Biohydrogen production from waste: experimental investigation and deployment prospect for transportation

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Topic 1: Sustainable resources for decarbonising the economy
Sub-topic 1.5 Municipal and industrial wastes

Aim and approach

The need of sustainable municipal solid waste management and the requirement of a reliable and constant source of renewable energy are the pillars of the current environmental agendas of many developing and developed countries. The interest has recently polarized towards a combined solution represented by the use of waste as a source of renewable energy. This can also favour the decarbonisation of critical sectors like domestic heating and public transport, for which an effective solution has yet to be developed. Hydrogen (blue, green or bio) will be essential to support the UK and EU's commitment to reach carbon neutrality by 2050 and for the global effort to implement the Paris Agreement while working towards zero pollution. One promising approach is hydrogen production by gasification of waste and the subsequent upgrading of the syngas to bioH_2 for use in public transportation (trains, buses and trucks). The aim of this work is the development of a detailed process model for bioH_2 production in a commercial plant capable of meeting the fuel cell specification of hydrogen purity with high recovery. In order to inform and validate the process model, experiments will be conducted in a waste gasification plant for BioSNG production operated by ABSL in Swindon (UK)[1]. Laboratory-scale experiments will also be conducted to test the suitability of the produced bioH2 for use in PEM fuel cells.

Innovation and relevance

In recent years, hydrogen has received increasing attention as a high efficiency potential fuel that could be produced from non-fossil fuel sources, since this can be generated with low

[1] Materazzi, M. et al., 2018. Production of BioSNG from waste derived syngas: pilot plant operation and preliminary assessment. Waste Manage. 79, 752–762. https://doi.org/10.1016/j.wasman.2018.08.031.

greenhouse-gas (GHG) emissions, and it generates no emissions at the point of use. Hydrogen is being promoted as an ideal energy vector for heating and transport, especially on bus and train routes that are not suitable for electrification, but can also help with other transport sectors such as heavy goods vehicles and shipping. In this work, a semi-commercial process for the production of affordable, low carbon hydrogen from waste is investigated. Waste-to-Hydrogen technologies represent a valid alternative to the most predominant pathways for production of low carbon hydrogen (e.g. blue H_2 via steam methane reforming and green H_2 via electrolysis). The solution presented aims to tackle the problem of municipal solid waste management and pollution, by considering waste not as a burden to be dealt with but as a valuable feedstock. It can reduce greenhouse gas emissions from public transport to address climate change and environmental sustainability. It is estimated that the carbon intensity of the biohydrogen will be around 80% lower than hydrogen made by reforming natural gas and a negative impact is possible when carbon capture and sequestration is accounted.[2] Moreover, while thermochemical conversion of biomass in fluidised bed reactors can be successfully achieved at commercial scale, more difficult feedstocks, such as RDF and other solid waste streams with high content of volatile matter, are still under investigation at laboratory and pilot scale.

Preliminary results and conclusions

Preliminary model results enabled to assess and investigate the performance of a commercial waste gasification plant and what are the cleaning steps necessary to meet the requirements and the standards for transport-grade hydrogen. The model showed that it is possible to produce a bioH_2 stream (H_2 purity >99.98% and CO content well below 0.2 ppm) with the technologies commercially available (PSA for hydrogen purification, gas conditioning units) and a plasma assisted gasification process. Reduction of carbon monoxide to very low levels will be achieved both with conventional separation technologies and chemical conversion. Preliminary tests on long-term operation of PEM fuel cells on biohydrogen will be presented.

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[2] Materazzi, M. et al., 2019. Production of biohydrogen from gasification of waste fuels: Pilot plant results and deployment prospects. Waste Manage. 94, 95–106. https://doi.org/10.1016/j.wasman.2019.05.038