Using carbon nanotubes to improve bio-oil refining

June 1 2015

New catalyst structures based on multi-walled carbon nanotubes are set to make the refining of commodity chemicals and fuels from bio-oil more competitive.

Bio-oil is obtained by pyrolysis, which involves heating biomass (from sources such as corn cobs, grain bran or sawdust) to high temperatures in an oxygen-free or oxygen-limited environment.

Pyrolysis is a proven method, but it creates a lot of burnt waste by-products called char or coke, as well as a complex brew of other undesirable impurities including acids, sugars and water. These by-products lower the heating value of bio-oil, reduce its stability over time, thicken it and/or turn it acidic – all bad in a transportation fuel. Such contaminants can also quickly ruin expensive metal-refining catalysts such as platinum, making the cost-effective production of commercially pure products a challenge.

One solution is to add a prior, lower-temperature, pressurised-hydrogen refining stage called hydroprocessing. This method helps remove reactive impurities to stabilise raw bio-oil, while extending the life of metal catalysts, but it brings its own issues. Some hydroprocessing catalysts require sulphur to work, which then contaminates the end product.

However, scientists at the Agency for Science, Technology and Research (A*STAR) in Singapore have lab-tested several methods to remove part of the oxygen and stabilise bio-oil during the hydroprocessing stage. The new process involves adding hydrogen in the presence of catalysts supported on a multi-walled carbon nanotube substructure with a very large surface area.

The catalyst substructures that they developed need only a thinly dispersed catalyst metal coating to produce good results more efficiently. Besides being relatively inexpensive, these substructures are stable and longlasting when exposed to the heat and moisture from hydroprocessing.

The scientists plan to build on their existing research by making new catalyst substructures for other types of biomass conversion. They say such catalysts promise to improve the cost-effectiveness of future bio-refineries. A single refinery could apply several types of catalyst at different stages of the refining process to extract multiple commodity chemicals and fuels from its biomass. Thus, refinery operators could extract more product and profit from a given amount of raw feedstock, with less waste left over to dispose of.

Provided by Agency for Science, Technology and Research (A*STAR), Singapore