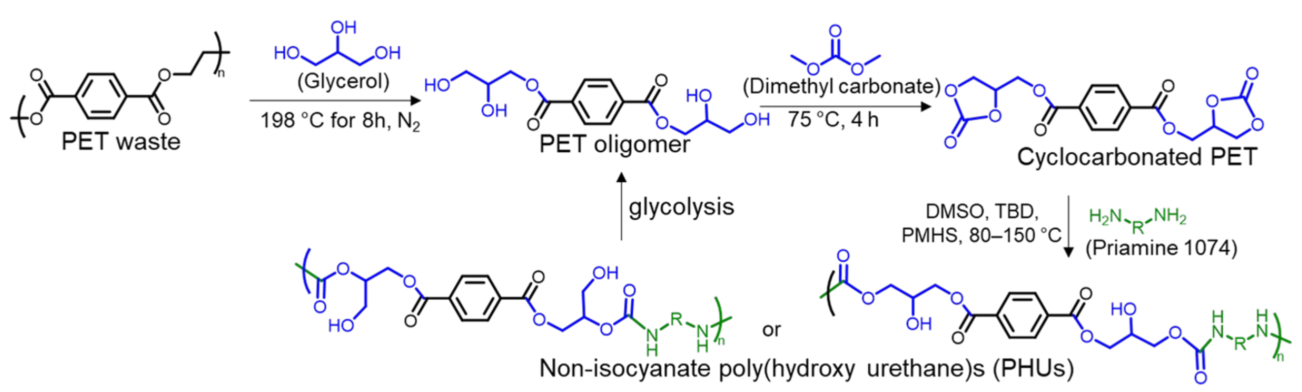
# CREATING NON-ISOCYANATE THERMOPLASTIC POLYURETHANE FROM WASTE PET

UNIVERSITY OF DELAWARE | CENTER FOR COMPOSITE MATERIALS

**Meghana Akella[2] (BSC), Dr. Kasturee Nayak[1] (PD), Dr. Srikanth Pilla[1]**
University of Delaware | Center for Composite Materials[1] | Department of Chemistry[2]

## Introduction




- PET waste accumulation poses significant environmental challenges.
- Thermoplastic Polyurethane (TPU) typically utilizes toxic chemicals for synthesis.
- Utilizing organic synthesis to convert waste PET into Non-Isocyanate Thermoplastic Polyurethane (NITPU) properly addresses environmental concerns while providing an effective, viable alternative to traditional polyurethane production.

## Methods

*Functionalized Oligomeric Precursor Synthesis*

- Post-consumer PET is broken down by glycolysis to produce PET oligomer with hydroxyl end groups.
- PET Oligomer conversion to cyclocarbonated PET (ccPET) using dimethyl carbonate.

*Polymer Synthesis*

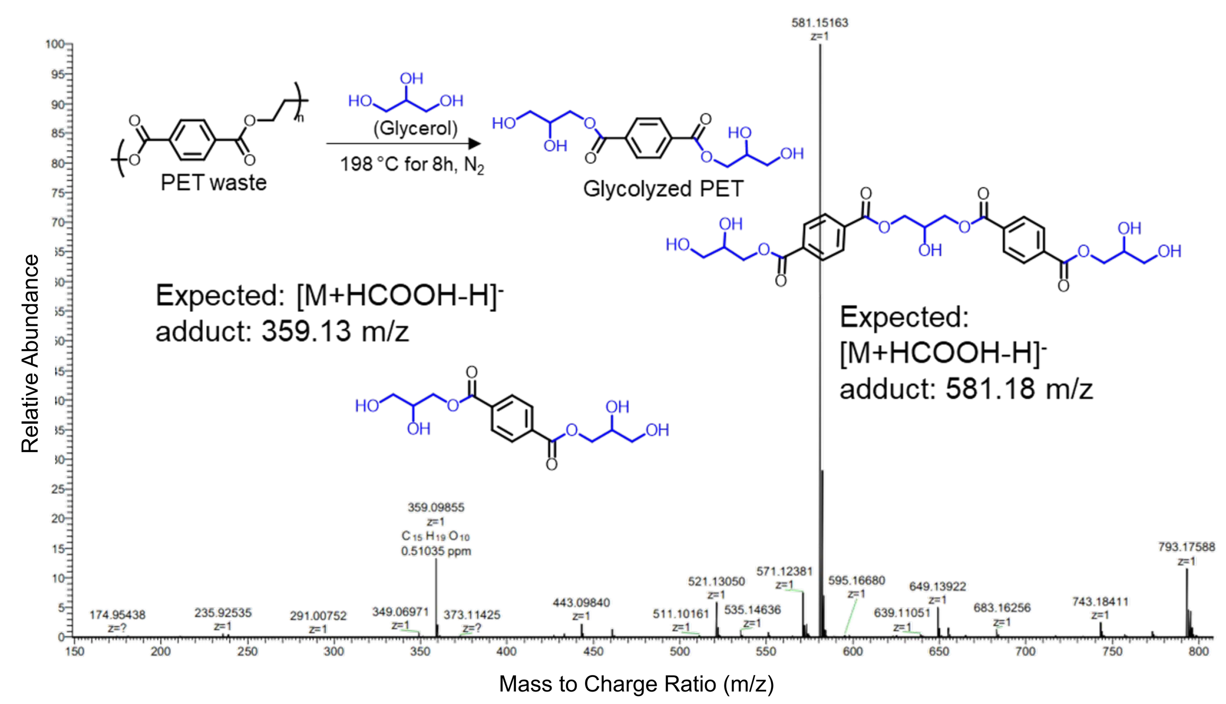
- Ring-opening polymerization of cyclic carbonates through use of biobased diamines.
- Implementing a "green" isocyanate-free route for the production of polyurethanes.

*Characterization*

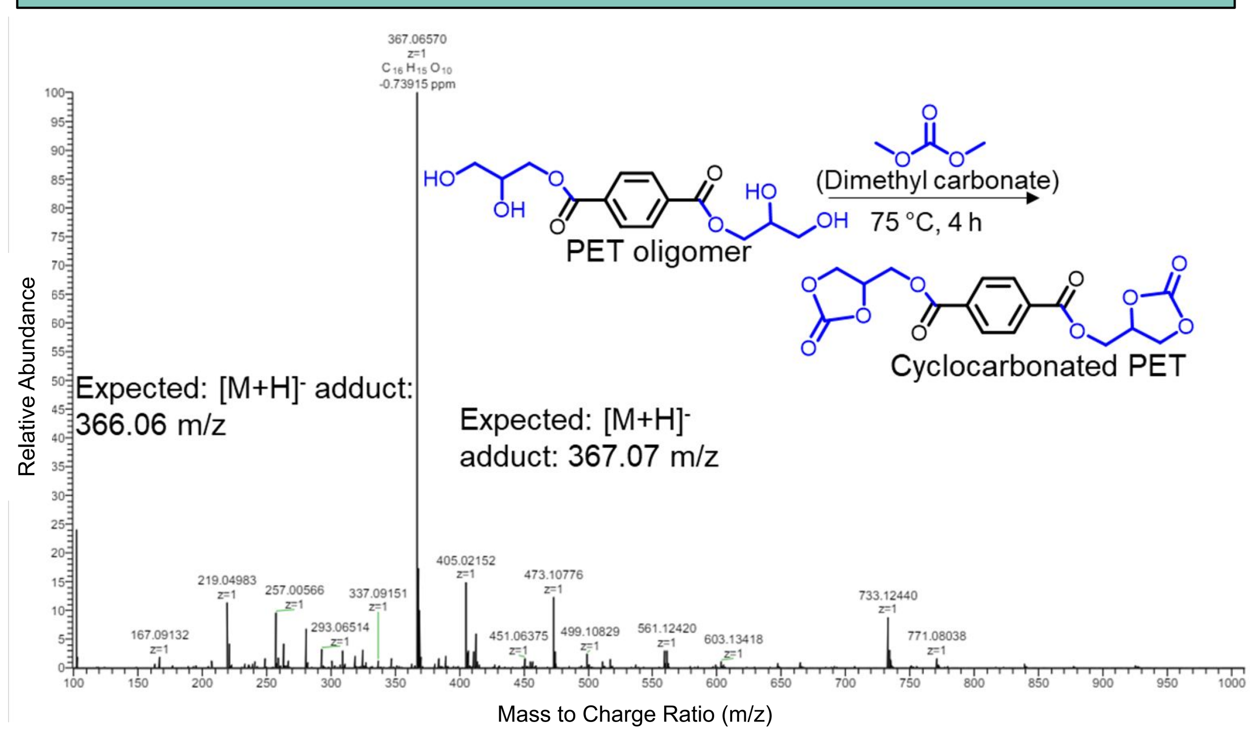
- Analysis of ESI-MS, $^1$H NMR, and FTIR peaks.
- Thermal Analysis and Material Properties of TPU (DSC, TGA).

## Mass Accuracy in Reaction

### Weight Determination of PET Oligomer (MS)



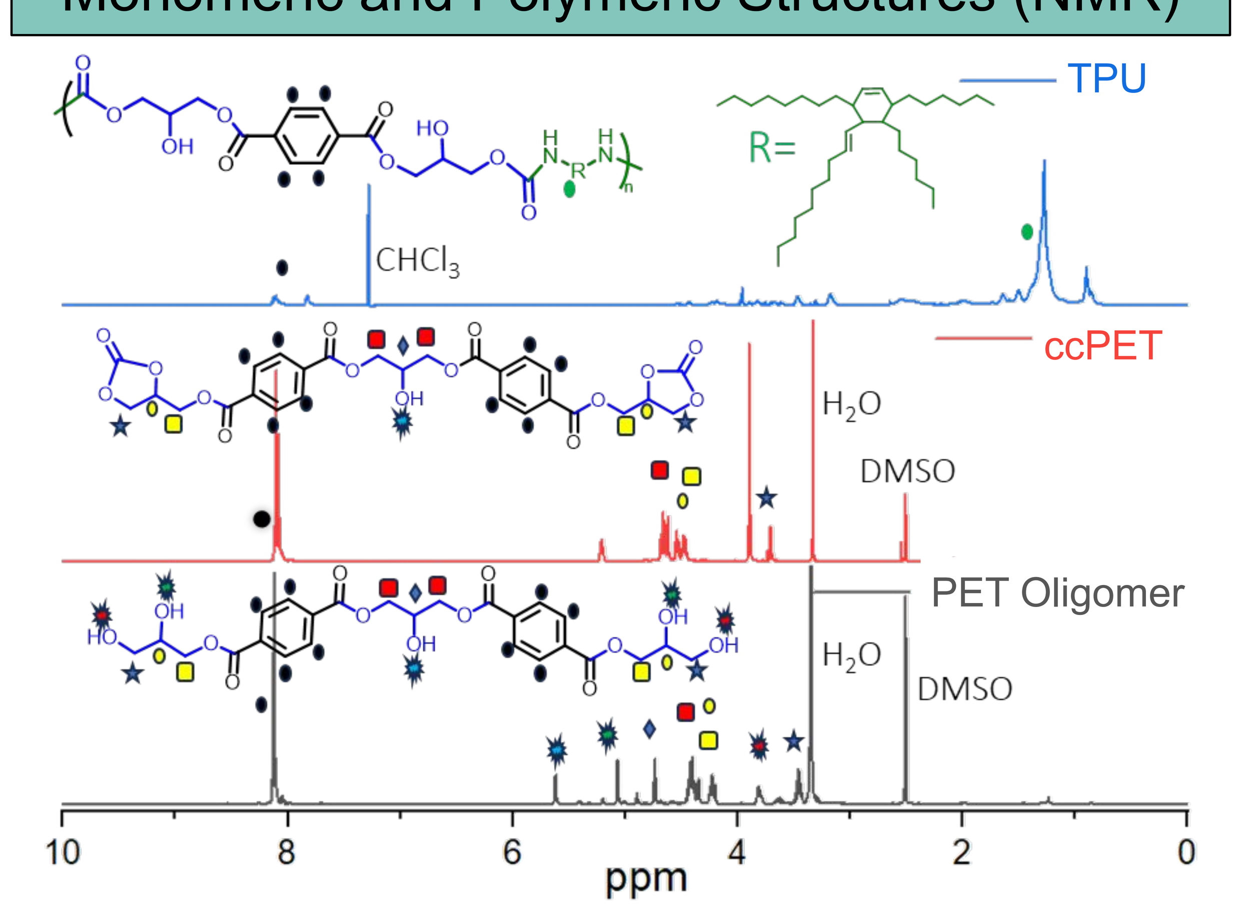

### Weight Determination of ccPET (MS)



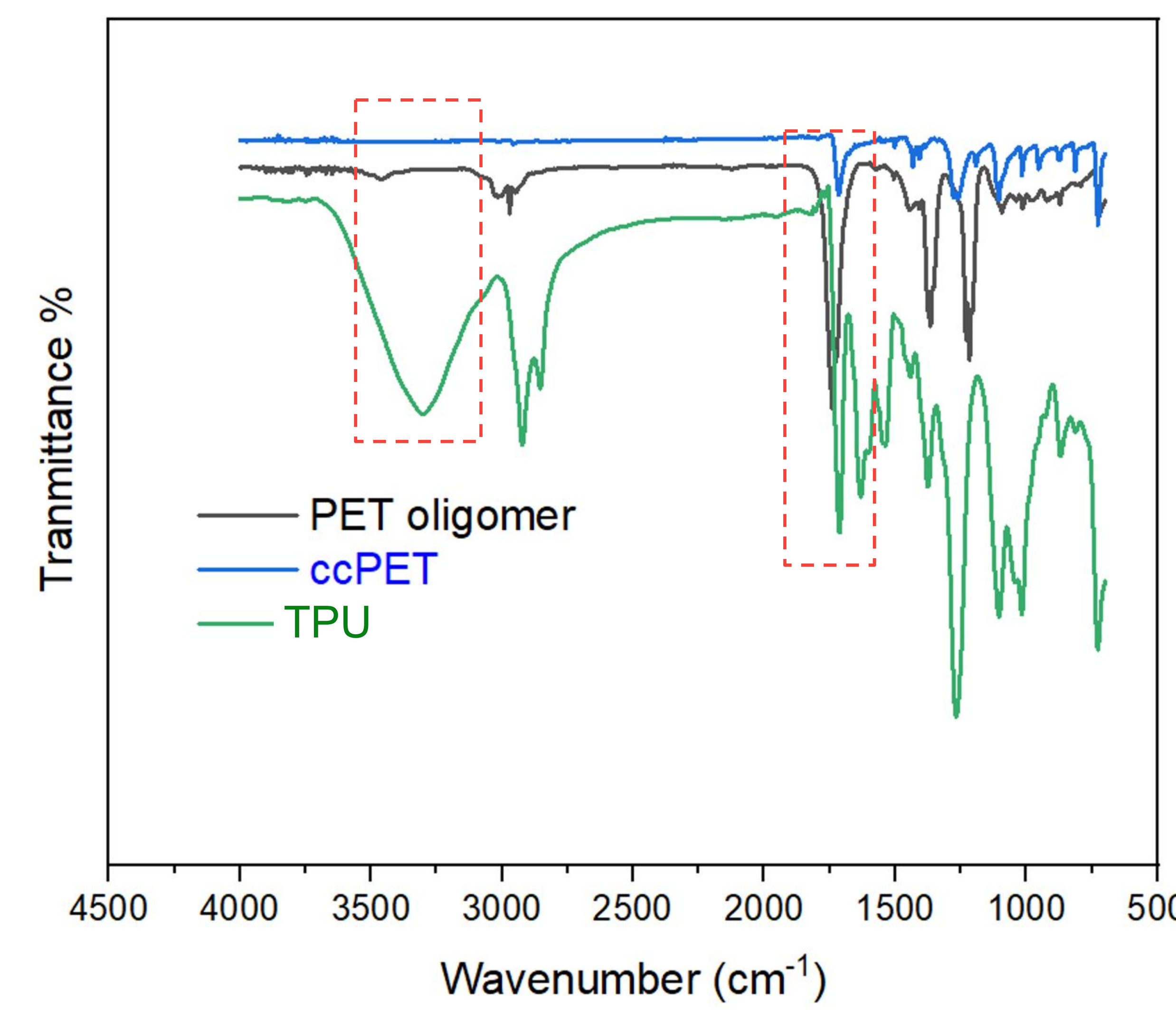

- ESI-MS Data of Recycled PET Oligomer and ccPET confirm that the experimental masses match with the exact masses.

## Confirmation of Reaction Pathway

### Monomeric and Polymeric Structures (NMR)



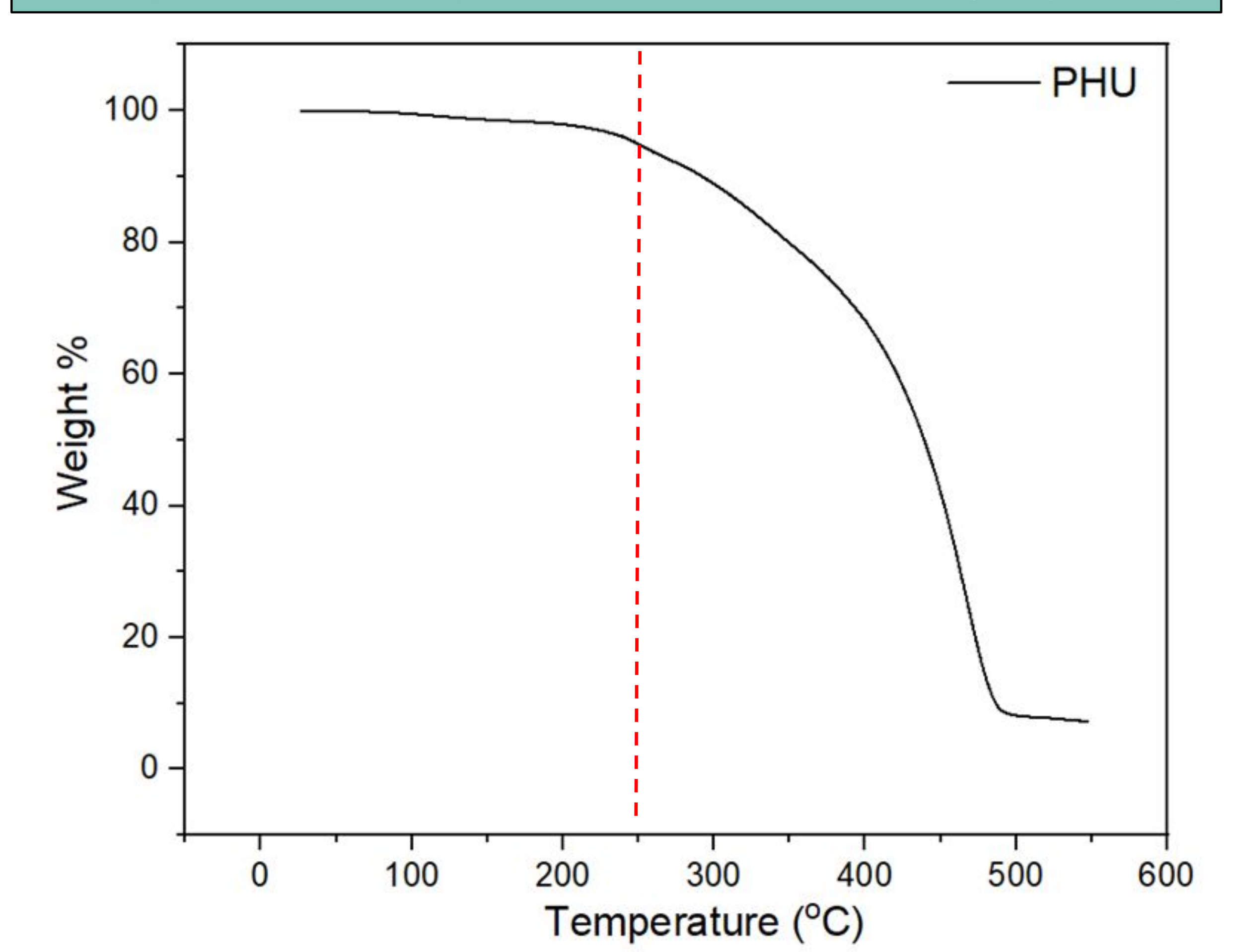

## Vibrational Spectral Characterization (FTIR)




- $^1$H NMR Data of PET Oligomer, ccPET Oligomer, and TPU all confirm the successful reaction pathway during synthesis.
- ATR-FTIR Data identifies cyclo-carbonate peak at 1739 cm$^{-1}$ disappearing in TPU, where new peaks for N–H bending and stretching were found at 1531 cm$^{-1}$ and 3326 cm$^{-1}$, respectively, indicating amine presence.

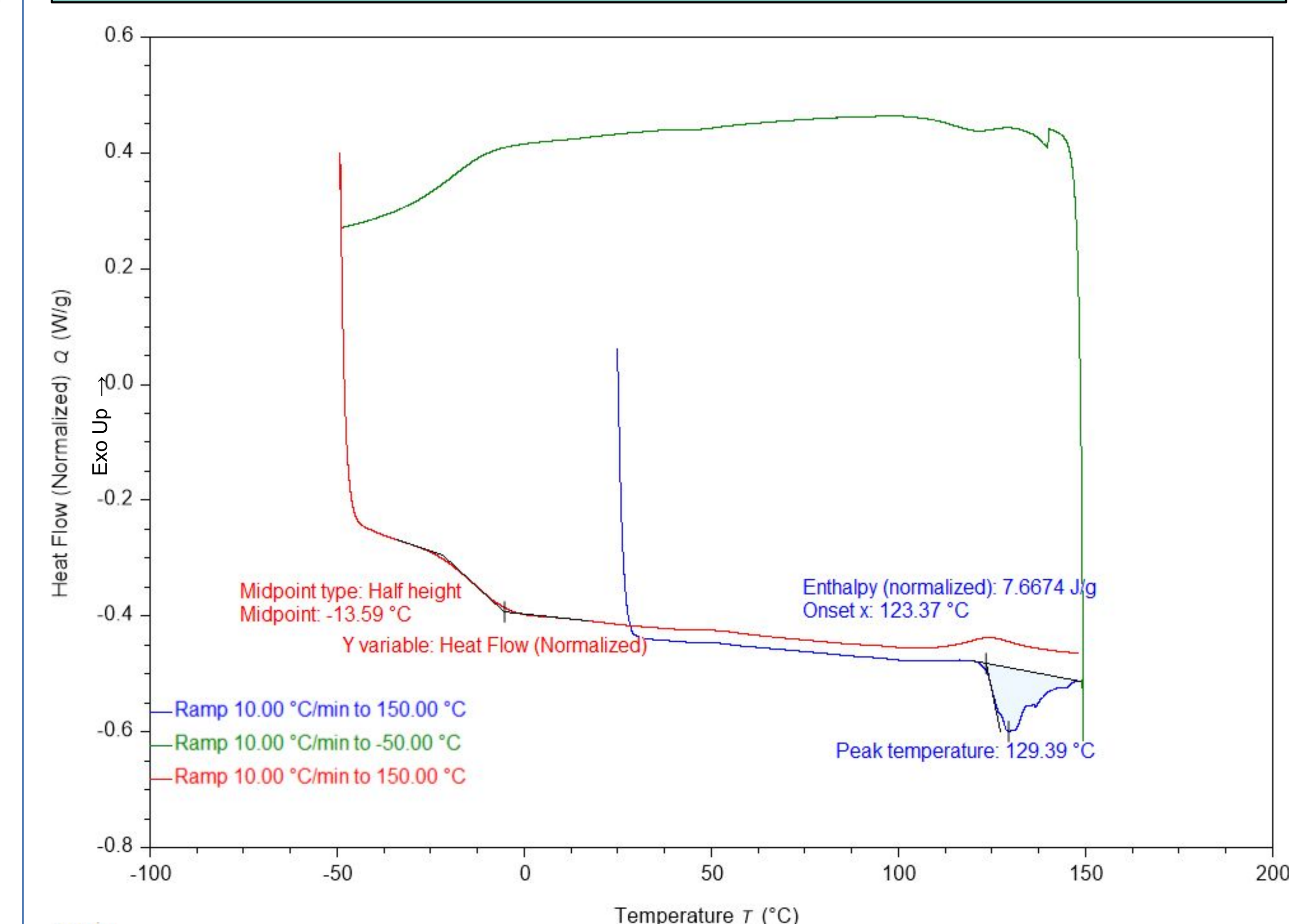
## Analysis of Material Properties

### Temperature-Dependent Mass Change (TGA)




- TGA Analysis discovers that TPU is found to be thermally stable up to 250 °C.

## Thermal Stability and Degradation of TPU (DSC)




- DSC shows glass transition temperature of TPU observed below room temperature (-25 ºC) and melting temperature at 125ºC.

## Conclusion & Future Work

- Successfully synthesized high-quality functionalized monomeric precursors from post-consumer PET waste.
- NITPU was produced, demonstrating:
  - **Glass Transition (Tg):** -15ºC
  - **Melting Temperature (Tm):** 130ºC
- TPU exhibits high thermal stability and flexibility. Future work will explore optimal processing and application conditions, further investigating mechanical and chemical properties and specific uses.
- Upcoming efforts will center on the "E3" Assessment to identify the optimal balance between economy, energy, and environment.

## Acknowledgements

*This work was supported as part of the AIM for Composites, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences at the University of Delaware under award #DE-SC0023389.*