol H2/mol glucose, C. saccharolyticus was able to produce H2 directly from mechanically-comminuted SWG without any physicochemical or biological pretreatment. Combining four processing steps (pretreatment, enzyme production, saccharification and fermentation) into a single biorefinery operation makes C. saccharolyticus a promising CBP candidate for cost-efficient, environmentally-friendly and sustainable H2 production with overall production cost savings exceeding 50%.

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