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토양바이오필터를 이용한 NOx 제거에 있어서 최적의 오존농도 및 상대습도 도출에 관한 연구

A Study on Simultaneously Optimize the Ozone and Relative Humidity Composition for the NOx Degradation using Soil Bio-filter

조기철 · 이내현[1] · 여현구[2]
동남보건대학 바이오환경과, [1]주)전략엔지니어링, [2]강원지방중소기업청

1. Introduction

This work investigated the methodology to simultaneously optimize the ozone and relative humidity composition for the NO_x degradation using soil biofilter. Experiments were made as a function of inlet ozone concentration(0~-1,770ppb) and relative humidity(38~-81%). Factorial design(2^2+3) and response surface methodology by central composite designs were used to examine the role of two factors and optimal response condition on NO_x degradation. It was found that a second-order response surface model can properly interpret the experimental data with an R^2-value of 0.9730 and F-value of 71.83, based on which the maximum NO_x degradation was predicted up to 92.8% within our experimental conditions.

2. Experiment method

In Table 1, the experiment conditions related to the initial concentration of O_3 and NO, flow rate, and relative humidity are shown. The initial injected concentration of NO was maintained around 100ppb and the initial O_3 injected to oxidate the NO gas was changed within the range of 0-1770ppb and the injected flow rate of O_3 was 1,000mL/min. The charged content of water put into the soil bio-filter was adjusted within the range of 38-81% and the relative humidity of the injected mixed gases was adjusted to the same level of water content as the soil within the bio-filter and injected into the reactor.

The soil bio-filter in the reactor is charged with a total volume of 196cm^3. Once the initial injected concentration of O_3 is determined and stabilized using a separate pipe, while maintaining the concentration of initial injected NO as 100ppb with pure air, the O_3 is injected into the mixer tank and made to react with the NO. And then after injecting the mixed gases(Air+NO gas+O_3 gas) into the reactor, the removal rate can be calculated by measuring the concentration of ejected NO, NO_2, O_3 at the exit of the reactor.

Table 1. Design and operation parameters.

Parameters	Condition of experiment
Initial concentration of NO(ppb)	100±2
Initial concentration of O_3(ppb)	0~-1,770
O_3 gas flow rate(mL/min)	1,000
Total flow rate[Air+NO+O_3] (mL/min)	2,000
Moisture content of packing material(%)	38~-81
Size of used mixture reactor(Φ×H)	50mm×100mm

3. Results and Discussion

This research had the purpose of suggesting a mathematical model by finding the optimization of the concentration of ozone and relative humidity in order to maximize the NOx degradation by using soil bio-filter. In this study, we used full factorial analysis and response surface analysis which are useful to optimize the concentration of injected ozone to oxidate NO gas and the relative humidity of both mixed gases injected into the bio-filter and within the bio-filter.

In this study, central composite design among response surface analysis was used to draw the optimization and as a result of this research, it was shown that ozone concentration, relative humidity, and the interaction of ozone concentration relative humidity were all influential to the removal rate of NOx, and the most influential factor to the NOx degradation was the concentration of injected ozone to oxidate NO.

The optimization result of ozone concentration and relative humidity to remove NOx using central composite design was that when the levels of concentration of injected ozone and relative humidity were high, the removal rate of NOx was high. And the maximum removal rate of NOx was estimated to be 92.8% as a response surface optimization under 81.2% for relative humidity and 1691.5ppb of ozone concentration. In the process, the following mathematical model was obtained:

$$Y=76.574+14.576+1.079-8.733+5.7^{x_1 x_2}$$

As a result of review by the model where moisture content was adjusted to 60% as the optimal growth condition of microorganisms, the removal rate of NOx was estimated to be about 82.6% under 1381ppb of ozone concentration and 60% of relative humidity. To confirm the validation of this estimated value, when the replication test was performed under the above same conditions, the removal rate by the experiment was shown to be 81.5% which is similar to the estimated value by mathematical model. Therefore we can conclude that the mathematical model used in this research is valid.

Afterwards, based on the result of this research, the mathematical models related to discover the optimal response time of injected gases and soil bio-filter, the correlation with the concentration of injected NO gases, the optimization of the amount of injected ozone and the concentration of injected NO gases etc. will be drawn up.

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