Hydrogen production via hydrothermal gasification of algal biomass using hydrochar catalyst as a solid waste of the process

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Abstract

Catastrophic environmental effects resulting from the combustion of fossil fuels along with the fast depletion of the fossil reserves threaten both energy security and environmental sustainability as the objectives of sustainable development in the context of energy. Hydrogen, which is regarded as the main energy carrier of the future is one of the most versatile alternatives for energy supply in the future and to approach carbon-free society for combating climate change. However, hydrogen can't be found in its pure form in nature while it can be made from some hydrogen-containing resources. Nowadays, more than 90% of hydrogen is produced from steam methane reforming method which uses methane as a fossil fuel. Biomass as an abundant and renewable resource which contains significant amounts of carbon and hydrogen have been used for production of energy carriers and chemicals in the recent decades.

Algal biomass as third generation of feedstocks has advantages over agricultural wastes. More availability of cellulosic content, minimum and usage for cultivation and no conflict with food cycle are among these advantages. Hydrothermal gasification has been known as an efficient method for producing hydrogen-rich gas from bio-waste materials. However, there are some challenges in the decomposition of biomass depending on its structure and operational conditions of the reactor system. Catalysts are used mostly to enhance the yield of intended products. Gasification of *Enteromorpha Prolifera* as macroalgae found in Caspian Sea has been investigated in this study using stainless steel batch micro-reactor in supercritical water media (T>374 °C, P>22.1 Mpa). Solid waste of this process was employed as a catalyst to improve the gasification efficiency and increase hydrogen yield. Non-catalytic experiments were performed first, to obtain the optimum condition in term of hydrogen yield.

Catalytic experiments were carried out using the solid waste of hydrothermal gasification named hydrochar as a catalyst. The algal hydrochar contained significant amount of Alkali and alkaline earth metals favored it for enhancing the decomposition of biomass and for higher gas production. Moreover, K and Na existed in the hydrochar accelerated the water-gas shift reaction which produced H_2 and CO_2 by the consumption of CO and H_2O. The produced hydrochar had also a porous structure which made it suitable for catalytic use. H2 and CO2 production were promoted significantly by re-adding hydrochar as a catalyst to the process and it was comparable with that of conventional catalysts made of transition metals.

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