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Removal of fuel oxygenates from water using advanced oxidation technologies by means of falling film reactor

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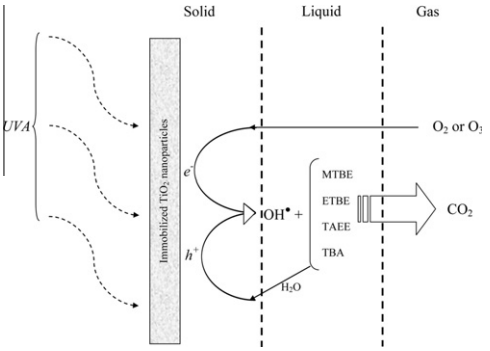
HIGHLIGHTS

- The falling film reactor showed good results in the degradation of oxygenates.
- Photocatalytic ozonation removed the oxygenates from water after about 10 min.
- 70–80% of the aqueous solutions of oxygenates were mineralised after 1 h.
- The removal of TBA and TBF as oxidation by-products was sufficiently achieved.
- Increasing the concentration of oxygenates increased their degradation rates.

GRAPHICAL ABSTRACT



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ABSTRACT

In this study, the application of different advanced oxidation technologies for the degradation of three common fuel oxygenates (ethers) in aqueous solutions was investigated. Methyl *tert*-butyl ether (MTBE), ethyl *tert*-butyl ether (ETBE) and, *tert*-amyl ethyl ether (TAEE) were chosen for this study. The removal of *tert*-butanol (TBA) and *tert*-butyl formate (TBF) as oxidation by-products of MTBE and ETBE, from water was also investigated. This was performed using an annular falling film reactor where TiO_2 particles were immobilised on the reactor wall and irradiated by UVA-light in the presence of oxygen or/and ozone. Photocatalytic ozonation (TiO_2/UVA/O_3) completely removed the chosen oxygenates from water and wastewater after about 10 min, while other investigated oxidation methods decomposed them more gently. The aqueous solutions of oxygenates was also mineralised by 70–80% after 1 h using photocatalytic ozonation.

1. Introduction

The application of various kinds of catalysts and photocatalysts combined with different reagents such as ozone or hydrogen peroxide as "Advanced Oxidation Technologies" for water and wastewater treatment has received increasing attention [1–4]. These technologies promote *in situ* generation of free hydroxyl radicals as highly oxidative reagents for the decomposition of pollutants in water and wastewater. OH radicals oxidise almost all categories of organic and inorganic compounds non-selectively. Numerous reactor designs have been applied and used in this way for the degradation and removal of a wide range of chemicals existed in water as contaminant substances [5–8].

Fuel oxygenates are a group of chemicals added to gasoline to increase its oxygen content [9]. Among other oxygenates, methyl *tert*-butyl ether (MTBE) is often chosen mainly because of its relatively high cost-effectiveness and better mixing properties with gasoline [10]. In 1995, the US Geological Survey reported that

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