Catalysts for better biofuel production

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Credit: Antoni Shkraba from Pexels

Biomass is far more complex than conventional feedstock and the development of the necessary catalysts is traditionally a lengthy and complicated process. For Europe to meet its long-term target of reducing greenhouse gas emissions by 80-95 % by 2050, cost-effective biomass conversion to fuels is essential.

The EU-funded FASTCARD project used two different routes to meet European commitments to the production of advanced biofuels. The first involved the 'liquefaction' of biomass and is the closest to competing economically with fossil fuels, while the second employed gasification of biomass, which can be economically challenging over the short-term. "The initiative integrated fundamental theoretical studies and insights conducted at the molecular level with models and experimental activities carried out at a pilot scale," says project coordinator Dr. Duncan Akporiaye.

Research enabled the short- and long-term implementation of advanced biofuel production based on the rapid and risk reducing industrialisation of nano-catalytic processes via liquid-based and gas-based value chains. The consortium combined it with micro-kinetic and process design level modelling to better understand the mechanisms and economics underlying these processes. "These models will assist in identifying promising next generation catalysts, as well as in the scale-up from the laboratory to the industrial scale," explains Dr. Akporiaye.

Improved performance

Researchers developed a novel 'rational design' for nano-catalysts based on scalable mathematical and physical models. This was used to predict the performance of bio-feedstocks for better control. They also created industrially relevant, insightful downscaling methodologies for evaluating the impact of diverse bio-feedstocks on catalyst performance. According to Dr. Akporiaye: "The micro-kinetic models can be applied to the four major steps of the two routes to advanced fuels."

Project partners addressed the main challenges influencing the efficiency and implementation of the four key catalytic steps in biobased processes. They included improving selectivity and stability in hydrotreating (HT) and increasing bio-oil content co-fluid catalytic

cracking (co-FCC), which both form the liquid value chain. Use of HT helped develop a new generation of catalysts to produce a co-feed to existing FCC units, thereby minimising the overall level of treatment. Challenges included catalyst performance in lowering hydrogen consumption, pressure and temperature to improve durability and increase selectivity in relation to oxygen removal.

The co-FCC step was able to co-process bio-feeds and crude oil distillates in FCC units, showing similar or better performance than a state-of-the-art FCC catalyst, by maximising the content of the feed blend. The new catalyst should match specifications for hydrothermal stability and reduce the use of strategic resources like rare earths and precious metals by at least 20 %.

Reduced risk

Scientists also selected and tested hydrocarbon (HC) reforming catalysts under realistic conditions for producing syngas from biomass and investigated the effect of nickel and/or palladium with iron on catalytic properties. In addition, the carbon dioxide tolerant Fischer Tropsch step was used to develop novel catalysts aimed at small delocalised 500-3 000 barrels per day biomass-to-liquid-fuel-plants, which improved C5+ HC selectivity and stability to operating at higher temperatures, under fluctuating syngas conditions. This resulted in increased productivity, greater energy savings and reduced capital expenditure.

FASTCARD provides greater understanding of the process at the pilot scale for the two key routes to advanced biofuels. "The project will help participating companies to translate the experimental results previously carried out at the lab scale to the pilot scale, thereby reducing the risks and uncertainties associated with going forward towards full commercialisation," points out Dr. Akporiaye.