Predicting Products from Algae

Hydrothermal liquefaction (HTL) is a process that uses water at high temperatures and pressures to convert wet biomass into liquid biocrude oil. One such source of biomass, microalgae, is being investigated as a promising source of renewable liquid fuel, considering its relatively low requirement for land area and nutrients during cultivation. Microalgae's biochemical composition can also be manipulated to some extent during cultivation. For example, by depleting nitrogen in the culture media, energy-dense lipids or fatty acids are known to accumulate in microalgal cells.

HTL is directly affected by cell composition, suggesting that it may be possible to tailor feedstocks to achieve optimized HTL products, yields, quality, and energy recovery. However, the relationship between feedstock composition and HTL product characteristics has not been well characterized. Therefore, a group of researchers, including ISTC's B.K. Sharma, set out to predict HTL products from microalgal biochemical composition. They systematically manipulated the growing conditions of microalgae Nannochloropsis oculata to achieve different cell compositions and characterized the HTL products from each treatment.

One set of algae was defatted by a solvent-mediated extraction of lipids, another was not manipulated, and the rest were starved of nitrogen to varying degrees, resulting in different levels of lipids and proteins. Biocrude oil yield and energy recovery percentage increased as feedstock lipid content increased. Results also showed that lipid-rich feedstocks may be more amenable to processing with higher moisture contents, potentially eliminating a difficult-to-implement dewatering step during microalgae harvest. More generally, the research team was able to develop an integrated modeling framework to overcome what was a critical barrier to microalgae-based HTL biofuels and to enable a greater ability to predict HTL products.

Previous research

This research expanded on an earlier study, to which ISTC's B.K. Sharma and Kishore Rajagopalan contributed. The research team compared two methods for recovering energy from algal biomass: HTL and slow pyrolysis, which slowly heats dry biomass to high temperatures under ambient pressure in the absence of oxygen. Like HTL, pyrolysis yields bio-oil, but it also produces additional products known as syngas and **biochar**. The study compared, for the first time, the chemical properties of bio-oils produced from different algal feedstocks via the two processes.

Researchers looked at algal species Scenedesmus sp. and Spirulina sp. in raw and defatted form. They included the defatted products to determine whether they could recover additional energy-dense bio-oil from algaes whose lipids had already been extracted for biodiesel production. Energy-dense bio-oil was successfully produced from both thermochemical conversion routes, and had properties similar to Illinois shale oil. However, both conversion and feedstock type significantly influenced bio-oil molecular weight, percentage of low boiling compounds, and energy consumption ratio. The group concluded that HTL is more energetically favorable than pyrolysis for wet biomass, and that low biomass moisture increases the energetic favorability of both conversion types.

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Meet the Scientists

- **B.K. Sharma**
- **Kishore Rajagopalan**

Publications

- **Prediction of Microalgae Hydrothermal Liquefaction Products from Feedstock Biochemical Composition**
- **Thermochemical Conversion of Raw and Defatted Algal Biomass via Hydrothermal Liquefaction and Slow Pyrolysis**

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