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Subcritical and Supercritical Water Gasification of Xylose

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Abstract : Hemicellulose is one of the major constituents of all plant cell walls, making up 15-25% of dry wood. It is a biopolymer from many different sugar monomers, including pentoses, like xylose, and hexoses, like mannose. In an effort to gasify real biomass in subcritical and supercritical water in a single process, it is necessary to understand the gasification of hemicellulose, in addition to cellulose and lignin, in subcritical and supercritical water. In the present study, xylose is chosen as the model compound for hemicellulose, since it has the largest amount in most hardwoods. Xylose is gasified in subcritical and supercritical water for the production of higher-valued gaseous products. Experiments were conducted with a 16-ml autoclave batch-type reactor. Hydrogen peroxide is adopted as the oxidant in an attempt to promote the gasification yield. The major operating parameters for the gasification include reaction temperature (400 - 600°C), reaction pressure (5 - 25 MPa), the concentration of xylose (0.05 and 0.30 M), and level of oxidant added (0 and 0.25 chemical oxygen demand). 102 experimental runs were completed out of 46 different set of experimental conditions. Product gases were analyzed with a GC-TCD and determined to be mainly composed of H_2 (10 – 74 mol. %), CO (1 – 56 mol. %), CH_4 (1 – 27 mol. %), CO_2 (10 – 50 mol. %), and C_2H_6 (0 – 8 mol. %). It has been found that the gas yield (amount of gas produced per gram of xylose gasified), higher heating value (HHV) of the dry product gas, and energy yield (energy stored in the product gas divided by the energy stored in xylose) all increase significantly with rising temperature and moderately with reducing pressure. The overall best operating condition occurred at 873 K and 10 MPa, with a gas yield of 54 mmol/g of xylose, a gas HHV of 440 kJ/mol, and an energy yield of 1.3. A seemingly unreasonably energy yield of greater than unity resulted from the external heating employed in the experiments to drive the gasification process. It is concluded that xylose can be completely gasified in subcritical and supercritical water under proper operating conditions. The addition of oxidant does not promote the gasification of xylose.

Keywords : gasification, subcritical water, supercritical water, xylose
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