Imitating Lignocellulosic Substrates in Acetic Acid Fermentation

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A crucial segment of sustainable jet fuel production is the fermentation of lignocellulosic-based sugars to acetic acid. Biomass from non-food sources such as wood, switch grass, and waste materials can be fractionated into their raw sugar components (glucose, xylose, mannose, arabinose, and galactose). These sugars can later be fermented to acetic acid, reduced to ethanol, dehydrated to ethylene, then oligomerized and hydrogenated to produce jet fuel. Moorella thermoacetica is an obligate anaerobe that exclusively ferments sugars to acetic acid. Thus far, fermentation using M. thermoacetica has been achieved with synthetic glucose and xylose. It is essential to investigate the fermentation of all five sugars in order to validate lignocellulosic biomass as a feedstock for this process. In this work five synthetic sugars were fermented in flasks at 58°C without pH adjustment. Samples were taken every 4 to 6 hours over a period of 48 hours and were analyzed offline by high performance liquid chromatography (HPLC). The trend of sugar consumption shows that M. thermoacetica has a substrate preference of xylose over glucose, and glucose over other sugars. The sugar consumption was 100% for xylose, 98% for glucose, and 30 - 40% for the rest of the sugars. Successful five sugar fermentation suggests a concrete potential to upscale the bioconversion process and build a feasible market for jet fuel produced from lignocellulosic biomass.

Fermentation of Xylose and Glucose into Acetic Acid by Moorella thermoacetica
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There has been a lot of interest in fermentation processes utilizing monomeric sugars in lignocellulosic biomass to acetic acid product: a key precursor for many industrial applications such as the production of jet fuel. The selected microorganism for this study is Moorella thermoacetica (Clostridium thermoaceticum). This strain is a thermophilic obligate anaerobe and can homoferment glucose and xylose to acetic acid using CO₂ as an electron acceptor at temperatures between 55-60°C and pH 6.5-6.8. This study investigates the production of acetic acid by this homoacetogen from a 1:1 mixture of glucose and xylose, the two major monomeric sugars in lignocellulosic biomass. The research is a necessary step to further study of fermenting a sugar model of lignocellulosic hydrolysates and hydrolysates. Additionally it facilitates application of Raman spectroscopy as quantitative measurements in real-time during fermentation. This is unlike the traditional way of using High performance liquid chromatography (HPLC) which is used in this study. Compared with current analytical techniques, Raman Spectroscopy (RS) allows analytes in samples to be measured simultaneously. Utilization of xylose and glucose as the main sugars for producing lignocellulosic acetic acid proves useful as a foundation for building industrial applications such as jet fuel through bioconversion of lignocellulosic biomass.