Evaluation of a kinetic model for sulfur utilizing autotrophic denitrification reaction in an up-flow packed bed reactor; application of respirometry and DAPI Staining

W. Park, Y. H. Ahn, K. J., S. Y. Kim, In S. Kim†

Bio-Environmental Engineering Laboratory, Dept. of Environmental Science and Engineering,

Kwang-Ju Institute of Science and Technology, 1 Oryong-dong, Buk-gu, Gwangju, 500-712, Korea.

†Tel.:+82-62-970-2436, Fax.:+82-62-970-2434, E-mail:iskim@kjist.ac.kr

ABSTRACT

Respirometry and DAPI staining were employed in order to evaluate a mathematical model for sulfur utilizing autotrophic denitrification in an up-flow packed-bed reactor. Respirometry based on nitrogen gas was for rapid monitoring of denitrification and determination of effective height while DPAI staining was for investigation of biomass distribution corresponding to the reactor height. The effective height was determined so that reaction rate constant could have a relationship with reactor height. The autotrophic denitrification was found as a first order reaction within the range of nitrate concentration in this research. A simple and basic kinetic model was obtained by using gas production rate and then the model was modified with respect to biomass distribution because reaction rate constant was directly related to the amount of biomass. The reaction rate constant based on unit volume of effective area was ranged from 2.67 to 3.07 without compensation whereas from 1.73 to 3.05 when compensated. The effective height was around 23.8 % and 50 % of the total height for 11.8 and 5.9 hours of packed bed contact time (PBCT), respectively. The kinetic model contained the term of change in average biomass concentration and thus it could give an explanation on the vertical profile of nitrate concentration in the reactor.

References

1. Koenig, A. and Liu, L. H. (1996), Autotrophic denitrification of landfill leachate using elemental sulfur, *Wat. Sci. Tech.* **34**(5-6), 469-476.
2. Koenig, A. and Liu, L. H. (2001), Kinetic model of autotrophic denitrification in sulfur packed reactors, *Water res.* **35**(8), 1969-1978.
3. Hoor, A. T. (1981), Cell yield and bioenergetics of Thiomicrospira denitrificans compared with Thiobacillus denitrificans, *Autonie van Leewenhoek* **47**, 231-243.
4. Batchelor, B. and Lawrence, A. W. (1978), Autotrophic dentrification using elemental sulfur, *Journal WPCF* **50**, 1986-2001.

5. Till, B. A., Weathers, L. J., and Alvarez, P. J. J. (1998), Fe(0)-supported Autotrophic Denitrification, *Environ. Sci. Technol.* **32**, 634-639.
6. Visser, J. M., Robertson, L. A., Van Verseveld, H. W. and Kuenen, G. (1997), Sulfur production by obligately chmolithoautotrophic thiobacillus species, *Applied and Environmental Microbiology* **63**(6), 2300-2305.
7. Sublette, K. L. and Sylvester, N. D. (1987), Oxidation of hydrogen aulfde by thiobacillus denitrificans: desulfurization of natural gas, *Biotechnology and Bioengineering* **29**, 249-257.
8. Ravenschlag, K., Sahm, K., Amann, R. (2001), Quantitative molecular analysis of the microbial community in marine arctic sediments (Svalbard), *Appl Environ Microbiol.* **67**(1), 387-395.
9. Snaidr, J., Amann, R., Huber, I., Ludwig, W. (1997), Schleifer, K.H., Phylogenetic analysis and in situ identification of bacteria in activated sludge, *Appl Environ Microbiol.* **63**(7), 2884-2896.
10. Oh, S. E., Chae, K. J. and Kim, I. S. (2000), The Characteristics of Autotrophic Denitrification by Denitrifying Colorless Sulfur Bacteria Using Microbial Respirometer, *Journal of Korean Society of Environmental Engineering* **22**(9), 1651-1659.
11. Oh, S. E., Kim, K. S., Choi, H. C., Cho, J. and Kim, I. S. (2000), Kinetics and physiological characteristics of autotrophic denitrifying sulfur bacteria, *Wat. Sci. Tech.* **42**(3), 59-68.
12. Chang, Y. C., Huang, C. and Li, C. F. (1997), Removal characteristics of H_2S by thiobacillus CH3 biofilter in autotrophic and mixotrophic environments, *J. Environ. Sci. Health.* **A32**(5), 1435-1450.
13. Zhang, T. C. and Lampe, D. G. (1999), Sulfue:Limestone autotrophic denitrification processes for treatment of nitrate-contaminated water: Batch experiments. *Wat. Res.* **33**(3), 559-608.