Hydrothermal Liquefaction of Polyethylene

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Research Objective

To utilize the hydrothermal liquefaction (HTL) of polyethylene (PE) from waste electrical cables to produce a crude oil product. Implement catalysts to suppress char formation and improve oil yield [1]. Various solvents and catalysts will be investigated to determine which conditions will yield the most crude oil.

Background

Plastic does not degrade easily, and making plastic utilizes finite petroleum resources. PE makes up the largest portion of the plastic waste stream, making it vital to find a viable recycling method.

HTL yields of SRP waste with Ionic liquid

SRP: Water	Ionic Liquid	Temperature, °C	Residence time, min	Oil yield, %	Solid yield, %	Gas yield, %	HHV (MJ/kg)
1:20	-NA-	350	90	4.64	42.32	53.03	37.74
1: 20	BMIM [TFSI], 3 ml	350	90	2.8	70.0	27.2	37.94
1:20	BMIM [BF_4], 3 ml	350	90	16.5	50.0	33.5	32.88
1:20	BMIM [PF_6], 3 ml	350	90	4.92	65.02	30.06	35.62
1:20	BMIM [I], 3 ml	350	90	1.73	80.14	18.13	23.23

Research has been conducted on the HTL of PE using ionic liquids and acid catalysts to increase oil product yield. Experiments with BF4 showed the highest oil yield. Current work looked into the effect of using different solvents with and without various catalysts.

Research Methods

Experiments were initially conducted without the use of catalysts. 3 grams of PE and 30 mL of solvent were placed into a 100 mL PARR reactor with a 4843 controller. When catalysts were added, 0.3 grams were used. Experiments were conducted at 350 °C and held for 90 minutes. Products were separated gravimetrically with dichloromethane, and the solids left over on the filtrate side will be used for mass balance and product yield calculations. The composition of oil and gas products will be characterized using gas chromatography/mass spectrometer, elemental analyzer, bomb calorimeter, and FT-IR spectroscopy.

Catalyst	SRP,g	CSARS,g	solvent	oil yield,%	char yield,%
Csars	3	0.298	Acetone	28.067	57.7333333
Cbh	3.002	0.301	Ethanol	28.181213	36.775483
Ccs	2.999	0.3	Ethanol	29.743248	36.8456152
Cnayzeolite	3	0.301	Ethanol	22.6	45.3
Cps	3.004	0.301	Ethanol	26.931	41.8109188
Crs	3.002	0.303	Ethanol	20.087	43.7375083
Csabh	3	0.301	Ethanol	22.8	35.8666667
Csacs	3.001	0.304	Ethanol	28.457	40.11996
Csaps	3.004	0.3	Ethanol	27.996	56.391478
Csars	2.998	0.3	Ethanol	31.454	46.197465
Csaps	3.0036	0.3026	IPA	20.475	56.0327607
Csaps	3.001	0.3	Methanol	15.695	59.9466844

Acknowledgments

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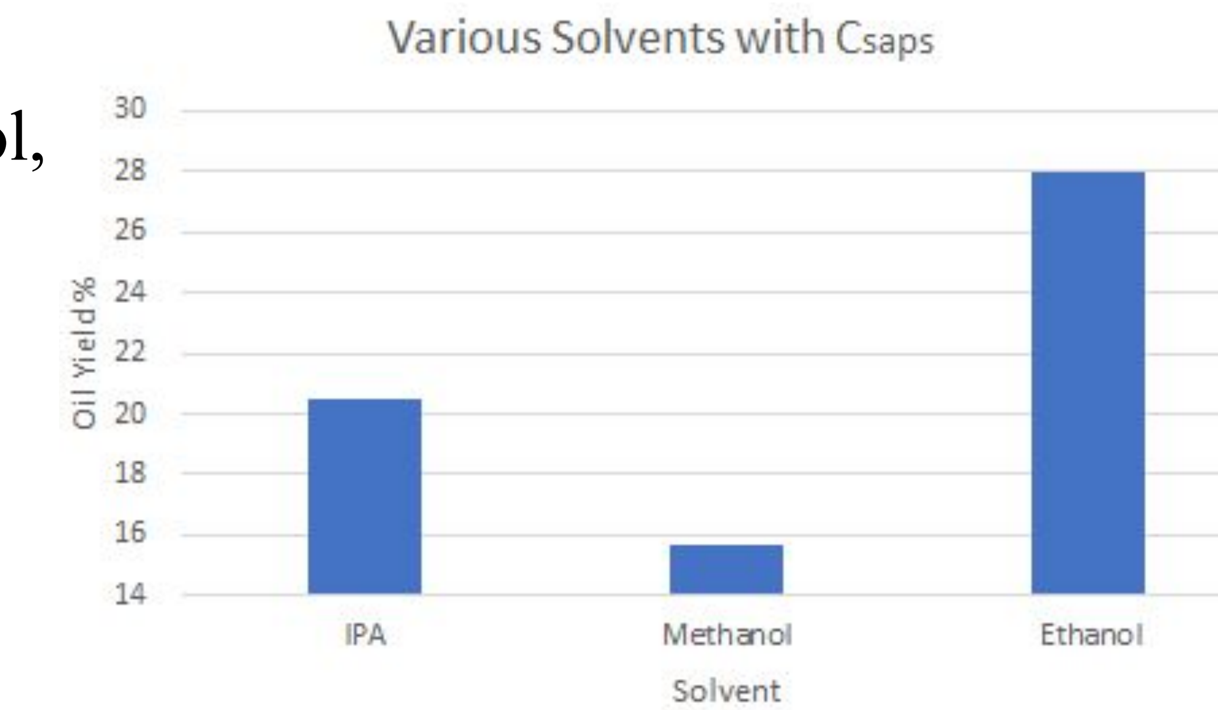
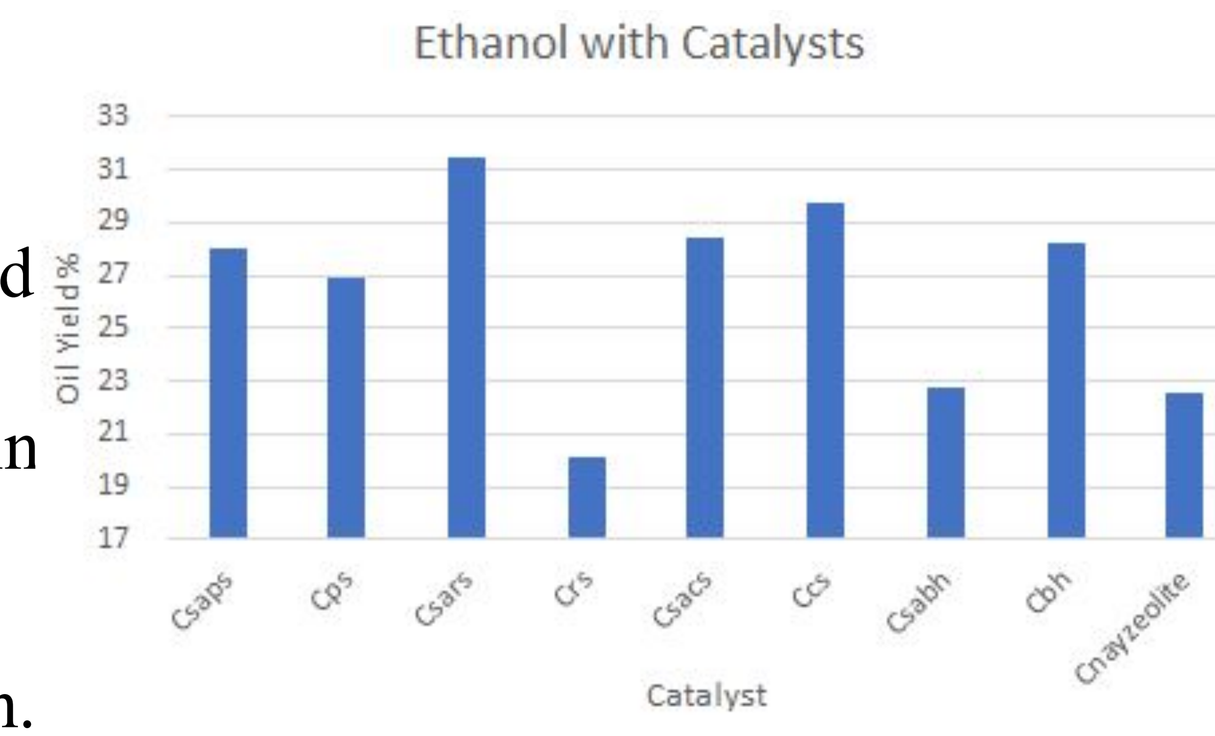
Results and Discussion





Oil yields of isopropyl alcohol (IPA), methanol, and ethanol with the same catalyst were compared initially. Ethanol had the best yield, and was tested with various catalysts and zeolites. The catalyst Csars had the best oil yield, at 31.454%. Data collected agrees with literature, which shows that certain catalysts and zeolites have the potential to suppress char formation. This leads to a higher oil yields with better quality oil [2].

Future Work

Research will continue on the HTL of various solvents with catalysts and zeolites. Current samples will need additional analysis to determine the HHV and composition of the crude oil produced. From there, it can be determined which parameters produce the most oil, and which produce the best quality of oil. Other types of plastic can also be investigated at a later time.

[1] Dimitriadis A, Bezergianni S, Hydrothermal liquefaction of various biomass and waste feedstocks for biocrude production: A state of the art review. Renewable and Sustainable Energy Reviews, 2017, 68: 113-125.
[2] Park, D.; Hwang, E.; Kim, J.; Choi, J.; Kim, Y.; Woo, H. Catalytic Degradation of Polyethylene over Solid Acid Catalysts. Polymer Degradation and Stability 1999, 65 (2), 193–198