Recycling of Polyethylene Terephthalate

Doni Thomas, Haibin Ning, Julia Brown, Siddhartha Brahma
Department of Materials Science and Engineering
Materials Processing and Applications Development Center

UAB SCHOOL OF ENGINEERING
The University of Alabama at Birmingham
Department of Materials Science and Engineering

National Science Foundation
WHERE DISCOVERIES BEGIN

Introduction

- Polyethylene terephthalate (PET) accounts for approximately 10% of the plastic produced worldwide and is nearly exclusively used for **single use** bottle packaging.
- Thermoplastics, such as PET (polyethylene terephthalate), has the highest potential to be mechanically recycled.
- Improvements in the reprocessing of recycled PET (rPET) for applications will in turn diminish the demand for virgin PET and have a favorable impact on our environment.
- Mechanically reprocessing rPET poses numerous challenges including thermal degradation which occur during reprocessing procedures.

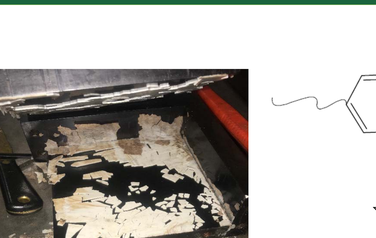


Figure 1: Plastic pollution

- Almost half of all plastic ever manufactured has been made since 2000.
- Nearly a million plastic beverage bottles are sold every minute around the world.
- Roughly 8 percent of the world's oil production is used to make plastic
- Some 18 billion pounds of plastic waste flows into the oceans every year from coastal regions.

Source: National Geographic

Objective

The goal of this project is to study the processing potential of film stacking rPET water bottles within a compression mold to generate a mechanically sound rPET plate by:

- Optimizing processing procedures such as heat time, temperature, and pressure
- Differential scanning calorimetry (DSC) and Fourier-transform infrared spectroscopy (FTIR) to determine changes in structural integrity
- Flexural, tensile and impact testing to determine the materials mechanical properties

Materials

- Single use PET water bottles were used.
- The density of the bottles was 0.82 g/cm^3.
- The thickness of the bottles ranged from 0.1 mm to 0.15 mm. DSC testing shown in Figure 3 indicated that the peak melt temperature was 244°C.

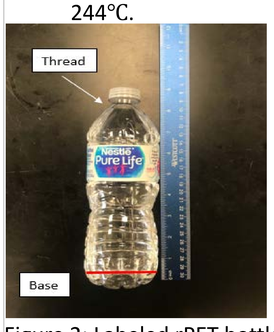


Figure 2: Labeled rPET bottle

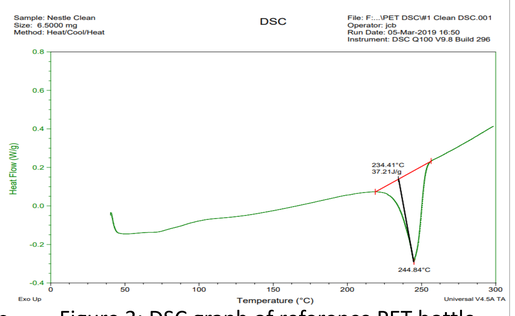


Figure 3: DSC graph of reference PET bottle

Initial Processing Trials

Figure 4: Compression molding; 2 hour heating time; 257°C; 1 MPa; Obvious thermal degradation

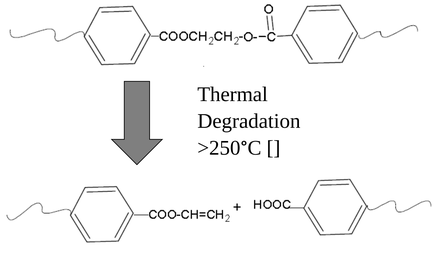


Figure 5:Traditionally challenges in recycling PET are due to its thermal degradation

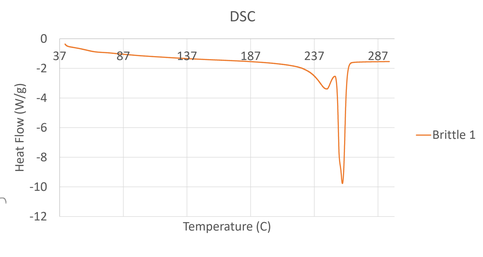


Figure 6: DSC Verification of thermal degradation

Processing Optimization

Figure 7: PET bottle sheet

2 minute heating time;
Above melting temperature;
2MPa

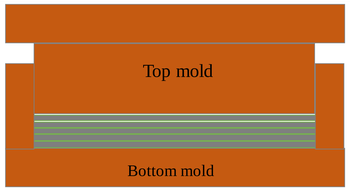


Figure 8: Stamp Molding Schematic

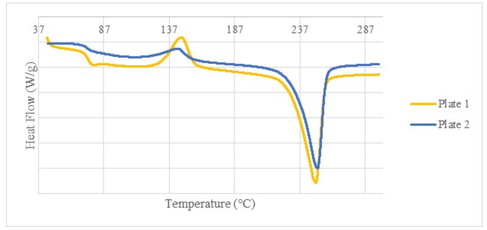


Figure 9: DSC graph of Plate 1 and Plate 2

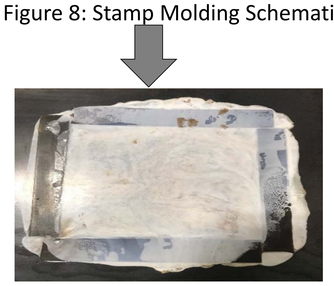
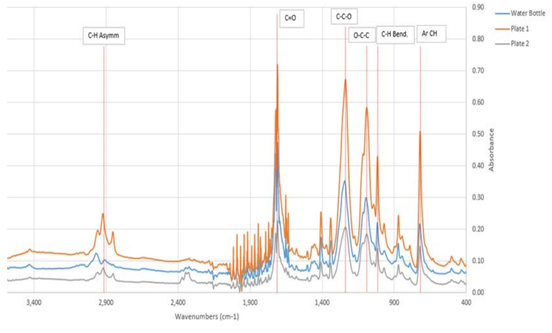


Figure 10: rPET plate

Results

Fourier-transform infrared spectroscopy

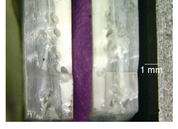
Fourier-transform infrared spectroscopy (FTIR) was used to measure the materials radiation absorbance of an infrared light as a function of its frequency. The testing was performed on samples Brittle 1, Brittle 2, Plate 1, Plate 2, and a reference a water bottle.



Mechanical Testing

Tensile Testing

Flexural Testing



Tested Sample

	Tensile Testing		Flexural Testing		Impact Testing
	Avg. Tensile Strength (MPa)	Avg. Young's Mod. (GPa)	Avg. Flexural Strength (MPa)	Avg Flexural Mod. (GPa)	Avg. Impact Strength (J/mm^3)
Plate 1	32.4	2.1	64.8	2.2	0.01
Plate 2	22.7	2.5	84	2.7	0.006

Conclusion

- Traditionally challenges in reprocessing rPET are due to its thermal degradation.
- Stamp molding process was successfully developed for reprocessing rPET to avoid thermal degradation
- Temperature, pressure, and heat time exposure are parameters which must be closely controlled in order to optimize the materials' mechanical and structural properties.
- The processing could be further optimized to achieve higher mechanical properties.
- As a result, the demand for studies involving the reprocessing of rPET will significantly increase and in turn provide a major incentive for more recycling of PET bottles and PET manufacturers to diminish the use of virgin PET altogether.
- Future work could be optimization of processing by including the addition of fibers to create a composite material with improved mechanical properties.

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