Hydrothermal Liquefaction of Food Waste

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Introduction

One of the biggest challenges today is the sustainable management of food waste

40% of the food produced in the US goes to waste

An effective use of this waste could be chemical conversion into biofuel through hydrothermal liquefaction (HTL) process

Red mud is an abundant, cheap, alternative catalyst, composed of metal oxides, that could be used in the HTL process

Objectives

- To test the effectiveness of red mud as a potential catalyst for HTL of food waste.
- To test the effectiveness of pure metal oxides derived from red mud's composition as potential catalysts
- Compare the results to that of Ceria Zirconia in the hopes of finding a cheaper alternative

Experimental Methods

1. Charge the reactor with 100g of food waste slurry and 5g reactor
2. Heat reactor up to 300°C and 3000 Psi
3. Cool and depressurize the reactor

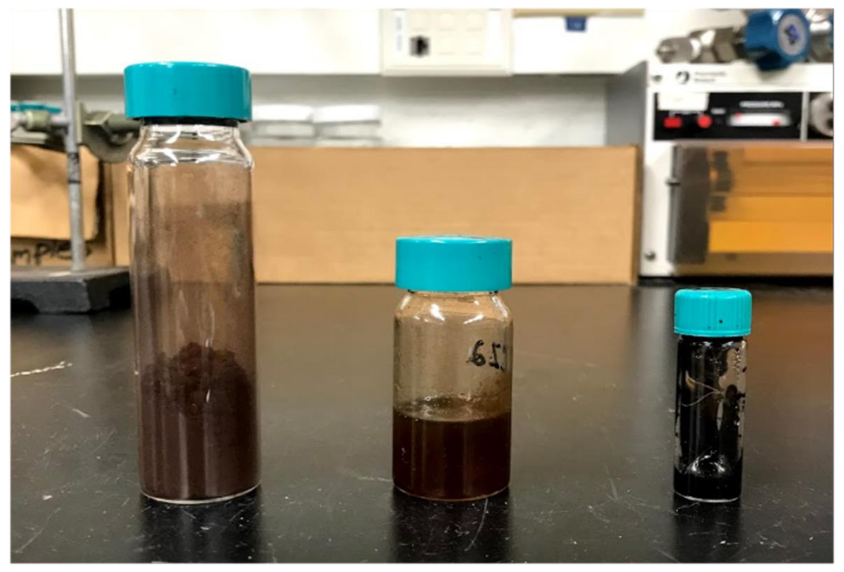
4. Use vacuum filtration to remove the aqueous phase
5. Wash the remaining solid with acetone
6. Use the rotary evaporator to obtain the oil phase from the acetone-oil mixture

Product Analysis

Aqueous Phase
- Gas Chromatography – Mass spectroscopy (GC-MS)
- Total organic Content (TOC) analysis

Oil Phase
- Infrared Spectroscopy (IR)
- Elemental Content Analysis (CHON)

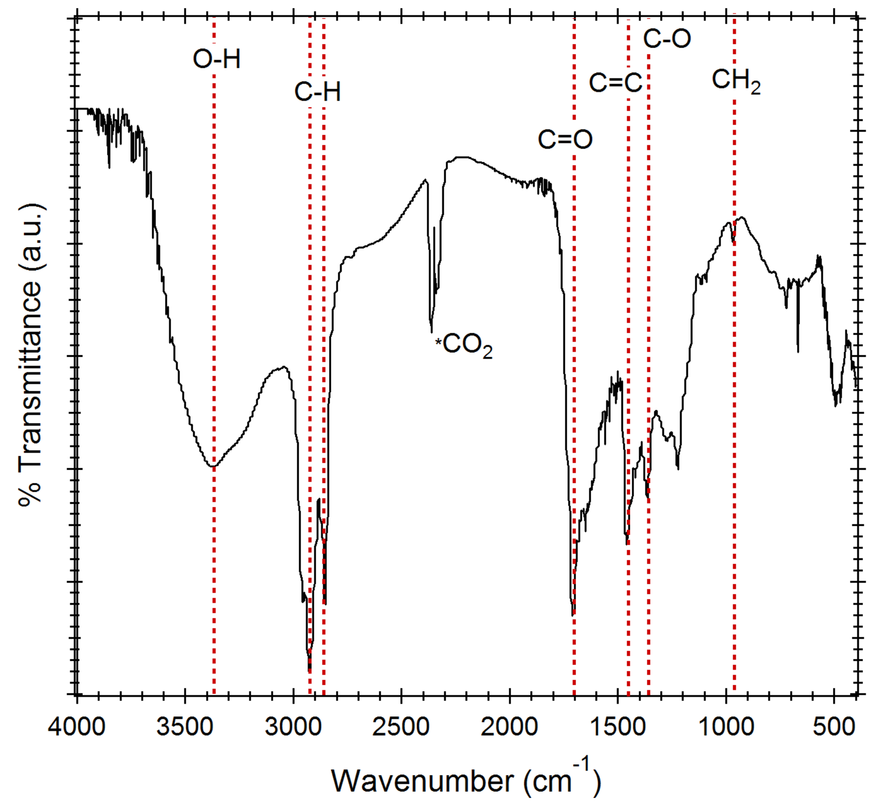
Solid Phase
- Decoke
- TXRF Analysis



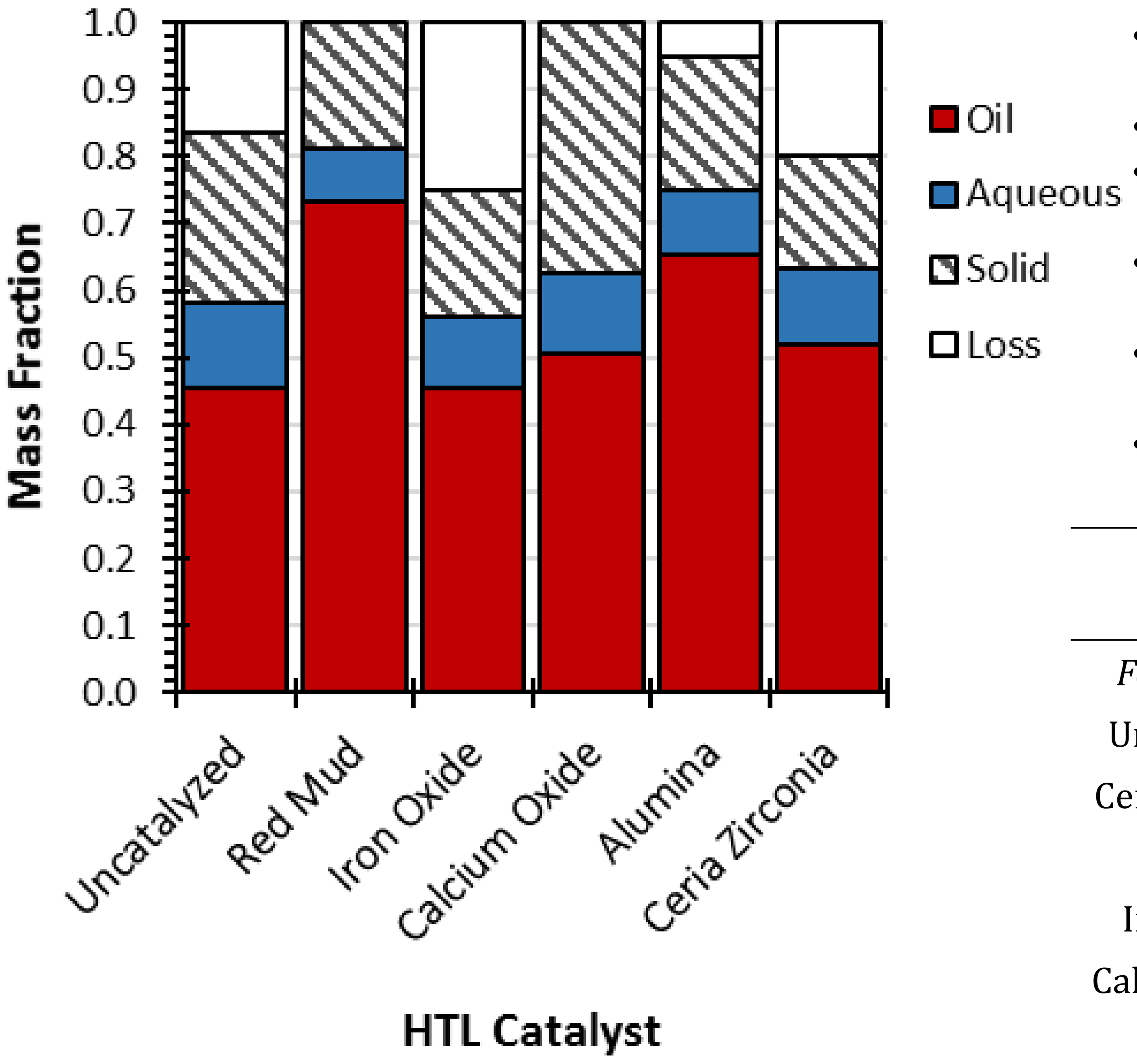
Red Mud Component	Weight Percent [%]
Silica	63.7
Alumina	15.2
Iron (III) Oxide	7.9
Potassium Oxide	4.1
Calcium Oxide	0.5
Phosphorous Pentoxide	0.3

The table on the left shows that results from the TXRF analysis for the red mud catalyst
- Component metal oxide catalysts were chosen based on these results

Figure on the right shows the IR Spectroscopy of the red mud oil phase
- The red mud oil has a high percentage of carbon (68.4%) supported by the IR graph
- IR shows the major functional groups and allows further understanding of the oil composition



HTL Product Results



- (Figure left) is the product distribution (oil, aqueous, and solid phases) after HTL reactions with the use of different catalysts
- Red mud and alumina catalysts improve oil yields compared to uncatalyzed reaction
- Oil properties (table below) reports elemental content (carbon, oxygen and nitrogen), higher heating values (HHV) and energy recovery of the oil
- Red mud and calcium oxide both improve the energy recovery of the HTL process compared to the use of other catalysts
- Red mud has the lowest total organic content (TOC) in the water phase, while calcium oxide had the highest TOC
- Therefore red mud catalyst seems most desirable and results indicate a shift in organic products from the water phase to the oil phase

Catalyst	C Content [%]	O Content [%]	N Content [%]	HHV [MJ/kg]	Energy Recovery [%]	HTL Water TOC [ppm]
Food Waste	*58.3*	*29.3*	*2*	*24.6*	*N/A*	*N/A*
Uncatalyzed	72.5	13.8	3.7	35.8	66.1	24,300
Ceria Zirconia	67.8	19.1	4	32.3	68.2	19,800
Red Mud	68.4	19.4	3.8	31.4	93.7	16,700
Iron Oxide	72.0	14.3	4.4	34.6	63.8	19,500
Calcium Oxide	72.1	14.2	5	33.5	69.0	25,300
Alumina	45.4	44.4	1.2	21.2	56.3	18,900

Conclusions

- **Hydrothermal liquefaction is an effective means for converting food waste**
- **The oil produced could be a possible replacement for crude petroleum**
- **Organics in the aqueous phase pose a limitation to system economics**
- **The addition of catalysts increases oil yields & decreases aqueous organics**
- **Cheaper metal oxide catalysts perform as well as Ceria Zirconia**
- **The Red Mud catalysts gave the best oil yield of any catalyst tested**
- **Red Mud had 80% oil yield and 90% energy recovery**
- **Mixes of metallic catalysts like red mud should be explored further**

References

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