Tackling real-stream complexity in the valorization of microalgae HTC wastewater via aqueous phase reforming

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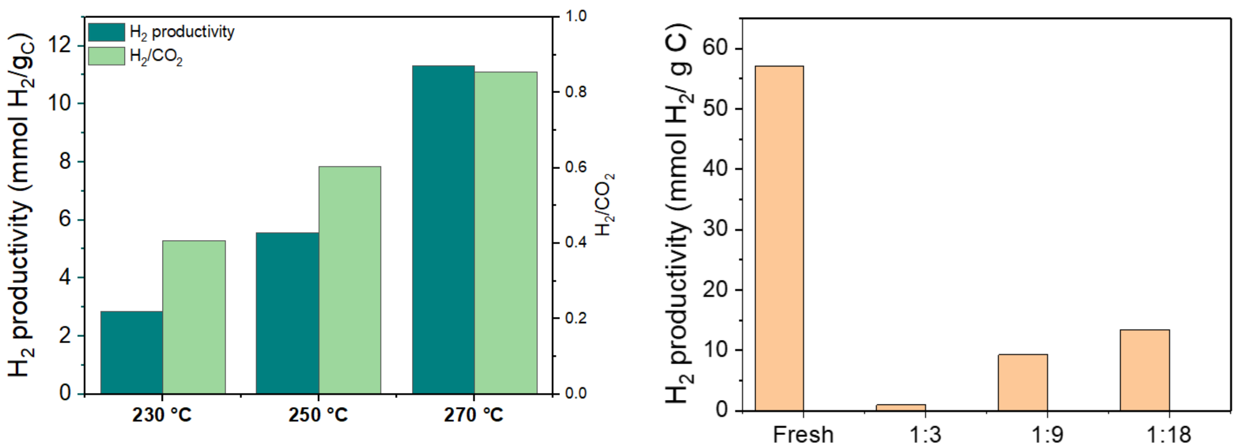
Hydrothermal carbonization (HTC) mimics natural coalification to convert wet biomass into a carbon-rich solid (hydrochar) with high fuel value. However, the process also generates a significant aqueous by-product (HTC-AP), accounting for up to 20 wt% of the biomass. This liquid stream contains a complex mix of organic and inorganic compounds and poses both environmental and economic challenges due to disposal costs. To address this issue, we explored the aqueous phase reforming (APR) process, which converts biomass-derived compounds dissolved in water into hydrogen and alkanes at moderate temperatures (220–270 °C) and pressures. Despite its potential, APR of HTC-AP from microalgae remains unexplored—mainly due to the analytical and operational challenges of real feedstocks.

Here, we present the first APR study of HTC-AP from microalgae, with three main objectives: i) developing a reliable method to characterize the organic and inorganic content of the wastewater; ii) identifying APR conditions that maximize gas production—especially hydrogen—while minimizing residual organics in the liquid; iii) reducing solid residue formation, a key cause of catalyst deactivation. The figure below shows two representative outcomes. On the left, increasing the reaction temperature boosts both hydrogen productivity and selectivity, driven by higher glycerol conversion. On the right, we demonstrate that diluting HTC-AP (from 1:3 to 1:18) mitigates catalyst fouling, as confirmed by reuse tests with glycolic acid, a model compound (namely fresh, in the figure). Improved performance under diluted conditions marks a step toward long-term viability of APR for treating complex aqueous waste. These results support the integration of HTC and APR in a circular bioeconomy framework, enabling the conversion of both solid and liquid outputs into energy carriers.



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