Photocatalytic removal of odorous compounds from aqueous solutions

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1 Introduction

During the last decades, the number of large-scale agricultural operations and food industries with high amounts of waste waters have increased. These operations generate numerous types of odors that may be harmful to health or cause a nuisance and, thus, need to be controlled to an acceptable level. Odor compounds in water originating e.g. from washing can be harmful in the indoor and outdoor air. The human nose can detect and discriminate odors at concentrations even lower than those detectable by gas chromatography. A variety of health symptoms mostly attributed to odors include eye, nose, and throat irritation, headache, nausea, diarrhea, cough, chest tightness, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations in mood (Schiffman et al. 2001; Wing & Wolf 2000).

There are several entrenched conventional technologies for odor controlling, including adsorption by activated carbon, biofiltration and bioscrubbing, wet chemical scrubbing, thermal oxidation, and preventing the formation of odorous compounds (Mills 1995). An alternative or an additional remediation technology for removal of these components is heterogeneous photocatalytic oxidation (PCO), which is one of the Advanced Oxidation Processes (AOPs). Titanium dioxide (TiO_2) is the most widely used catalyst for environmental applications and it could be a promising material for treatment of a wide variety of malodorous compounds such as aldehydes, ketones, alcohols, acids, ammonia, amines, sulfides, mercaptans, and other volatile organic compounds (VOCs) (Sun et al. 2008, Rappert & Müller 2005).

Studies of the photocatalytic removal of odorous components are usually done in gas phase. For example only a few articles concerning the photocatalytic oxidation of ammonia in aqueous solutions have been published. However, it has been shown that ammonia can be converted to nitrite or nitrate by photocatalysis (Pollema et al. 1992). In liquid phase photocatalytic oxidation of ethanol, the first degradation compound is found to be acetaldehyde, but the degradation of acetaldehyde has mostly been studied only in the gas phase (Hu et al. 2006, Luo & Falconer 1999, Ohko et al. 1998). In addition, the degradation of an odorous alcohol, butanol, which can be found in waste waters, has been studied in gas phase as well (Manneyron et al. 2003).

This research studies the use of titanium dioxide for the photocatalytic degradation of odorous compounds in water. The performance of the catalyst on the reduction of the malodorous compounds is studied by batch experiments.

2 Objectives of the research

Photocatalytic degradation of organic odor components in water is studied in an annular type batch reactor at room temperature using air as the oxidizer. Liquid slurry of one liter having a desired amount of organic odor component (e.g. acetaldehyde, butanol, ammonia) and the desired amount of titanium dioxide catalyst in water is irradiated by an UV lamp placed in the middle of the reactor and having the maximum radiation at the wavelength of 350–360 nm. Before switching on the lamp, there is a 30 min dark period

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to stabilize the reaction conditions. Samples are taken periodically, filtered through 0.2 µm syringe filters and measured for pH. The removal of the odorous compounds is followed by measuring the Total Organic Carbon (TOC) and Chemical Oxygen Demand (COD) of the samples. The ammonia concentration of the samples is determined by a titrimetric method.

3 Relevance of the research

The PCO method and catalyst material, TiO_2, is common, inexpensive, and non-toxic, making it an attractive choice for odor control. Photocatalysis has been shown to be an effective method for the removal of organic compounds from wastewaters, since it results in complete mineralization with operation at mild conditions of temperature and pressure. If the odor compounds e.g. in wash waters in food industry could be oxidized or degraded to non-odorous and harmless compounds, the working environment would be more pleasant and motivating.

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