World Academy of Science, Engineering and Technology
International Journal of Chemical and Molecular Engineering
Vol:17, No:05, 2023

Harvesting Value-added Products Through Anodic Electrocatalytic Upgrading Intermediate Compounds Utilizing Biomass to Accelerating Hydrogen Evolution

Authors : Mehran Nozari-Asbemarz, Italo Pisano, Simin Arshi, Edmond Magner, James J. Leahy

Abstract : Integrating electrolytic synthesis with renewable energy makes it feasible to address urgent environmental and energy challenges. Conventional water electrolyzers concurrently produce H_2 and O_2, demanding additional procedures in gas separation to prevent contamination of H_2 with O_2. Moreover, the oxygen evolution reaction (OER), which is sluggish and has a low overall energy conversion efficiency, does not deliver a significant value product on the electrode surface. Compared to conventional water electrolysis, integrating electrolytic hydrogen generation from water with thermodynamically more advantageous aqueous organic oxidation processes can increase energy conversion efficiency and create value-added compounds instead of oxygen at the anode. One strategy is to use renewable and sustainable carbon sources from biomass, which has a large annual production capacity and presents a significant opportunity to supplement carbon sourced from fossil fuels. Numerous catalytic techniques have been researched in order to utilize biomass economically. Because of its safe operating conditions, excellent energy efficiency, and reasonable control over production rate and selectivity using electrochemical parameters, electrocatalytic upgrading stands out as an appealing choice among the numerous biomass refinery technologies. Therefore, we propose a broad framework for coupling H2 generation from water splitting with oxidative biomass upgrading processes. Four representative biomass targets were considered for oxidative upgrading that used a hierarchically porous CoFe-MOF/LDH @ Graphite Paper bifunctional electrocatalyst, including glucose, ethanol, benzyl, furfural, and 5-hydroxymethylfurfural (HMF). The potential required to support 50 mA cm-2 is considerably lower than (~ 380 mV) the potential for OER. All four compounds can be oxidized to yield liquid byproducts with economic benefit. The electrocatalytic oxidation of glucose to the value-added products, gluconic acid, glucuronic acid, and glucaric acid, was examined in detail. The cell potential for combined H_2 production and glucose oxidation was substantially lower than for water splitting (1.44 V(RHE) vs. 1.82 V(RHE) for 50 mA cm-2). In contrast, the oxidation byproduct at the anode was significantly more valuable than O_2, taking advantage of the more favorable glucose oxidation in comparison to the OER. Overall, such a combination of HER and oxidative biomass valorization using electrocatalysts prevents the production of potentially explosive H_2/O_2mixtures and produces high-value products at both electrodes with lower voltage input, thereby increasing the efficiency and activity of electrocatalytic conversion.

Keywords : biomass, electrocatalytic, glucose oxidation, hydrogen evolution
Conference Title : ICESTE 2023 : International Conference on Energy Storage Technology and Electrochemistry
Conference Location : London, United Kingdom
Conference Dates : May 15-16, 2023