Hydrothermal liquefaction of microalgae and subsequent heterogeneous catalytic upgrading of biocrude oil

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Both macroalgae and microalgae are both renewable feedstock, with the potential of the production of biofuels to displace fossil fuels and without jeopardising food and feed production. The major drawback is their high water content. Consequently, algae processing including lipid extraction and common thermochemical conversion techniques require a prior drying step which comes with both an energy and a cost penalty. Hydrothermal liquefaction (HTL) is a thermochemical conversion technique in which the feedstock is converted into a liquid biocrude by means of hot, compressed water. HTL as such can process wet algae and avoids the required drying step. Apart from the biocrude, HTL also yields a gas, an aqueous and a solid phase.

Multiple species of microalgae were liquefied and biocrude yields around 50-60 wt% (daf) were obtained in both batch and continuous reactor systems. The resultant biocrude contained significant quantities of oxygen (up to 15 *wt*%) and nitrogen (up to 8 *wt*%). Hence, upgrading experiments were carried out to reduce the heteroatom content (O, N and S) in the biocrude by means of hydrotreating using heterogeneous catalysis. Hydrotreating was carried out in small batch 10 ml micro-autoclaves at 400°C, with 20 *wt*% catalyst, for 4 hours. The catalysts tested were Pt/Al_2O_3 and HZSM-5, and a control treatment without catalyst was carried out in conjunction. Hydrogen pressures of 4 to 8 MPa were applied.

Results showed a significant reduction in O and S content after hydrotreating, while the N-content reduction appeared to depend on the algae feedstock the HTL oil was made of. The overall higher heating value of the upgraded oils was around 40 MJ/kg. However, no significant differences were noticed between the control (i.e. no catalyst) and the heterogeneously catalysed treatments in terms of oil yield and oil composition. Although the hydrotreatment achieves the stated goal of producing a refinery-blendable liquid, the small-to-insignificant effect of the catalyst addition is likely due to mass transfer limitations (i.e. improper mixing) and selection of sub-optimal catalyst types. Future research efforts should be directed at tackling these two issues.