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Experimental determination of mass transfer coefficients of volatile sulfur odorants in biofilter media measured by Proton-Transfer-Reaction Mass Spectrometry (PTR-MS)

Dezhao Liu [a], Rune Røjgaard Andreasen [b], Tjalfe Gorm Poulsen [b], Anders Feilberg [a,*]

[a] Department of Engineering, Faculty of Science and Technology, Aarhus University, Blichers Allé 20, Tjele 8830, Denmark
[b] Department of Chemistry, Environment and Biotechnology, Aalborg University, Sohngaardsholmsvej 57, Aalborg 9000, Denmark

HIGHLIGHTS

- ▶ A method of mass transfer coefficient determination in biofilter media was developed.
- ▶ PTR-MS supplied profile measurements in biofilter media for volatile sulfur odorants.
- ▶ Injection strategies were performed for optimization of breakthrough curves.
- ▶ Mass transfer was determined by PTR-MS data combined with computer modeling.

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ABSTRACT

Mass transfer from air to the liquid phase is an important process that may limit the efficiency of biological air filters used for abatement of odor from livestock production facilities. Mass transfer limitation is especially important for volatile sulfur compounds with relatively low aqueous solubility. A better understanding of limitations of mass transfer is therefore important in order to enhance the performance and design of biofilters. In this study, a method based on Proton-Transfer-Reaction Mass Spectrometry (PTR-MS) has been developed in combination with a developed model to determine the mass transfer coefficients of volatile sulfur compounds for selected packing material used in biofilters. PTR-MS was used to measure breakthrough curves for sulfur compounds with adequate sensitivity, time resolution and reproducibility. The overall mass transfer coefficient for the selected biofilter media was then estimated by fitting an advection–dispersion equation modified for mass transfer between the gas and liquid phases to the measured profile of individual sulfur compound. Different injection strategies were evaluated and an optimal measurement procedure was developed. The method was validated by comparison of mass transfer coefficients to literature values for toluene, which was used as a reference compound in this study. By applying the method to compounds with different Henry's law constants, the application range of the method was demonstrated regarding solubility in water. This study demonstrates a method for determination of mass transfer coefficients of sparingly soluble gaseous compounds for selected biofilter media by applying PTR-MS in combination with modeling.

1. Introduction

Biofilters has been recognized as suitable for treating volatile organic compounds with low concentrations and large flow rates [1]. In recent years, biofilters have also been increasingly used for treating odorous emissions from animal production facilities [2–5]. Those offending odorous compounds consist of several species including volatile sulfur contaminants such as hydrogen sulfide, methanethiol and dimethyl sulfide [6]. Compared to other technologies for odor reduction (e.g., slurry oxidation and chemical treatment [7]), biofilters are generally acknowledged as a cost-effective technology [2,8,9]. However, low removal efficiencies have been observed for volatile sulfur compounds present in the ventilation air to be treated [5,10]. Due to the high air velocity typically applied in an animal house ventilation system, short empty bed residence times (EBRTs) are common in order to reduce the pressure drop across the biofilter [2,4,11].Volatile organic sulfur compounds such as methanethiol or dimethyl sulfide have relatively low solubility in the aqueous phase in biofilters, which become a challenge when biofilters are used to remove those compounds from the ventilation air [12]. Since the mass transfer from the gas phase to the

* Corresponding author. Tel.: +45 8715 7647; fax: +45 8715 6000.
E-mail address: Anders.Feilberg@agrsci.dk (A. Feilberg).

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