

Evidence of chemical transfer in fresh or salt water during UV irradiation of plastic debris

Gaëlle Bissagou Koumba^a, Marcello Brigante^a, Florence Jestin^b, Sophie Commereuc^b, Vincent Verney^{a,c}

^a Clermont Université – Université Blaise Pascal - ICCF

^b Clermont Université – ENSCCF - ICCF

^c CNRS, UMR 6505, ICCF, BP 10448, F-63000 CLERMONT-FERRAND

Corresponding author email: gaellybk@yahoo.fr, vincent.verney@univ-bpclermont.fr

ABSTRACT

After use, discarded plastics can stay in outdoor environment if their conditions of storage are not enough safe. They will be then exposed to climatic factors (UV solar radiations, heat, rain, pollution,...) and will end up in freshwater or in marine water. They are submitted to photo ageing and a consequence a possible size reduction through a fragmentation process which results in micro plastic formation. In parallel the macromolecular polymer undergo a photo chemical oxidation mechanism leading to the formation of degradation by-products.

We have studied and examined how chemicals molecules can be transferred from the solid plastic pieces to the aqueous medium along this degradation process. We focused on the detection and quantification of short chain carboxylic acids (mainly C1 – C2) as a probe of this mechanism. Plastic films (PP and PS, thickness about 100 µm) are cut into small pieces (about 1cm²) and then 30 pieces are stirred in a glass reactor filled with either freshwater or saltwater. Aqueous solutions were irradiated in a thermostated cylindrical reactor (40 mL), cooled by water circulation at a temperature of 20 °C in order to limit thermal reactions. A Lot-Oriel solar simulator equipped with a Xenon lamp and a Pyrex filter was adopted to cut short radiations source (wavelengths below ~290 nm). For dry UV-ageing plastic films are irradiated at 60°C in an ATLAS SEPAP12.24 oven equipped with four mercury lamps. At regular time, some water quantity is taken of and then analyzed by Ionic Chromatography. Other UV-vis spectroscopy and Total Organic Carbon analysis (TOC) were performed in order to investigate the spectroscopic changes and organic content in water.

These ageing conditions enable us to carry out three tasks:

- The first one consists in studying the fate of plastic debris thrown to the soil, and exposed to UV rays.
- The second one simulates the fate of plastic debris thrown to the soil and transported in freshwater.
- The last task is similar to the second one but this time in salt water, simulating the marine water's role.

The main result is that we can put in evidence the formation of formic and acetic acid as soon as irradiation starts. Moreover the sequence dry/freshwater/saltwater ageing leads to an increase in the concentration of carboxylic acids transferred.