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BIOMASS CATALYTIC PYROLYSIS FOR BIO-FUELS

Fast pyrolysis experts are fine-tuning production systems for FUELS AND CHEMICALS MADE FROM PLANT LIGNIN.

Rapidly heating plant dry matter using fast pyrolysis is the cheapest and fastest method for producing bio-fuels and renewable industrial chemicals, according to Rui Xiao, who leads a team at Southeast University's School of Energy and Environment.

His group has been leading efforts to design commercially viable bio-fuel production systems for more than 10 years.

Producing bio-oils for fuel involves two stages, Xiao explains. The first is fast pyrolysis, a thermal breakdown process that occurs in an inert atmosphere at moderate temperature. The resulting lignocellulosic biomass produces bio-oils that contain roughly 40% oxygenated organic compounds, which are unstable and corrosive. The second stage involves upgrading the oil via deoxygenation, so that it can be mixed with refinery fuels for use in conventional transport. However, completed deoxygenation is an energy-intensive process that demands the use of costly catalysts and hydrogen.

▲ **Lignin is plant dry matter and is one of the largest sources of renewable carbon and aromatics on Earth.**

In 2009, Xiao and his team devised a one-chamber fast pyrolysis and catalytic bio-oil upgrading system. "This eliminates the costly separate condensation and re-evaporation process required for upgrading," explains Xiao.

The team then used the chamber, with a HZSM-5 zeolite as a catalyst, to produce a bio-oil from corncobs. The result had a 'higher heating value', and hydrogen-to-carbon and oxygen-to-carbon molar ratios, close to that of jet-fuel, and thus it may be usable in transport.

In addition, by regulating the deoxygenation process and retaining some oxygen, Xiao's team developed a new approach to producing alcohols and ethers for use as diesel additives to reduce combustion soot emissions. This process could significantly reduce the cost of deoxygenation, says Xiao.

In the journal, Science, in 2010, Xiao and partners in the United Kingdom and United States also showed that bio-oils produce via fast pyrolysis can be efficiently converted via zeolite catalysis into raw materials for alcohols, diols, aromatic hydrocarbons, and olefins.

LAUDABLE LIGNIN

Lignin is the largest renewable aromatic source on Earth, so today Xiao's team looks more closely at lignin chemical structures. "The chemical changes during pyrolysis of lignin were very little understood," he explains.

In 2016, his team found that the preservation of β–O–4 linkages in lignin extracted from stalks or straws significantly contributed to its depolymerization. Using a hierarchical microreactor catalyst, depolymerization was further improved by reducing mass-transfer resistance, enabling a one-container conversion of lignin to aromatic components used in bio-jet fuel.

Each finding is a step forward, says Xiao. Lignocellulosic biomass, which can be sourced from agricultural waste, is the most abundant, inexpensive and sustainable source of base carbon for renewable fuels and chemicals. "So we will probably see scaleable efforts to produce bio-fuels and bio-feedstocks from lignocellulosic biomass in the next five years," says Xiao. ■

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