Measurements of Gaseous Nitrous Acid (HONO) Emission from Activated Sludge and Denitrifying Bacteria

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Introduction

Gaseous nitrous acid (HONO) is known as a precursor of OH radicals, a strong oxidant in the atmosphere. Up to 34 % of OH radical is produced from HONO in a city and a rural area[1)]. Therefore HONO is an important species to know OH radical behaviors.
The high HONO concentration have been observed during daytime in spite of the HONO photolysis. There are several known HONO sources: gas phase reactions, heterogeneous reactions and combustion process. Also, HONO emission from soil by the equilibrium between gaseous nitrous acid and aqueous nitrous acid in the soil and the direct emission by nitrifying bacteria have been observed[2)3)]. In the soil, there are not only nitrifying bacteria but denitrifying bacteria. However the emission by denitrifying bacteria is not studied.
The research purpose is to determine whether or not denitrifying bacteria in the activated sludge emits HONO directly.

Experimental

HONO emissions from activated sludge in aerobic condition and anaerobic condition were measured. Also HONO emission from the sterlized supernatant solution was measured. HONO emissions from biological process and chemical process were compared. Activated sludge in Duran bottle was purged with air or N_2 for 1 day to 4 days and HONO was captured with a filter pack. The sludge was aerobic with air purge and anaerobic with N_2 purge. Duran bottle and filter packs were covered with tin foil to avoid HONO photodissociation. Dissolved Oxygen was measured to keep the condition of activated sludge and pH was stabilized at 7.8-8.1 by adding 0.1 M HCl solution or 50 g/L $NaHCO_3$ solution not to decrease the bacteria's activity. The flow speed was controlled at 2 L/min with mass flow controllers.
Also, activated sludge and its sterilized supernatant solution were purged with room air and N_2 at 22 ℃. Also the activated sludge was purged with N_2 at 27, 32 ℃. The activated sludge in a Duran bottle was put in the water which is controlled with a heat controller to stabilize the temperature of activated sludge. In these experiments, three filter packs were placed for each experiment. Air or N_2 was purged in 4.5 L/min because three filter packs were prepared and the purged gas was controlled to flow through each filter pack in 1.5 L/min. The NO_2^- concentrations of the sludge and supernatant were measured before these experiments with the pack test. The purging time was 8 hours in order to keep controlling pH.

Results and Discussion

In this experiment, HONO emissions from the sludge were observed at anaerobic condition. The contribution of biological process was more than 90%. However, calculated activation energy from temperature dependent experiment was much bigger than that of the denitrifying bacteria. Thus, there is a possibiliy that denitrifying bacteria reduce NO_3^- to NO_2^- and the increase in NO_2^- concentration increased the HONO emission from the chemical process. Also, NO_2^- concentration in the sludge should be measured more accurately because it has influence on HONO emission.

Reference

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3) Oswald, et al. *Science* **341**, 1233-1235 (2013).

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