Structural Characterization of Pyrolysis Oils from Woody Biomass

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With rising petroleum prices and greater awareness of the environmental impacts of fossil fuels, there has been an increased call for the development of alternative energy sources.\(^1\) Compared with petroleum, plant biomass is a source of sustainable carbon and provides convenient raw materials for conversion to fuel.\(^1,2\) Alcohol fuel and biodiesel have been produced from a variety of crops such as maize, sugar cane, and soy. However, price and slow production inhibit their full utilization.\(^2\) Competition with food production also presents a challenge as farmers have to decide between using these crops for food or for fuel.\(^1,3\) One possible alternative energy source is pyrolysis oil, a liquid fuel that is generated by the pyrolysis of woody lignocellulosic biomass. Pyrolysis oil has several advantages over other bio-oils. Lignocellulosic biomass does not compete with food production and can be cheaply produced.\(^1,2\) It is obtained as waste from non-edible portions of crops and from wood industries such as paper mills.\(^1\) Being a liquid fuel, it can be used with many current infrastructures, such as generator boilers and large diesel applications, without the need for major modifications.\(^2\) Because lignocellulosic biomass contains low concentration of nitrogen and sulfur, few toxic materials are released during combustion.\(^3\)

Unfortunately, the directly produced oil is not an efficient fuel because of its high oxygen content. In collaboration with scientists at U. Maine Orono, research is underway to improve the oil’s performance either through upgrading reactions or by modifying the pyrolysis process. A current focus is to study how different pyrolyzing temperatures affect the pyrolysis of lignin, a major component of woody biomass that likely contains most of the energy content of pyrolysis oil.

To tackle this problem, isolated lignin samples are pyrolyzed and the resulting complex mixtures are first extracted into different solvents. This groups the chemicals present in the mixture based on solubility and simplifies the analysis. Extraction starts with toluene and follows by ethyl acetate. This separates chemicals based on polarity, with the less polar going into toluene. Evaporating the solvent (either toluene or ethyl acetate) shows roughly how much of the oil is extracted.

The extracted solutions are analyzed with GCMS and MALDI-FTMS, both are mass spectroscopic techniques that identify compounds based on mass. From this we can determine individual chemicals and how their abundance change with different pyrolysis conditions. Once the composition is determined, we can improve the upgrading and creation process for pyrolysis oil.

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