IMPROVING DEGRADED MICROPLASTIC IDENTIFICATION USING FTIR-BASED CNN MODELING

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INTRODUCTION:

Identifying plastics in the environment is difficult as their chemical compositions change due to ultra-violet (UV) exposure. This work captures **the degradation of plastics in a controlled environment and trains a Convolutional Neural Network (CNN) model to better identify these plastics**.

- **Fourier Transform Infrared (FTIR) Spectroscopy:** Uses infrared light which is absorbed at different frequencies in the atomic bonds of a sample. This absorption is observed in spectra data and helps to identify different bonds.
  - Is **more sensitive to the oxidation process polymers undergo during the degradation process**.

METHODOLOGY

Sample Preparation

Samples are prepared into 2-5mm sample sizes and then grinded down in a Planetary Ball Mill PM 100 [1] .

Polystyrene (PS)

Polypropylene (PP)

Each sample is extracted and diluted in two beakers with 300mL of deionized water.

UV-light Degradation

QUV Accelerated Weather Tester

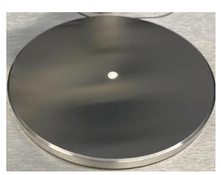
Control

Test

Samples are degraded in a UV weathering chamber, at an intensity of 340 UVA. Samples are taken out every 4 days and undergo centrifugation at 3000-3500 rpm. 3-10µL of concentrated sample is dried and scanned using FTIR Spectroscopy.

Data Collection

Fisher Scientific Accuspin 8C Clinical Centrifuge



Stage of the FTIR

Additional samples are scanned including:

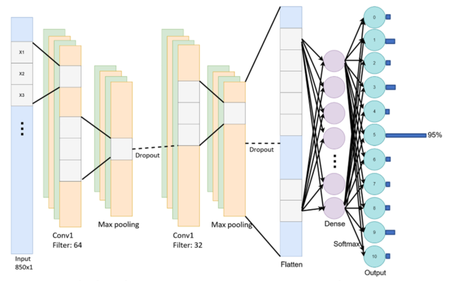
- polystyrene (PS)
- polypropylene (PP)
- polycarbonate (PC)
- polyvinyl chloride (PVC)
- polyethylene terephthalate (PET)
- polyethylene (PE)
- nylon (PA)
- polyester

METHODOLOGY:

Model Training

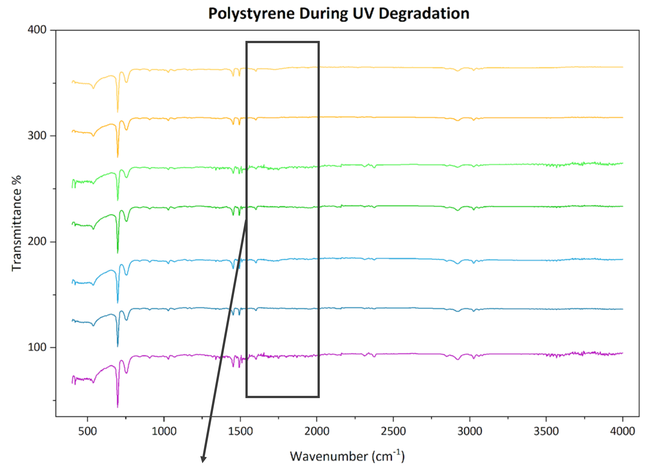
A dataset focused on these eight plastics and polyurethane is created with FTIR spectra data from the FLOPP and FLOPP-e library [2] and sample scans.

- # of spectrums used: 363
- Spectra range used: 675-4000 cm^{-1}

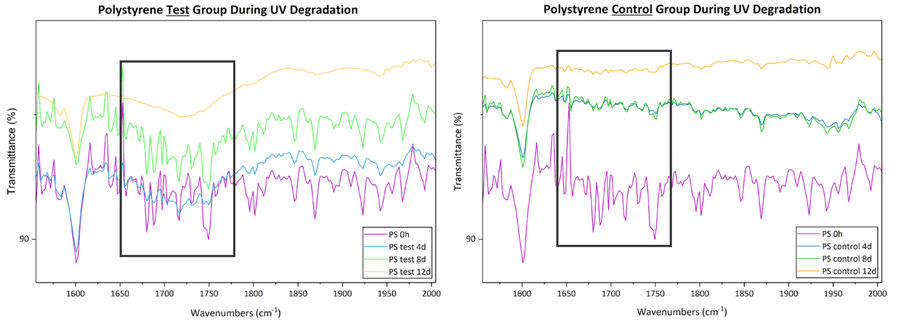


This data is used to train a 1-D CNN model. The CNN structure used is shown above [3].

RESULTS:



FTIR spectra of polystyrene UV degradation of both groups during a 12-day period.



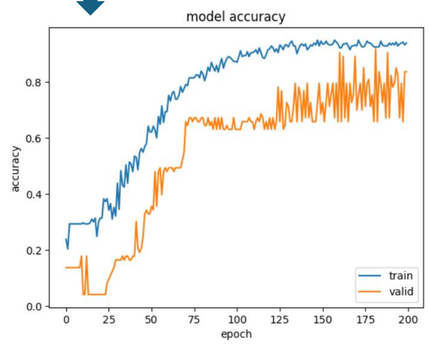
The peak at ~1725 cm^{-1} indicates a carbonyl bond is present, a sign of oxidization which is not present in the control group. This agrees with other literature where carbon-oxygen bonds occur during UV exposure [4] and validates the methodology used.

RESULTS:

Below showcases the split in validation (20%) and training sets.

```
history=model.fit(x_train, y_train, batch_size=64, epochs=200,
validation_split = 0.2, verbose=1)
```

Below are the training and validation accuracy curves graphed.



Training: How well the model performs on training data.
Validation: How well the model performs on new data.
Epochs: How many times the model looks at the data.

Training Accuracy: 94.6%
Validation Accuracy: 83.6%

FUTURE WORK:

- Conduct data augmentation to further improve accuracy
- Collect more data on different plastics (polyurethane)
- Further degrade existing samples and different plastics
- Use a saline solution (3.5% sodium chloride in a water solvent) and study the UV degradation of plastic samples in saltwater environments (left).

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