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Factors and by-products from degration of trimethylamine using electron beam irradiation

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***Abstract*—Trimethylamine emitted from various sources such as dyeing factories, was investigated with some factors using an advanced oxidation technology hooked up with electron beam. In this work, the removal tendency of TMA after electron beam irradiation and optimum condition were demonstrated. After the irradiation, the efficiency of 200ppmv TMA was 86% at 10 kGy, but 50ppmv TMA was nearly completely removed. In addition to initial concentration and absorbed dose, changing humidity was also a significant control factor .**

Keywords-component; Trimethylamine (TMA); advanced oxidation technology; SPME; electron beam; humidity; dose

I. INTRODUCTION

TMA ($N(CH_3)_3$) is one of the major odorous compounds which can affect human beings and our atmospheric environment, a well-known indicator of spoilage as pungent odor of rotting seafood [1]. In Korea, TMA has been managed by law since 2005. However, complaints from residents have been increased since they were apt to get exposed to offensive odor compounds generated from industrial facilities [2].

It is quite difficult to control TMA using conventional technologies such as absorption, adsorption and combustion which have not really effective efficiency [3, 4, 5]. Consequently, in this work, electron beam was applied for finding out removal characteristics of TMA which is known as good at massive scale and low concentration. The removal efficiency of TMA using electron beam, had been changed at several conditions (initial concentration, absorbed doses, different humidity) were tested with batch and continuous flow system to examine the removal efficiency of TMA using electron beam

II. EXPERIEMTNTAL METHODS

A. Electron beam irradiation

1 MeV electron beam accelerator (maximum power 40 kW, ELV-4 type, Korea Dyeing Technology Center, Korea) was used for this research.

Absorbed doses were adjusted from 2.5 to 10 kGy during the experiment to examine the decomposition efficiency of TMA.

B. Mixing/flow system

The whole experiment was conducted using batch and continuous flow systems. TMA used at present study were prepared with different concentrations from 50 to 200 ppm. A batch system with 1 L volume capacity Tedlar bag (SKC, USA) was used as a reactor, and different background gases such as O_2, N_2, and He were used. Meanwhile, the continuous flow system consisted of zero air system, VOC generator, reactor and sampling port. Air flow was introduced into the control system with 15L/min of zero air flow [6].

C. Analytical method

In this study, TMA was analyzed by GC-NPD (Agilent 7890 Hewlett Packard, USA) to conduct the quantitative analysis of TMA with capillary GC column (DB-1 50 m × 0.32 mm I.D. × 0.52 ㎛, SPME Fiber, PDMS/DVB, 65 ㎛, Supelco) was used to enrich for injection. A CO/CO_2 analyzer (Gas data PAQ, GAS data Ltd, UK) was used for measuring the amount of CO and CO_2 produced by the oxidation of hydrocarbons. Ozone produced after radical reaction was observed by O_3 Analyzer (Medel 49C, Thermo Electron Corporation, USA).

III. Results and Disscussion

A. TMA Decomposition ratio under different initial concentration

The removal characteristic of TMA using electron beam irradiation is shown in Figure 1. TMA concentrations were 50 ppmv, 100 ppmv, 200 ppmv, while the absorbed dose rose up from 2.5 to 10 kGy. After the irradiation, 200ppmv TMA was decomposed with a removal efficiency of 86%, but 50ppmv TMA was nearly completely decomposed. In general, when the target compound has lower concentration levels, the efficiency of lower ones is better than higher ones.

The reaction mechanism for the oxidation of TMA by electron beam treatment is associated with radical reactions such as OH radical attack initiating degradation of this compound [8].

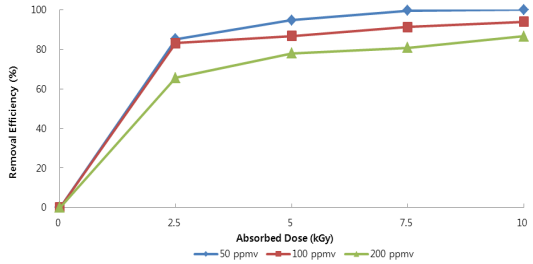

Figure 1. Decomposition ratio of TMA at various initial concentrations.

B. Relationship with humidity and removal efficiency

Moisture in gas phase is one of the influential factors to control volatile organic compounds (VOCs) [9]. OH radicals which are very oxidative and produced by chemical reaction, can reacts with chemicals in double-quick time if there is moisture in atmospheric environment [10, 11].

$$H_2O + e^- \rightarrow H_2O^+ \rightarrow H^+ + \cdot OH$$

$$H_2O + e^- \rightarrow H_2O^* \rightarrow \cdot H^+ + \cdot OH$$

$$\cdot H + O_2 \rightarrow HO_2 \cdot$$

$$HO_2 \cdot + HO_2 \cdot \rightarrow H_2O_2 + O_2$$

$$\cdot H + H_2O_2 \rightarrow H_2O + \cdot OH$$

Figure 2 illustrated the removal efficiency with respect to different humidity conditions. In this work, it was found that higher humidity condition resulted in lower C/C_0. This trend is analogous with former researches [6, 10]

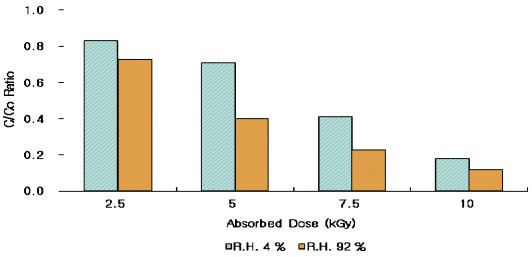

Figure 2. Removal efficiency of TMA at different humidities.

C. By-products

After advanced oxidation processes, ozone was detected by an O_3 analyzer. However, when absorbed dose rose, the reactor temperature went up, and then it was found that O_3 concentration suddenly dropped down. According to precedent studies on electron beam, O_3 were decomposed due to high temperature [12, 13].

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