Environmental and techno-economic assessment on local distributed hydrogen production by low-grade aluminum and acidic hot spring water

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Hydrogen is the cleanest burning fuel found abundant in nature with a high energy density of 142 MJ/kg and thus regarded as a future energy carrier. Global hydrogen production mainly involves fossil fuel use, which is not environmentally friendly unless it considers carbon capture storage. Renewable hydrogen production is then becoming a prominent option worldwide. However, challenges on renewables owing to intermittency, seasonal, and geographic constraints have concerned its deployment. Therefore, hydrogen feedstock is required to go hand-in-hand with the best potential of local resources.

We used low-grade aluminum and acidic hot spring reactions to produce hydrogen onsite at Tamagawa hot spring neutralization facility. The low-grade aluminum materials used were aluminum dross and aluminum chips. The acidic hot spring used had extremely low pH (~1) and boiling temperature (~100ºC). The study also involved an environmental and techno-economic assessment for further development on the local scale.

Our results confirmed a potential application of low-grade aluminum and acidic hot springs for hydrogen generation with hydrogen by volume reaching 50-96 wt.%. Aluminum cutting chips had a higher yield than aluminum dross due to its higher aluminum content. The environmental assessment results indicated that low-grade aluminum and acidic hot spring reaction provided lower carbon dioxide emissions and energy consumptions than other methods, which was advantaged from a carbon dioxide reduction of the hot spring neutralization process [1]. The techno-economic assessment resulted in hydrogen cost in our system being slightly higher than other centralized production plants, but the capital cost was the lowest, even with a small plant capacity, which means the system is well-suited for local distributed hydrogen production. The hydrogen cost was within the range of 2.74-16.62 per kg hydrogen, which seemed realistic to satisfy Japan's 2030 target of ~$11.1 per kg (~$1 per Nm^3).

One of the potential sites for pilot plant implementation of this local initiative is Semboku City (Akita Prefecture, Japan), where Tamagawa hot springs are located. Semboku City can manage hydrogen fuel for tourism buses operation across renowned Tazawa Lake, Tamagawa Dam, Tamagawa Hot Spring Nature and Ecological Center, and surrounding areas.

[1] Alviani VN, Hirano N, Watanabe N, Oba M, Uno M, Tsuchiya N. Appl Energy 2021;293:116909. doi:10.1016/j.apenergy.2021.116909.

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