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Decontamination of MSW Improves Conversion Efficiency

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Changing the World's Energy Future

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Decontamination of MSW Increases Conversion Efficiency

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Background

The United States generates over 292 million tons of municipal solid waste (MSW) annually[1]. China accepted heavily contaminated recyclables prior to 2013. However, the passage of China's Green Fence and National Sword Policies criminalized importing contaminated MSW above a certain threshold. This MSW is now sent to material recovery facilities in the U.S. where much is eventually landfilled.

These MSW fractions offer a significant opportunity for energy conversion pathways. Paper and plastic fractions can be converted and upgraded to fuels through low- and high-temperature conversion, respectively. MSW paper resembles lignocellulosic biomass and therefore can undergo enzymatic hydrolysis to make sugars available for fermentation. MSW plastics can be broken down to oil, gas, and char through high heat processes like microwave pyrolysis.

Previous research has shown contaminants such as ink, stickies, and cross-contamination between fractions do not affect sugar yields[2]. However, other contaminants such as coatings, pigments, fillers, and adhesives in paper fractions and dirt/particulates in plastic fractions are hypothesized to decrease yields. **The objective of this study is to develop MSW paper and plastic decontamination methods to increase low- and high-temperature conversion efficiency.**

Methods

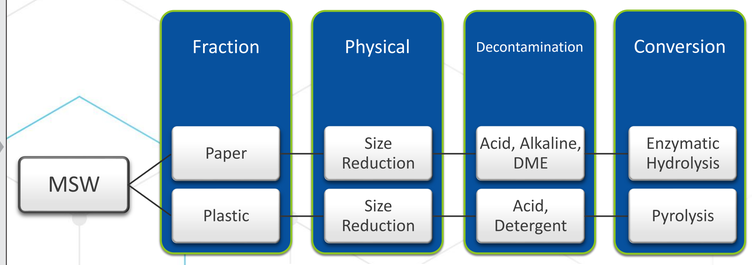
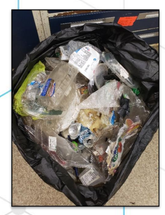
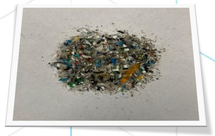


Figure 1. MSW conversion process overview.

Fractionating/Size Reduction

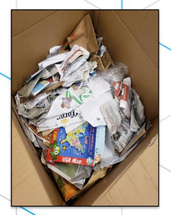
Mixed plastics

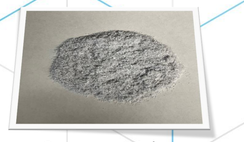




2 mm particles

Copy paper (CP)
Glossy paper (GP)
Newspaper (NP)
Paperboard (PB)
Cardboard (CB)





2 mm particles

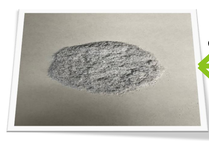
Decontamination

Mixed Plastics

Washes

Acid wash (H_2SO_4) – The samples were mixed with a 0.1 M sulfuric acid solution for four hours.

Detergent wash – The samples were mixed with a dish soap and water solution for four hours.



CP, GP, NP, PB, CB

CP, PB, CB

NP, PB, CB

CP, NP, GP

Acid wash (H_2SO_4) – The samples were mixed with a 0.1 M sulfuric acid solution for four hours.

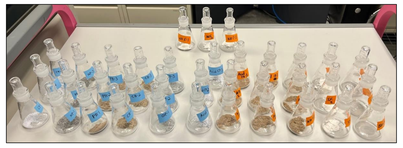
Alkaline wash (NaOH) – The samples were mixed with a 0.1 M sodium hydroxide solution for four hours.

Dimethyl ether wash (DME) – The samples were mixed with a DME solution for two hours using a condensable solvent system.

Conversion

Paper – Enzymatic Hydrolysis (EH)

- Samples, citric acid buffer, and enzyme cocktail added to flasks in triplicate.
- Samples incubated for five days at 50°C.
- Liquid was vacuum-filtered for high-performance liquid chromatography (HPLC) analysis.



Plastic – Microwave Pyrolysis

- Samples pressed into one gram pellets.
- Pelleted samples inserted into microwave pyrolysis instrument.
- Liquid, char, and gas products were analyzed.

Results

Paper: Washed vs. Unwashed Yields from EH

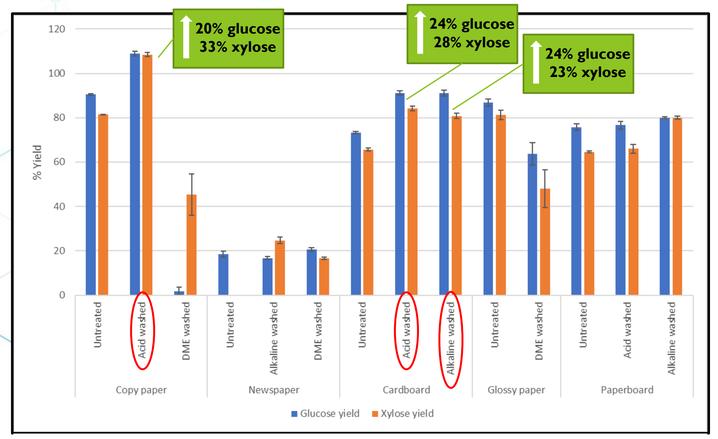


Figure 2. EH yields increased in acid washed copy paper, acid washed cardboard, and alkaline washed cardboard.

EH Results Discussion

- Glucose and xylose yields increased significantly for acid washed CP, acid washed CB, and alkaline washed CB.
- DME washes had low yields. We hypothesize the samples are becoming hydrophobic and cellulose/hemicellulose is not being fully converted to glucose/xylose.
- Results suggest there may be no need for a pretreatment (PT) step for acid washed CP, acid washed CB, and alkaline washed CB. Traditionally, PT is the most expensive step in conversion of feedstocks to fuels.

Plastic: Washed vs. Unwashed

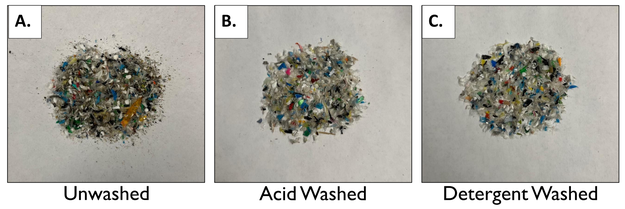


Figure 3. Unwashed (A), acid washed (B), and detergent washed (C) mixed plastic samples.

Pyrolysis Results Discussion

- Acid and detergent washed plastic samples were prepared, but reliable pyrolysis data has not yet been collected.
- Liquid oil products from pyrolysis condensed into a white powder. We hypothesize the white powder is composed of waxes and lighter hydrocarbons.
- Char was sticky and difficult to separate from the condensed white powder.
- A second quartz tube is being fabricated that will separate the char from condensate.

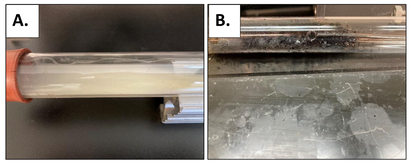


Figure 4. Liquid oil products (A) and char (B) from pyrolysis.

Conclusion

Glucose and xylose yields increased significantly for acid washed CP, acid washed CB, and alkaline washed CB, with acid washed CP reaching 100% yield. This suggests that PT is not necessary, and decontamination alone is enough for high yields in these fractions. Further work needs to be completed to combat the hydrophobicity of samples receiving DME washes.

Acid and detergent washed plastic samples were prepared. Dirt/particulates appear to be greatly reduced, but reliable pyrolysis data on oil, gas, and char yields have not yet been obtained.

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References

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[2]Brown RM, Hoover AN, Klinger JL, Wahlen BD, Hartley D, Lee H and Thompson VS (2022) Decontamination of Mixed Paper and Plastic Municipal Solid Waste Increases Low and High Temperature Conversion Yields. Front. Energy Res. 10:834832. doi: 10.3389/fenrg.2022.834832

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