Characterization of waste wood materials for the production of biofuels

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Introduction

- The use of lignocellulosic materials (e.g. waste wood materials–WWM) for isobutanol production requires four main processing operations: pretreatment, enzymatic hydrolysis, fermentation of glucose, and recovery of the biofuel from the fermentation broth (Fig. 1).
- Hydrolysis defines the efficiency of the process.
- During enzymatic hydrolysis, cellulases can irreversibly bind to lignin, thus reducing loss in enzymatic activity.
- Other factors, interrelated during the saccharification process, can also impact enzymatic hydrolysis.
- These factors can be classified into: enzyme-related factors (e.g., enzyme concentration and adsorption, synergism, end-product inhibition, binding to lignin) and substrate-related factors (e.g., cellulose crystallinity, degree of polymerization, available/accessible surface area, particle size, and presence of associated materials such as hemicellulose and lignin).
- Phenolic molecules and proteins and ash can also act as inhibitors.
- WWM are very heterogeneous. Techniques used for characterization of homogeneous materials are not sufficient.
- Literature is poor on providing tools for characterization of WWM and on describing methods for determining inhibitors present in WWM that could limit hydrolysis/saccharification.
- More study is required to elucidate the viability of producing biofuels from WWM via enzymatic hydrolysis.

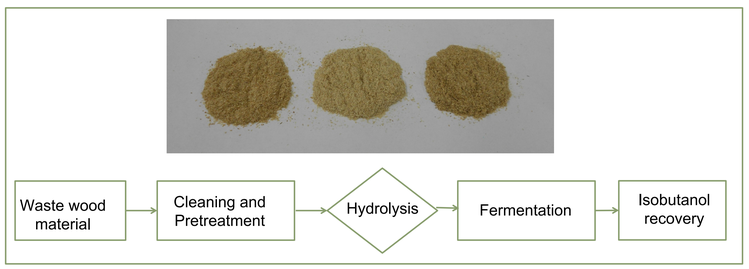

FIGURE 1 – Main steps for using WWM to produce isobutanol

Objective

The aim of this work is threefold:

a) Review literature related with techniques for characterizing WWM intending the production of biofuels, particularly isobutanol.

b) Characterize WWM, with emphasis on properties that could potentially limit using WWM for biofuels .

c) Identify possible inhibitors in WWM that could negatively impact the production of isobutanol via enzymatic hydrolysis.

Materials

Three samples of wood waste recycling materials were used: “sample 1” (provided by Company “a”), “sample 2” and “sample 3” (provided by Company “b”, and identified by the company as “Mulch” and “Hog Fuel 1”), with different particle size distribution (Fig. 2).

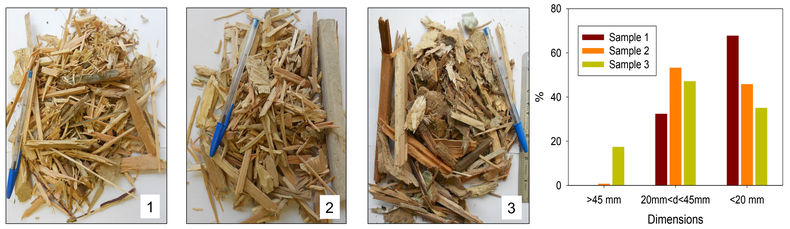

FIGURE 2 – Pictures of the samples used in the work and their corresponding particle size distribution.

Methods

- Visual inspection, removal of extraneous materials, determination of moisture content as received, particle size distribution, drying at room temperature.
- Further characterization:
  - Proximate analysis: ash, volatiles, fixed carbon.
  - Elemental analysis (CHNO)
  - Extractives (ASTM D11107-07)
  - Phenolic compounds, lignans, and fatty acids in extractives
  - Change of mass as materials are heated and thermal stability (by TGA) and Activation Energy (ASTM E1641).
  - Chemical composition (cellulose, hemicellulose, lignin) (ASTM E1758)
  - Chlorine content (by micro-XRF – energy-dispersive micro X-ray fluorescence spectrometry)
  - Heavy metals (ICP-MS)
  - Surface area of ground materials (BET)

FIGURE 3 – Pictures of contaminants found in WWM samples: Metals (left) were found in sample 1 and other materials (e.g. plastics and fabrics) were found in sample 3.

Preliminary Results

TABLE 1 – Proximate analysis results (RT–room temperature)

Sample	MC as received (% odb)	MC after drying at RT (% odb)	Ash content (% odb)	Volatiles (% water and ash free basis)	Fixed Carbon (% water and ash free basis)
1	12.78±0.70	5.42	1.16	79.38	20.62
2	14.03±0.04	5.99	11.47	81.22	18.78
3	25.22±0.46	6.09	3.39	79.94	20.06

TABLE 2 – Elemental compositions results (% ash and moisture free basis)

Sample	C	H	N	O
1	48.72±0.73	5.64±0.06	0.44±0.02	45.20±0.79
2	46.01±0.98	5.42±0.09	0.19±0.01	48.38±1.07
3	42.26±0.77	5.08±0.08	0.42±0.01	52.24±0.86

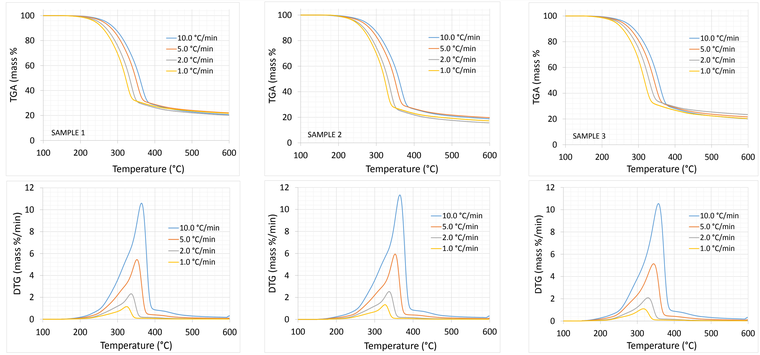

FIGURE 4 – TGA and DTG (at different temperatures)

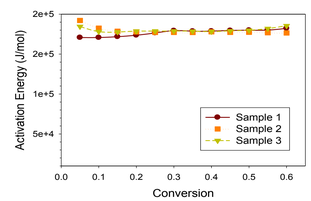

FIGURE 5 – Activation Energy of the three samples (conversion up to 60%)

Preliminary Conclusions

- Materials are very different in particle size, moisture content, and ash content.
- Removal of metals is required.
- More study is necessary to determine how contaminants (plastics/fabrics) could impact further steps for biofuels.
- Relatively high amounts of N (samples 1 and 3) deserve attention in further steps.
- Activation Energy is quite similar for all samples.

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