PHOTOLYSIS AND HETEROGENEOUS PHOTOCATALYSIS FOR REMOVAL OF EMERGING POLLUTANTS FROM WATER

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Abstract

Heterogeneous photocatalysis using the catalyst titanium dioxide (TiO_2) in a photoreaction is one of the advanced oxidation process tested in recent years for removal of pharmaceutical compounds from water. The possibility of using solar radiation is one of the main advantages of this process. The present investigation assessed the efficiency in lab-scale of photolysis only (sunlight lamp) and catalysed photolysis (sunlight lamp and TiO_2) for removal of six pharmaceuticals from Milli-Q water (N=2) after 0 min (control), 60 min and 120 min of treatment. A mix of pharmaceutical compounds in environmentally relevant concentrations (100 µg/l each) included sulfamethoxazole, ibuprofen, bromazepam, diazepam, 17α-ethynylestradiol and levonorgestrel. The detection/quantification method was established with liquid chromatography (UPLC/MS/MS Tandem Quadrupole Mass Spectrometer). Photolysis alone was able to degrade sulfamethoxazole (93-97% after 60 min and below detection limit after 120 min). However, photolysis degraded only a small percentage of hormones such as 17 alpha-ethynylestradiol (0-12% after 60 min and 10-15% 120 min) and levonorgestrel (0-15% after 60 min and 5-8% after 120 min). Photolysis was not able to degrade diazepam, bromazepam and ibuprofen under tested conditions. On the other hand, heterogeneous photocatalysis degraded to below detection limit (<DL) sulfamethoxazole, ibuprofen and 17α-ethynylestradiol already after 60 min and degraded partially diazepam (33-34% after 60 min and 48-59% after 120 min); bromazepam (34-38% after 60 min and 55-59% after 120 min) and; levonorgestrel (37-45% after 60 min and 60-73% after 120 min). These last three can be considered as recalcitrant compounds, due to the molecular complexity and resistance against heterogeneous photocatalysis. This preliminary investigation already provided new information about degradation of both bromazepam and diazepam (benzodiazepines compounds) in water using TiO_2. Future investigations include process optimization for removal of individual and mixed pharmaceuticals from real sewage using heterogeneous photocatalysis in bench scale and then, in a solar pilot reactor.

Keywords

Photolysis; Heterogeneous photocatalysis; Anxiolytic pharmaceuticals; Oestrogen; TiO_2; UPLC/MS/MS.