Plant scraps are the key ingredient in cheap, sustainable jet fuel

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Scientists in China have developed a process for converting plant waste from agriculture and timber harvesting into high-density aviation fuel. Their research, published March 21 in the journal *Joule*, may help

reduce CO2 emissions from airplanes and rockets.

Cellulose, the main component in the biofuel, is a cheap, renewable, and highly abundant polymer that forms the cell walls of plants. While chain alkanes (such as branched octane, dodecane, and hexadecane) have previously been derived from cellulose for use in jet fuel, the researchers believe this is the first study to produce more complex polycycloalkane compounds that can be used as high-density aviation fuel.

Ning Li, a research scientist at the Dalian Institute of Chemical Physics and an author of the study, believes this new biofuel could be instrumental in helping aviation "go green."

"Our biofuel is important for mitigating CO2 emissions because it is derived from biomass and it has higher density (or volumetric heat values) compared with conventional aviation fuels," says Li. "As we know, the utilization of high-density aviation fuel can significantly increase the range and payload of aircraft without changing the volume of oil in the tank."

To produce this biofuel, Li and his team found that cellulose can be selectively converted to 2,5-hexanedione using the chemical reaction hydrogenolysis. They then developed a method of separating the compound 2,5-hexanedione by converting the 5-methylfurfural in hydrogenolysis product to 2,5-hexanedione, while keeping 2,5-hexanedione in the product unchanged. This resulted in a 71% isolated carbon yield—a 5% increase from the product yield in their initial work. Finally, they reacted hydrogen with the 2,5-hexanedione from wheatgrass cellulose to obtain the final product: a mixture of C12 and C18 polycycloalkanes with a low freezing point and a density about 10% higher than that of conventional jet fuels. Much of the biofuel's magic lies in this high density—it can be used as either a wholesale replacement fuel or as an additive to improve the efficiency of other jet

fuels.

"The aircraft using this fuel can fly farther and carry more than those using conventional jet fuel, which can decrease the flight number and decrease the CO2 emissions during the taking off (or launching) and landing," says Li.

Although the researchers produced the biofuel at a laboratory scale in this study, Li and his team believe the process' cheap, abundant cellulose feedstock, fewer production steps, and lower energy cost and consumption mean it will soon be ready for commercial use. They also predict it will yield higher profits than conventional aviation fuel production because it requires lower costs to produce a higher-density fuel. The biggest issue holding the process back is its use of dichloromethane to break down cellulose into 2,5-hexanedione; the compound is traditionally used as a solvent in paint removers and is considered an environmental and health hazard.

"In the future, we will go on to explore the environmentally friendly and renewable organic solvent that can replace the dichloromethane used in the hydrogenolysis of cellulose to 2,5-hexanedione," says Li. "At the same time, we will study the application of 2,5-hexanedione in the synthesis of other fuels and value-added chemicals."

More information: *Joule*, Liu et al.: "Integrated Conversion of Cellulose to High-Density Aviation Fuel" www.cell.com/joule/fulltext/S2542-4351(19)30085-6 , DOI: 10.1016/j.joule.2019.02.005

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