SINCHEM 2016 doctoral research subject

Catalytic hydrogenation of vegetable oils and concurrent reforming of glycerol in the same medium to produce highly sustainable renewable biofuels

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PROJECT DETAILS: The search for sustainable synthesis pathways for biodiesel generation is still ongoing, although extensive research and development work on this topic has already led to a broad variety of process alternatives, utilizing different oil feedstocks, alcohols, catalysts and process parameters. Supercritical trans-esterification can easily treat feedstock that contains impurities or high free fatty acid (FFA) contents, which are both detrimental in catalytic processes. Conversely, the absence of any catalyst in supercritical conditions widens the windows of potentially valuable triglycerides sources. If required, the reaction could be also operated in the presence of a catalyst, in order to make the conditions milder and the whole process less energy-intensive.

Low quality oils (such as waste cooking oils) contain, apart from high amounts of FFA, also water. This commonly further reduces the biodiesel yield, since water causes the triglyceride hydrolysis and a further production of FFA instead of biodiesel. A very convenient answer to the simultaneous presence of FFA and water is the coupling of the following operating:

1) hydrolysis and transesterification for the production of biodiesel, with separation of the aqueous phase that contains residual alcohols and glycerol

2) Aqueous phase reforming of the alcohols and glycerol to produce hydrogen, to be fed for biodiesel hydro- deoxygenation (HDO).

Step 2) has several advantages: firstly, glycerol is a residue with little market value, representing a veritable mass loss of feedstock material. Its valorization through the production of hydrogen would be strongly beneficial, otherwise available only at large refinery sites. Alkanes are, clearly, side products of glycerol and alcohols reforming, having a non-negligible added value. The hydro-deoxygenation of biodiesel could lead to the production of so-called green diesel, O- and S-free, which is a perfect surrogate of diesel or jet fuel (depending on the nature of the HDO).

The main objectives of the SINCHEM PhD proposal are:

1) The selection of optimal operating conditions of step 1 and 2, in view of their process integration.

2) The catalysts' development for integrated hydrolysis and transesterification, as well as for integrated APR and HDO (the ones of APR-alone are being already tackled at Politecnico di Torino).

Both lab scale and pilot scale plant could be operated within the PhD, for the above-mentioned purposes.

Figure 3: Pilot-scale unit for supercritical biodiesel production, designed and manufactured within the framework of the COPIRIDE FP7 EU project (CP-IP 228853)