Effects of Photodegradation on the Chemical Composition of Plastics

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Background

Photodegradation is the process of changing the chemical makeup of a substance through heat and UV light energy. This may impact the results using Fourier Transform Infrared Spectroscopy (FTIR) when typing particles discarded in natural environments.

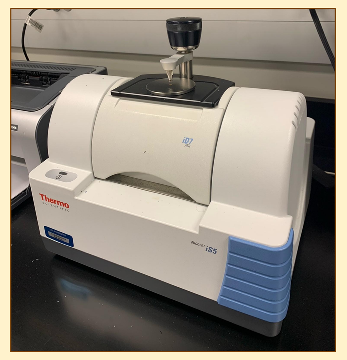
Colin Hardy,UNCW Chemistry Major, pioneered a hypothesis analyzing particles found in fresh water suggesting that weathered plastics could present as other types of substances like monoelaidin, a food additive. This may contribute to under-reporting of plastics found in the environment due to plastic composition changing dramatically under heat and light exposure and well as the potential impact on wildlife. For example, in a study on marine biota, it was found that after a substantial exposure to heat and light, zooplankton were found to increase plastic ingestion. (Vroom et al., 2017).

In this study, it is hypothesized that with heat and light exposure over a few weeks, plastic composition will change to the point of being compatible to non-plastic materials.

Materials & Methods

For this study, we used Thermo-FIsher FTIR - ATR, as well as the Atlas Suntest solar simulator.

The study required obtaining various plastic samples that would be degraded and tested. This includes commercially used plastics, locally found plastics in the environment, and pre production plastic pellets. The absorbance spectrum for each of these was obtained using the ATR attachment, and was recorded. Once all of the baseline spectra records, the UV light and heat application began. The particles were subjected to UV light at 100℃ for at least 24 hours. After each of these photodegradation periods, particles were removed and analyzed using FTIR-ATR in absorbance mode, the spectra would be taken and recorded. The plastics would be placed back into the solar simulator to be exposed to light and heat once again.



Results and Discussion

This study looked at the impact of heat and UV light on plastics. In most cases, substantial changes were observed after photodegradation. C=O and O-H bonds released the most energy, potentially meaning photo-oxidation is taking place.

Locally found plastics were not included, because there was not a strong disparity in their spectra.

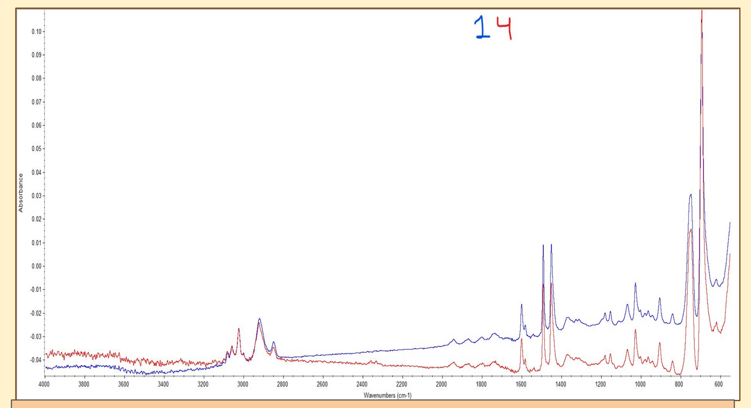


Figure 1: Pre-production polystyrene comparison

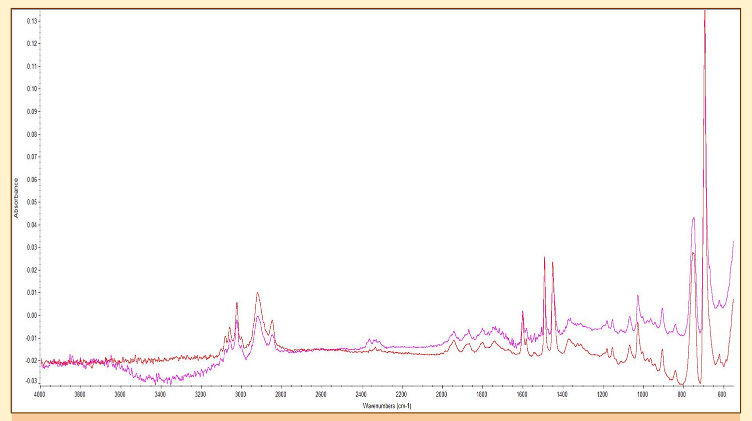


Figure 4: Used polystyrene comparison

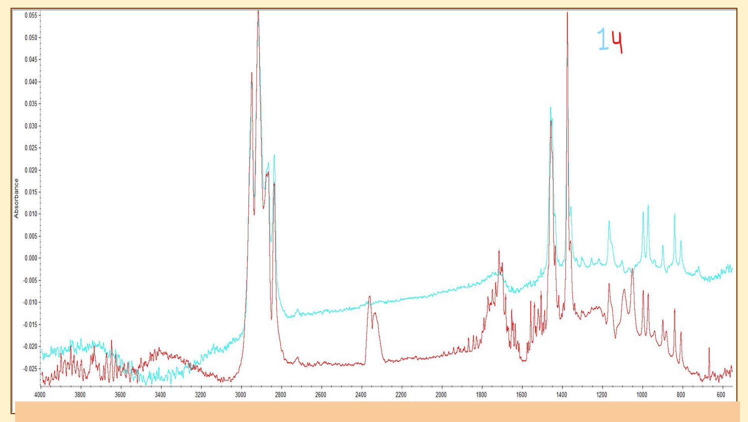


Figure 2: Pre-production polypropylene comparison

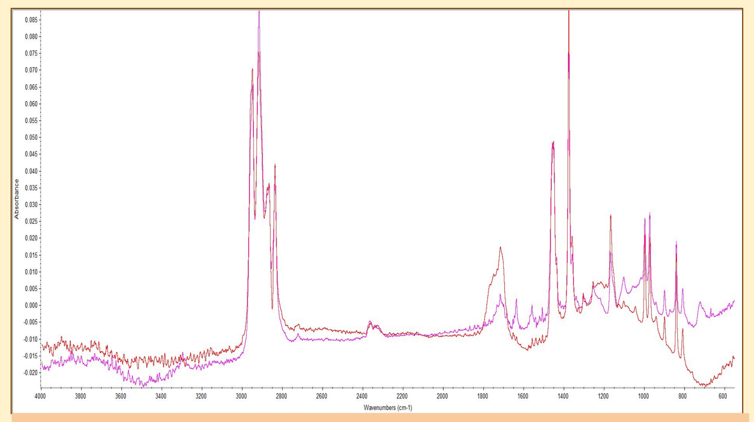


Figure 5: Used polypropylene comparison

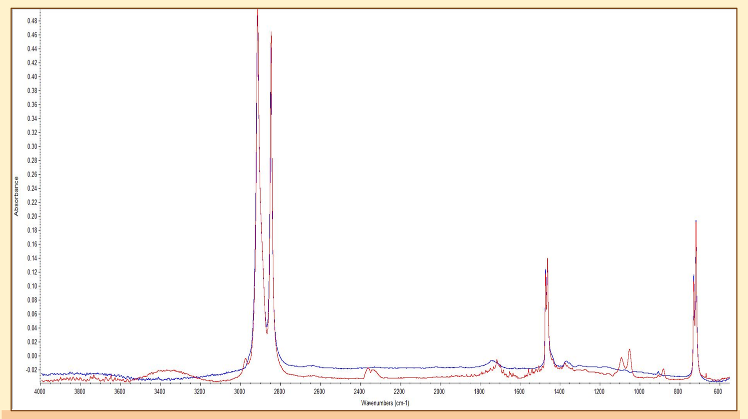


Figure 3: Pre-production polyethylene comparison

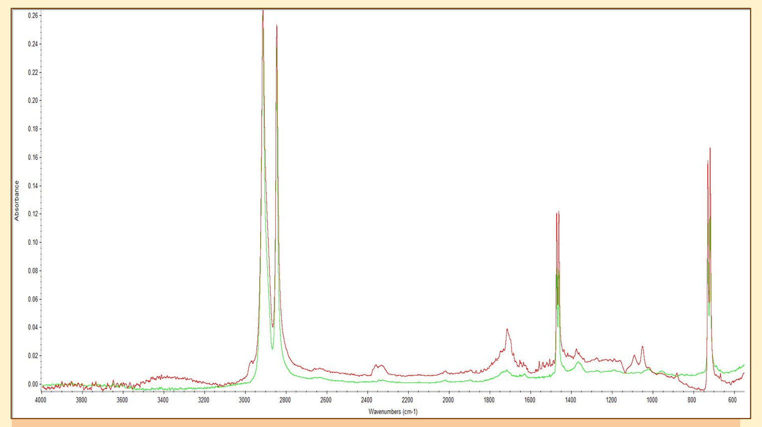


Figure 6: Used polyethylene comparison

Conclusion

This study does not completely support the hypothesis, since there were no consistent drastic changes over the time span of a 200 hours in the solar simulator. This does not mean that degradation is not occurring and recommend this study be run over a longer period of exposure. We were able to prove that the spectra did change with preproduction pellets perhaps because they do not contain the additives that slow down the degradation process, for example, UV radiation absorbers (El-Hiti et al., 2021). Microplastics are an increasing concern due to their potential impacts on the environment (Athey et al., 2020). Many effects of the changing composition of plastics remain unknown, but there is the potential for long lasting impacts as plastics degrade. The continuation of this study could potentially benefit plastic debris research by positively identifying degraded plastics that may be interpreted as food additives using FTIR thus causing the underreporting of plastic debris.

References/ Acknowledgements

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