Bio-oil Refining: Challenges and Opportunities

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Abstract: The content of this presentation will focus on current understanding of bio- oil chemical composition. Results presented here will detail the chemical characterization of ten bio-oils. Discussion will focus on the distribution of functional groups between the volatile and the heavy fractions. Results indicate that carbonyl groups were found to be almost equally distributed between the volatile and the oligomeric fractions. Between 85 and 95 % of the phenols in bio-oil are in the form of oligomers. Between 52 and 66 % of the carboxylic acids were detected by GC/MS with the rest in oligomeric form. These results confirm that the GC/MS detectable fraction, although only representing around 30 wt. % of the whole oil, contains more than half of the very reactive carbonyl and carboxyl functional groups found in the bio-oil. Results further indicate that an average 56 % of all the oxygen derived from the carbohydrate fraction that is collected in the oil, is in the form of water. Around 20 % is in the form of carbonyl groups, close to 12 % in the form of carboxylic groups and only 17 % is in the form of OH in aliphatic chains. These findings stress the importance of dehydration reactions (close to 70 % of the oxygen in the oil is in the form carbonyl or water).

The Van Krevelen plots of the data collected by FT-ICR-MS show that bio-oil oligomeric fractions contain heavy unknown water soluble oligomers produced by the gradual dehydration of cellulose primary depolymerization products. The oils were also analyzed by ^{1}H-NMR, FTIR, and UV fluorescence spectroscopies. ^{1}H-NMR results confirm that, with appropriate calibrations, this technique could be used to quantify the content of phenols and water. A good correlation was obtained between the total content of phenols measured by Folin-Ciocalteu and the area of the UV fluorescence peaks. The second section of the presentation will review products that have been obtained from whole bio-oils, their fractions and independent compounds. Other potential compounds that could be obtained will also be discussed. The third section of this presentation will be devoted to discuss the current state of the art of bio-oil separation technologies for sepration of bio-oil into fractions. Their implications in the development of new bio-oil refineries will also be covered. Lastly, a brief discussion of the cost reduction opportunities that exist if bio-oil refineries take advantage of existing infrastructure, will be included. Potential integration schemes with petroleum refineries, pulp and paper mills, sugarcane mills and dry corn ethanol plants will be discussed.