Hydrothermal Liquefaction for Processing Municipal Solid Waste without Separation

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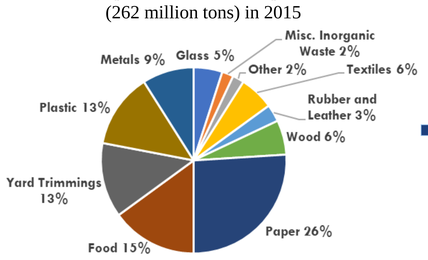
1 Purpose

1. Municipal Solid Waste specifically plastics pose a grave danger to the environment. Current sustainable technologies like recycling are limited by the need for separation of solid waste.
2. Biomass components of municipal solid waste have been previously broken down to bio-oil using Hydrothermal Liquefaction[1].
3. Preliminary work from our lab has suggested that plastics as well are converted to oil using Hydrothermal Liquefaction. High yields and heating values (HHV) were obtained.

Hypothesis: Hydrothermal Liquefaction provides a solution for utilizing Municipal Solid Waste to obtain oil and useful other by-products in an economically sustainable manner

2 This Study

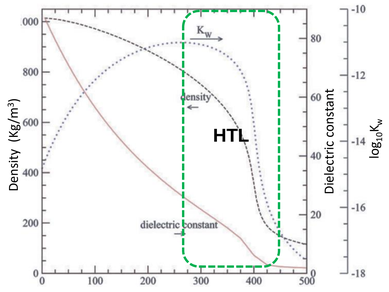
Municipal Solid Waste Composition[2]
(262 million tons) in 2015



Hydrothermal Liquefaction

- **Fuel gas** (gaseous phase) energy recovery
- **Crude Oil** (organic phase) energy recovery
- **Recyclable products** (all phases)

83 % of Municipal Solid waste contains carbonaceous components that can be converted to oil using Hydrothermal Liquefaction



Density, static dielectric constant, and ion product (K_w) of water at 30 MPa as a function of temperature[3].

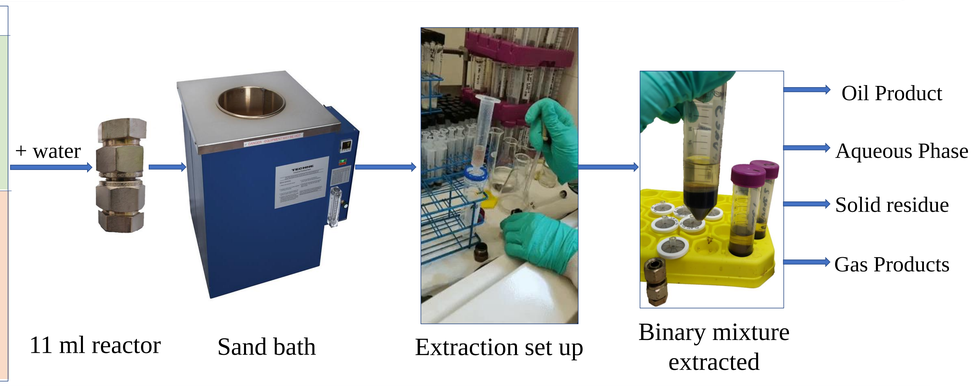
Objectives:

- Studying synergistic effects in mixtures of municipal solid waste using **model compounds**
- Explore the possibility of extracting recyclable components from HTL products[4]

3 Methods

Model Compounds:

1. Cellulose (Paper, Food)	Biomass
1. Starch (Food)	Biomass
2. Soy Protein (Food)	Biomass
3. Stearic Acid (Food)	Biomass
4. Lignin (Wood)	Biomass
5. Polypropylene (Plastic)	Plastics
6. Polyethylene Terephthalate (Plastic)	Plastics
7. Polystyrene (Plastic)	Plastics
8. Polycarbonate (Plastic)	Plastics



11 ml reactor | Sand bath | Extraction set up | Binary mixture extracted

Process Conditions: Temperatures - 300 °C, 350 °C, 400 °C, 450 °C, Pressure: 25 MPa, Time: 30 mins
Loading - 0.3986 g feedstock, 1.3 – 4.5 mL water (based on temperature)

4 Results and Discussion

Waste	Heating value of Oil from HTL (MJ/kg)	Oil Yield (%)
Food waste	35.8	45.3[1]
Paper	32.3	5.1[1]
Wood	34.3	27.5[5]
Plastic waste	41.12	60.1

- Biomass accounts for 60% of total MSW but provides bio-oil that has lower yield and heating values.
- Plastics account for only 13% of total MSW but provides higher yield and HHV values comparable to gasoline

Biomass waste + Plastic waste →
- Better quality of oil produced
- Higher quantity of oil produced
- Reduce the use of catalyst and the need for upgradation

References:

1: Gollakota, A. R. K., Nanda Kishore, and Sai Gu. Renewable and Sustainable Energy Reviews 81 (2018): 1378-1392.
2: Agency, United States Environmental Protection, "Advancing Sustainable Materials Management: Tables and Figures," 2015
3: Peterson, A. A.; Vogel, F.; Lachance, R. P.; Fröling, M.; Antal, Jr., M. J.; Tester, J. W. Energy Environ. Sci. 2008, 1 (1), 32
4: Williams, Paul T., and Edward Slaney, Resources, Conservation and Recycling, vol. 51, no. 4, pp. 754 - 769, 2007
5: Pedersen, Thomas Helmer, I. F. Grigoras,, Iulia Maria Daraban, Claus Uhrenholt Jensen, S. B. Iversen et al. Applied energy 162 (2016): 1034-1041.
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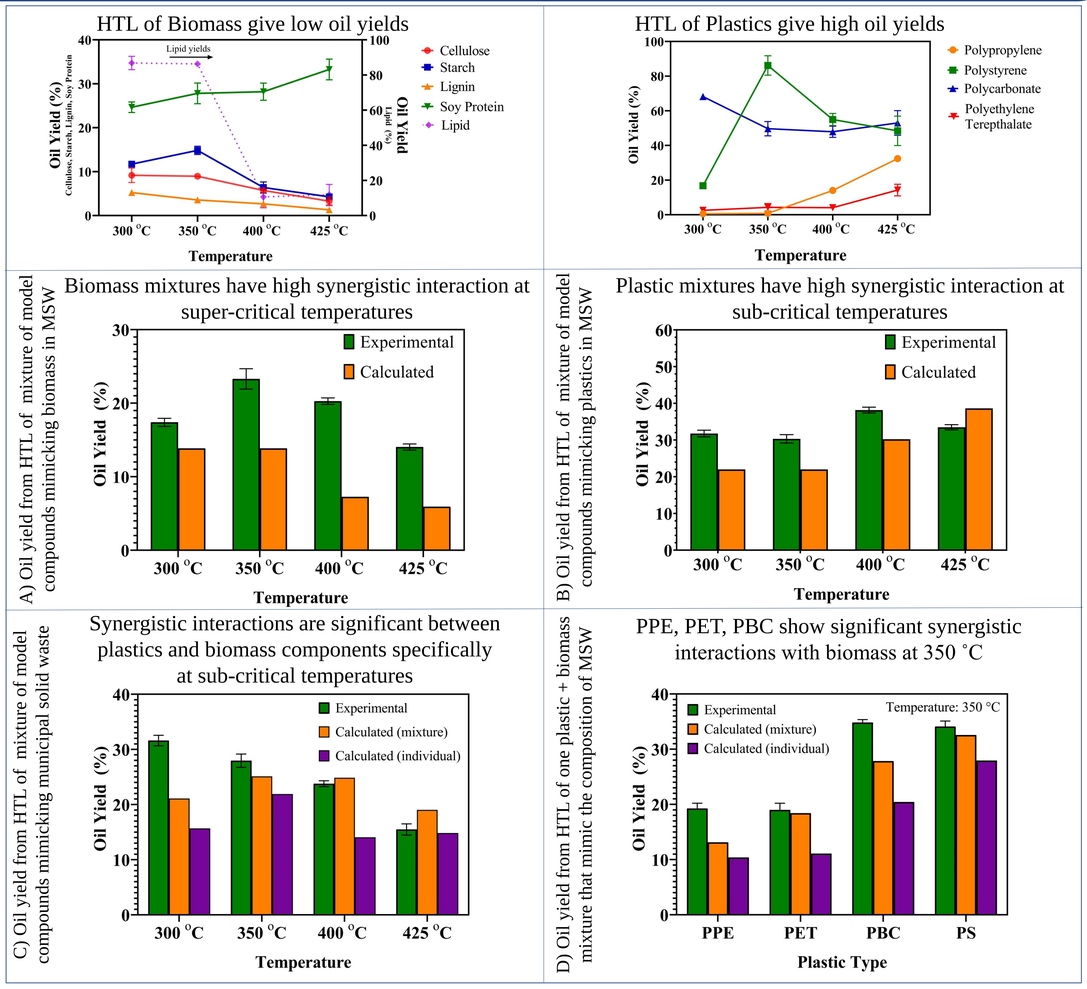
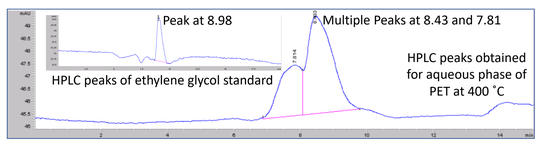
4 Results and Discussion (contd.)



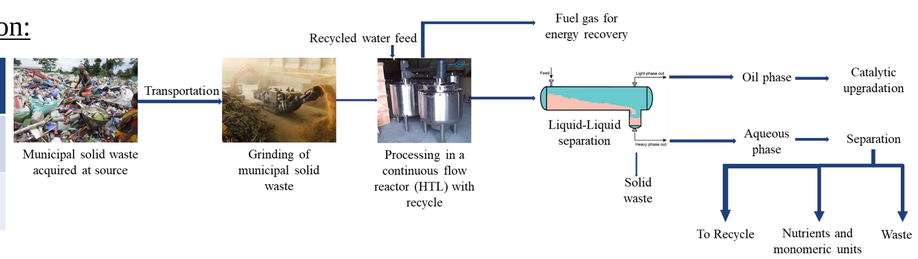
1. Favorable interactions observed between plastics and biomass mixtures result in increasing oil yield as well as decreasing plastic decomposition temperatures.
2. Synergistic interactions between plastics and biomass exceed the synergistic interactions in-between components of biomass/ plastics significantly in the sub-critical temperature regime.
3. Ionic reactions are attributed for the synergy caused by plastic components on biomass.
4. Substantial synergistic interactions are found between PPE, PET, PBC, and biomass model compound mixture (over 85.29, 71.09, 70.33 % increase in oil yield respectively).



The HPLC peaks obtained for aqueous phase of the HTL of PET indicates multiple components of which ethylene glycol is one. Further analysis is to be performed to quantify the same.

Commercialization:

Source	Cost ($/gallon)
Oil from HTL process	4.38 [6]
Commercial Gasoline	3



Municipal solid waste acquired at source | Grinding of municipal solid waste | Processing in a continuous flow reactor (HTL) with recycle

5 Conclusions

- ✓ Addition of plastic to biomass increases the net oil yield obtained by 101.67 % (experimental vs. calculated) at 300 ˚C. This is attributed to significant synergistic interactions between plastic and biomass components.
- ✓ Value addition from the HTL co-products is expected to improve the process' sustainability and economically viability

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