Chemical Engineering Journal 200–202 (2012) 645–653

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Treatment of organic waste gas in a paint plant by combined technique of biotrickling filtration with photocatalytic oxidation

Zhigui He [a,c], Jianjun Li [b], Jiangyao Chen [a,c], Ziping Chen [b], Guiying Li [a], Guoping Sun [b], Taicheng An [a,*]

[a] The State Key Laboratory of Organic Geochemistry and Guangdong Key Laboratory of Environmental Protection and Resources Utilization, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
[b] Guangdong Provincial Key Laboratory of Microbial Culture Collection and Application, Guangdong Institute of Microbiology, Guangzhou 510070, China
[c] Graduate School of Chinese Academy of Sciences, Beijing 100049, China

HIGHLIGHTS

- VOCs emissions in different paint production processes were analyzed.
- VOCs removal performance of single and combined BTF–PCO technology was evaluated.
- Potential risks for VOCs before and after treatment by BTF–PCO were predicted.
- Effect of technical parameters on the removal of mixture VOCs was investigated.

ARTICLE INFO

Article history:
Received 31 March 2012
Received in revised form 25 June 2012
Accepted 26 June 2012
Available online 2 July 2012

Keywords:
Biotrickling filtration
Photocatalytic oxidation
VOCs
Removal efficiency
Elimination capacity

ABSTRACT

A pilot-scale system integrated with biotrickling filtration (BTF) and photocatalytic oxidation (PCO) for the treatment of organic waste gas in a paint plant was investigated in this study. The components of volatile organic compounds (VOCs) and their concentrations were measured by gas chromatography–mass spectrometry (GC–MS). Results showed that the main components of organic waste gas in the paint plant were ethyl acetate, toluene, ethylbenzene, xylene, ethyltoluene and trimethylbenzene. The removal efficiencies of these VOCs ranged from 79.4% to 99.8% by BTF–PCO treatment even after 90 days operation. After BTF–PCO treatment, hazard ratio index based on threshold limit value for time weighted average (TLV-TWA) and VOCs concentrations indicated that the non-cancer risk of VOCs was rapidly reduced. At steady state of the treatment system, total VOCs (TVOC) removal efficiencies maintained steadily within the range of 95.8–98.2% with the increase of inlet TVOC concentration from 6.69 to 129.00 mg/m^3, and increased from 95.8% to 99.5% with the flowrate decrease from 3000 to 1333 m^3/h. In addition, the maximum elimination capacities of different systems in this study followed the order: BTF (47.8 g m^{-3} h^{-1}) > BTF–PCO (25.2 g m^{-3} h^{-1}) > PCO (19.2 g m^{-3} h^{-1}), while VOCs average removal efficiencies followed the order of BTF–PCO (95.6%) > PCO (88.7%) > BTF (73.7%). Overall, by the combination of BTF and PCO systems, the high concentration and multicomponent VOCs from paint plant were removed effectively and environmental friendly.

1. Introduction

Volatile organic solvents including aromatics, such as benzene, xylene, toluene and esters, such as ethyl acetate, ethyl butyrate are commonly used to dissolve resin in the paint production, which is one of the most important volatile organic compounds (VOCs) sources. According to National Emission Trend database from United States Environmental Protection Agency (USEPA) in 1999, annual emissions of VOCs from paint and allied facilities were estimated to be 26,500 tonnes [1]. The massive VOCs discharge results in occupational disease in the workplaces [2]. This is because most of VOCs are toxic, and some of them, such as benzene are considered to be mutagenic, teratogenic, and carcinogenic [3]. Although toluene and xylene are not currently classified as carcinogens, an increase of oesophageal, rectal and colon cancer incidences in workers with long-term exposure to these compounds have been reported [4]. In addition, another most significant problem related to the emission of VOCs is focused on the possible production of photochemical oxidants. For example, ozone and peroxyacetyl nitrate which are formed in the presence of sunlight from NO*x* and VOCs, are toxic to humans, damaging to crops and involve in the formation of acid rain [5].

* Corresponding author. Tel.: +86 20 85291501; fax: +86 20 85290706.
E-mail address: antc99@gig.ac.cn (T. An).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.06.117