Title: Life Cycle Environmental Assessment and Techno-Economic Analysis of Green and Low-carbon Ethanol Production by Low-value Tail gas

Abstract:

Conversion of low-value tail-gas from industries into ethanol (TG-ethanol) was a promising cutting-edge route for value-added utilisation of tail-gas. However, a systematic and objective understanding of the technol-economic analysis (TEA) and environmental impact benefits is still lacking. In this work, this technology's TEA and environmental footprint are systematically evaluated by life cycle assessment (LCA) and compared with its competitors. Results show the TG-ethanol is the most environmentally benign option, whose environmental impact value is 22%-25% lower than that of the Corn-ethanol and Coal-ethanol. By taking the tail gas from the Chinese steel industry as an example, it is found that TG-ethanol's carbon reduction potential can achieve 5.6 Mt CO_2/year by 2060, with 19.9-23.4 billion RMB economic profit compared with TG-originated power route. In addition, the carbon reduction potential of technologies was more focused in the context of carbon neutrality. To address the low carbon efficiency of TG-ethanol, we proposed an upgraded technology of TG-ethanol coupled with Electro-catalytic CO_2 reduction (ECR), which is modelled by modular engineering process with Aspen Plus and then performed the TEA and LCA analysis with Monte Carlo simulation. Results indicate that ECR $\leq$ 0.7 scenario was more attractive with a net present value (NPV)>0 in considered 17 scenarios. Furthermore, the enormous carbon reduction potential of CO-70% at an ECR-0.9 was 63%, which is an exciting result for the carbon neutrality target. Furthermore, a sensitivity analysis was performed to identify the high-impact variables for this research. We can conclude that the ethanol price and photovoltaic (PV) cost are the key factors affecting NPV, and coal-to-steam, PV and grid-power are the driving factors dominating LCA carbon reduction potential. Finally, we hope this work allows researchers and stakeholders to see technology's economic potential and environmental impact while it is still in development based on experimental and modelling work results.