Degradation of polystyrene nanoplastics by photo-Fenton oxidation in water

David Ortiz*[1], Macarena Munoz[1], Jorge Garcia[1], Jaime Carbajo[2], Carla Di Luca[1], Zahara M. De Pedro[1], and Jose A. Casas[1]

[1]Universidad Autónoma de Madrid – Ctra. Colmenar, km. 15, 28049, Madrid, Spain
[2]Universidad Complutense de Madrid = Complutense University of Madrid [Madrid] – Avda. de Séneca, 2, Ciudad Universitaria, 28040 Madrid, Spain

Abstract

The increasing widespread presence of microplastics (MPs) and nanoplastics (NPs) in aquatic ecosystems represents one of the most challenging environmental concerns nowadays. Given their low chemical and biological reactivity, the removal of these solids by conventional treatments is highly limited, especially for smaller particles. Although advanced oxidation processes (AOPs) have been extensively studied for the treatment of persistent pollutants in water, their application for MPs and particularly NPs removal have been scarcely addressed. In this study, the degradation of polystyrene NPs (140 nm) by photo-Fenton oxidation has been evaluated. The degradation experiments (6 hours) were carried out at pH0=3 in a pyrex glass reactor, using an initial NPs concentration of 20 mg/L. Firstly, a screening of UV-based technologies for the removal of NPs was investigated (UV, UV/H2O2 and photo-Fenton). A scarce degradation yield (< 30%) was obtained while evaluating photolysis, demonstrating that NPs are poorly degraded only by UV irradiation. The addition of H2O2 (UV/H2O2 treatment) significantly improved the removal of NPs (53% mineralization). Finally, by the photo-Fenton reaction, using iron salts as catalyst, almost complete mineralization was achieved (> 95%). Afterwards, a complete operating conditions study was carried out to analyze the impact of temperature (25-80 ºC), initial H2O2 dose (60-230 mg/L) and catalyst concentration (5-20 mg/L) on the photo-Fenton oxidation (standard conditions: temperature = 25 ºC; (Fe3+) = 10 mg/L; (H2O2)0 = 130 mg/L, with additional doses of H2O2 throughout the reaction). Remarkably, temperature did not significantly affect NPs degradation, reaching similar degradation values for the different temperatures studied. On the other hand, a higher oxidant concentration increased the initial degradation rate of the NPs while the effect of the catalyst concentration is currently under study. All in all, this study proves that photo-Fenton oxidation is a promising alternative for the removal of NPs from water.

Keywords: water treatment, photo, Fenton oxidation, microplastic, nanoplastic, polystyrene

*Speaker