Plastics to oil, NMR and GC/MS characterization of oils produced from a variety of plastics under a variety of reactor conditions.

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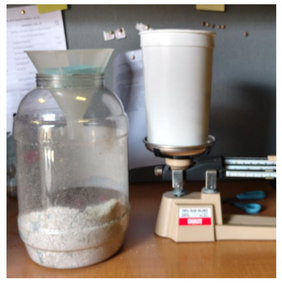
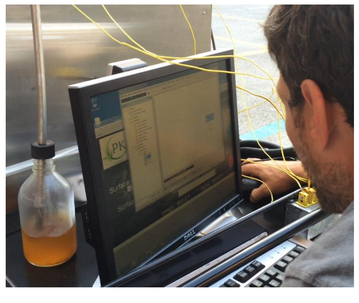
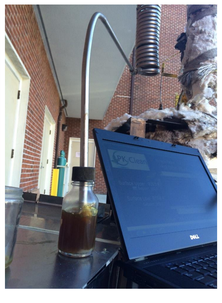
Abract and Introduction

Plastics waste ranks among the highest municipal and industrial waste. Solutions for plastics waste has been limited to: landfilling that accelerate the need for landfill space, incineration that emit known carcinogens such as dioxins, and recycling which eventually enters the waste stream. Plastic trash that do not reach municipalities can enter aquatic regions causing overall financial damage estimated at roughly $14 billion annually from harm inflicted on marine ecosystems. (UN Environmental Assembly)

Converting plastics to oil is emerging as a new waste management technology. This study analyzes oil rendered through a pyrolysis process using a prototype reactor at UNCW. The characteristics of the resulting oil depend on the plastics used and the reactor and distillation conditions. We varied reactor and reflux temperatures for a variety of plastics, including pure polyethylene and polypropylene, as well as mixed plastics from beach clean-up samples and plastics collected from the Sargasso Sea. Oils were characterized by 1D and 2D NMR and GC/MS. Oils from primarily polyethylene (PE) were found to be composed of a series of straight chain alkanes and terminal alkenes while oils from polypropylene (PP) contained more branched alkanes, alkenes and aromatics.







Materials and Methods

- Collect and sort plastic by the American Section of the International Association for Testing Materials(ASTM) resin identification code. When using distinguishable plastics, toxic polyvinyl chlorides were separated by density.
- Granulate plastics using IKA grinder
- Weigh and load in Depolymerizing Reactor.
- Fracture plastics at high temperatures and condense vapors into oil or wax, collect into graduated jar
- GC/MS samples prepared by diluting condensates (50 uL) in hexane (1 mL) and diluting again (10 uL in 1 mL).
- NMR samples prepare in CDCl3 (50 uL in 500 uL)

Results

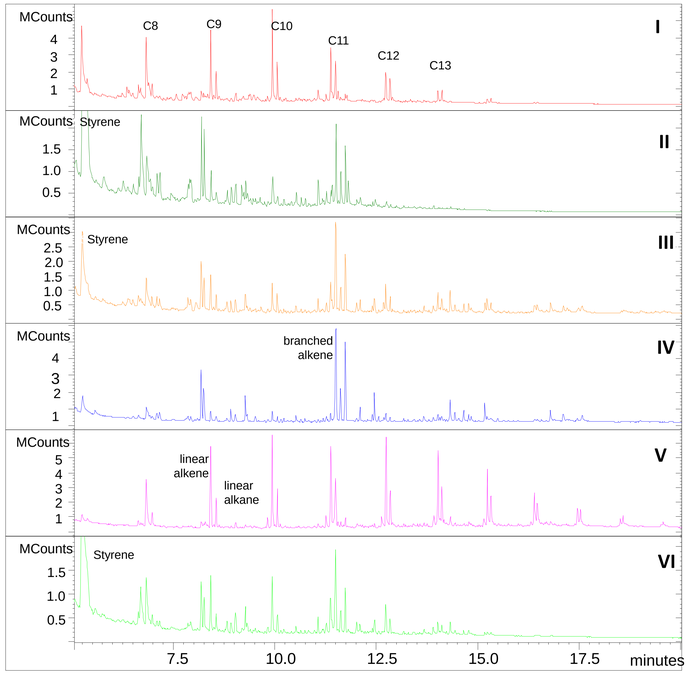


Figure 1. GC/MS of oils from 6 plastics; Varian Saturn 2200, DB5 column, temperature program 40C, 1 min., 40 – 320°C 10°C/min.

I. Marine plastics:
Collected from North Atlantic:
Reactor Temp: 1000F
Vapor Temp: 350F

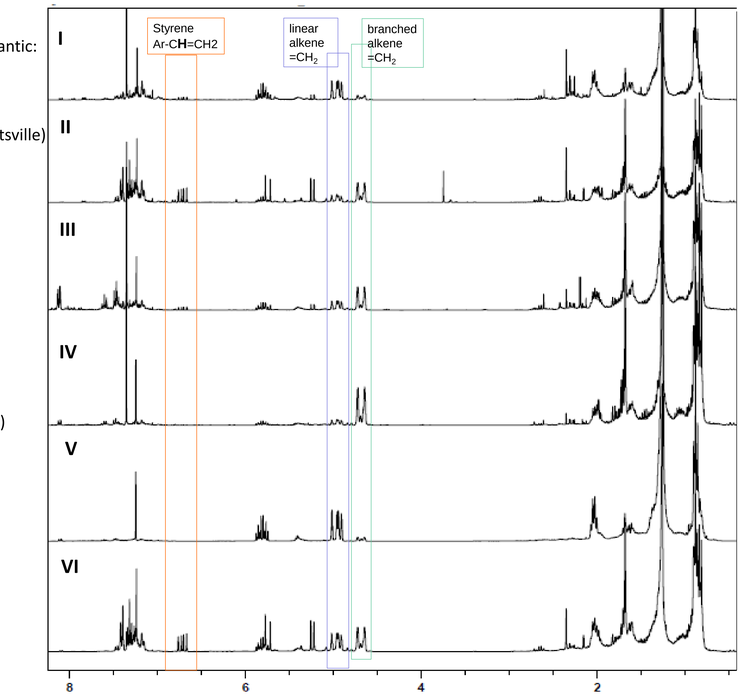
II. Beach Plastics (Wrightsville)
Reactor Temp: 900F
Vapor Temp: 400F

III. Household waste
Reactor Temp: 950F
Vapor Temp: 350F
(2nd run at 900 and 450)

IV. Polypropylene Caps
Reactor Temp: 800F
Vapor Temp: 350F
(2nd run at 950F and 350F)

V. HDPE Jugs
Reactor Temp: 1000F
Vapor Temp: 950F
paraffin

VI. Shipping Materials:
Reactor Temp: 900F
Vapor Temp: 700F



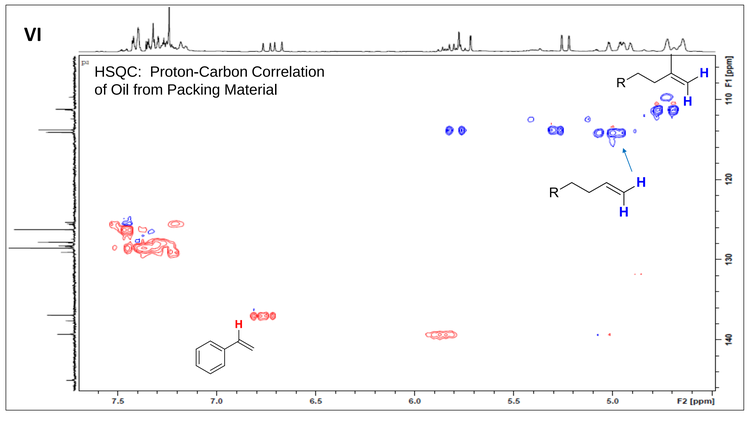


Figure 2. NMR, 300 MHz of oils from 6 plastics. *Top*, H-NMRs showing alkene signatures from styrene PE and PP; bottom, H-C correlation experiment used to confirm assignments

Discussion and Conclusion

- The type of plastics determine the chemical profile of the oils:
  - Polyethylenes produce primarily straight chain alkanes and terminal alkenes.
  - Polypropylenes produce branched alkanes an alkenes.
  - Polystyrenes produce complex mixtures containing a high percentage of styrene
  - Mixed plastics give complex mixtures of all of the above, usually containing a higher percentage of aromatics
- High return of oil to plastic, close to 1 to 1 (500 g produced 498 mL oil)
- Most oils appear to have relatively high cloud points.
- Paraffin seems to be a viable production.
- Changing the temperature in the of unit and reflux had little effect on sample composition

- **Future Work:**
  - Test cloud point, flash point, using ASTM standardized test D-975 and D-93. to verify fuel quality.
  - Capture volatiles, analyze and investigate for potential heating source for reactor.
  - Trap and analyze, using static head space GC, off gases of simply disposed plastics.

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