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Study of Low-Density Polyethylene Degradation by Molecular Fluorescence Spectrometry

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Palavras Chave: *low-density polyethylene, fluorescence spectrometry; plastic degradation.*

Highlights

- Molecular fluorescence spectrometry was applied to monitor LDPE degradation;
- Distinct changes in the fluorescence profile were observed at each degradation stage;
- The technique demonstrates potential for tracking synthetic polymer degradation in natural environments.

Abstract

The global production of synthetic polymers has grown substantially since the 1950s. As a consequence of their inadequate use and poor solid waste management, these materials have become persistent environmental contaminants, with estimates indicating that between 4.8 and 12.7 million tons (Mt) of plastic waste enter the oceans in a single year [1]. In aquatic environments, plastics undergo photodegradation, where polymer chains are cleaved, generating free radicals that, upon reaction with oxygen, lead to the formation of new oxygenated functional groups [2]. Consequently, the fluorescent properties of the material can be modified. This study aims to assess the degradation of low-density polyethylene (LDPE), one of the most widely used synthetic polymers worldwide, by means of molecular fluorescence spectrometry. For this purpose, 1 cm² LDPE plates were subjected to degradation for 15 and 30 hours and compared with non-degraded plates using 3D and 2D fluorescence spectra. The degradation experiments were conducted under conditions simulating the natural aquatic environment, in a photochemical system with UVI = 205, in simulated seawater solution.

In the spectrum of LDPE degraded for 15 hours, the fluorescence intensity decreased considerably (48,750 a.u.) compared to non-degraded LDPE (λex = 310 nm, λem = 450 nm, 97,500 a.u.). Furthermore, a shift in the fluorescence profile was observed, with a characteristic band of LDPE degradation appearing in the excitation range of 320-360 nm. After 30 hours of degradation, more intense bands (97,500 a.u.) reappeared at λex = 323 nm, with the emission wavelength slightly shifted to 430 nm. These spectral changes demonstrate the feasibility of using fluorescence spectrometry to monitor LDPE degradation, as the spectral profile of the samples changes with degradation times. However, complementary analyses are still required, such as FTIR to observe the formation of functional groups and polymer chain cleavage, as well as synchronous fluorescence analyses, providing better resolution to visualize changes in the molecular fluorescence profile. [1] Morgana et al. Trends in Analytical Chemistry, v. 172, p. 117559, 2024.

[1] Morgana et al. Trends in Analytical Chemistry, v. 172, p. 117559, 2024.

[2] Balbela et al. Marine Pollution Bulletin, v. 207, p. 116854, 2024.

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