Investigations into the Mechanism of Energy Transfer between Aromatic Microplastics and Pollutants during Photolysis

Hannah Olson; Xiolera Martinez2; M. Paul Chiarelli1
1Loyola University, Chicago, IL

Overview

Purpose
To determine if and how light energy is transferred between plastics containing aromatic polymers and absorbed pollutants during photolysis.

Methods
Absorption and Fluorescence spectroscopy of triclosan absorbed to different plastics is studied.

Results
Aromatic plastics reduce the rate of photolysis of triclosan relative to non-aromatic plastics because they can quench triclosan.

Introduction

Plastics are a widely versatile and durable material resulting in their widespread use in various industries today. Discarded plastics do not remain in their original form but rather degrade in the environment into pieces too small to recycle. Microplastics are defined as plastic particles that are less than 5 mm in diameter [5]. Microplastics present a unique challenge in that they cannot be recycled and can pass through the wastewater filtration system. Microplastic pollution is of concern to the environment due to the low solubility and rapid bioaccumulation in aquatic species [2]. Toxic compounds may concentrate on the surface of plastic particles and then transfer these toxins to aquatic animals by ingestion of these microplastics, resulting in the absorbed toxins to be spread throughout the food chain to humans eventually [5].

Past research has demonstrated that triclosan will undergo photolysis at a faster rate on the surface of plastics that do not absorb sunlight such as polyethylene and polymethylmethacrylate than it does in water with no plastic present [4]. We have also observed that the decomposition of triclosan is almost twenty times slower when absorbed onto plastics that are capable of absorbing sunlight such as PS and PC [4]. We have hypothesized that the aromatic polymer plastics will quench the triclosan after it absorbs light thus slowing the rate of photolytic decomposition. We are interested in investigating if and how light energy is transferred between triclosan and aromatic plastics. The goal was to carry out absorption and emission spectroscopy studies for these varying types of plastic to find evidence of energy transfer between triclosan and PE or PC.

Materials

The plastic particles for PMMA and PS were acquired from Copolymer in Santa Barbara, CA. PE plastic particles were obtained from Sigma Aldrich. The polycarbonate particles were made in our lab by piping 5 mL of saturated PC solution in THF into ice-cold (0°C) nanopure water. The triclosan used for these studies was obtained from Sigma Aldrich.

Results and Discussion

We acquired absorption spectra of the PE, PS, PMMA, and PC and PE beads in water to see if any of these plastics absorbed light in the 300 or 350 nm range (the wavelengths used for our photolysis studies). These absorption spectra are shown in Figure 2. The spectra demonstrate that only poly(carbonate) (PC) and poly(ethylene) (PE) absorb the wavelength used for photolysis (300 nm). Poly(methylmethacrylate) and PMMA showed no significant absorption at any wavelength compared to the PE and PS. These results suggest that PC and PS can absorb light energy used for photolysis. We then acquired emission spectra for the PC, PS, PMMA, and PE beads in water. Their spectra are shown in Figure 3.

The Figure 4 spectra show that triclosan will absorb at 280 nm and that this absorption may lead to emission at 415 nm. This suggests that energy transfer between triclosan and PE or PS may occur when photolysis is carried out at 300 nm. We also acquired absorption spectra of PE, PMMA, PC, and PS coated in TCS and diluted in water. These spectra of this study is shown in Figure 5. The similarity of the spectra suggests that triclosan is absorbing the light, not the PC or PS.

Conclusion

The results of our studies suggest that the primary reason why the photolysis of triclosan absorbed to plastics made from aromatic polymers proceeds at a rate up to 20 or 30 times slower than when absorbed to plastics composed of aliphatic polymers is because aromatic polymers quench the triclosan prior to fragmentation. Triclosan absorbed to PS or PC will transfer light energy to the plastic and thus have less to induce fragmentation. Triclosan absorbed to PE or PMMA will not transfer light energy to the plastic, thus energy will build up in the absorbed layer during photolysis and increase the rate of degradation to 2,8-DICD.

Reference