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Insights on the acetic acid pretreatment of wheat straw: changes induced in the biomass properties and benefits for the bio-oil production by pyrolysis

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Oral Presentations #15

Insights on the acetic acid pretreatment of wheat straw: changes induced in the biomass properties and benefits for the bio-oil production by pyrolysis

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Keywords: Acetic acid washing, Selective demineralization, AAEM removal, Biomass pretreatment, Fast pyrolysis

Agricultural lignocellulosic residues, such as wheat straw, are abundant renewable feedstocks for biofuels and chemicals. Nevertheless, their direct pyrolysis is hindered by ash, particularly alkali and alkaline-earth metals (AAEMs), which catalyze dehydration, cracking, gas and char formation, lowering bio-oil yield. Sustainable pretreatments to remove these species are essential.

This work investigates acetic acid washing as a green pretreatment for wheat straw, benchmarking it against water and ammonia washing. Each pretreatment was assessed by combining biomass characterization, including AAEM removal, holocellulose enrichment and thermal stability, with pyrolysis under nitrogen in a downflow fixed-bed reactor with two zones at 550 and 450 °C.

Acetic acid washing selectively removed the most catalytically active species, almost eliminating potassium and sodium and reducing magnesium and calcium. Unlike ammonia, which increased demineralization through silica removal, acetic acid targeted AAEMs involved in secondary reactions. It also extracted soluble lignin, extractives and acetyl-rich compounds, increasing holocellulose content and shifting cellulose decomposition to higher temperatures. Consequently, bio-oil* yield increased from 35 wt % for raw wheat straw to 53 wt% after acetic acid pretreatment, while water, gas and char decreased.

As shown in Figure 1, bio-oil* yield increases when total AAEM content decreases and holocellulose content increases. Thus, suppressing AAEM-catalyzed fragmentation, decarboxylation and condensation, while preserving holocellulose, is crucial for maximizing liquid production. Bio-oil* quality improved, with lower acids, ketones and ethers, and higher furans and anhydrosugars. Levoglucosan became the dominant valuable compound, reaching yields close to 10 wt%, due to inhibition of cellulose ring-scission reactions. Conversely, extracted matter samples mainly promoted char and gas.

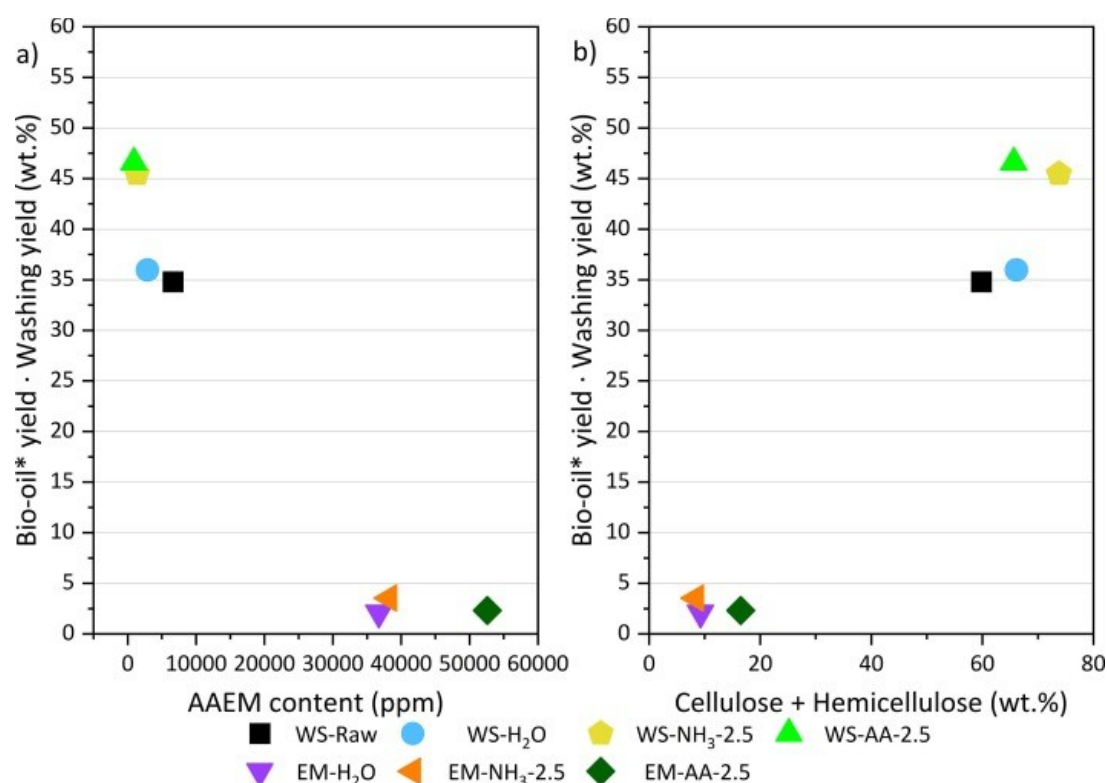


Figure 1. Bio-oil* yield versus (a) total AAEM content and (b) holocellulose content of raw WS, washed WS and EM samples. Bio-oil yields are calculated considering the washing yields of every WS and EM sample.

Acetic acid pretreatment improves wheat straw pyrolysis by separating holocellulose from catalytic inorganic species. Preliminary techno-economic analysis indicates that higher bio-oil* and levoglucosan revenues can offset acid, energy, and equipment costs, supporting its potential as a sustainable pretreatment for biorefineries.

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