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Removal of Nitrogen Dioxide and Sulfur Dioxide from Air Streams by Absorption in Urea Solution

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ABSTRACT

The study focuses on the absorption rates of NO2, SO2 and a mixture of these two acid gases into urea solution in packed bed column. The absorption rate was studied as a function of absorbent temperature, urea concentration and acid gas concentration. The influence of liquid temperature between 10 - 40?C, urea concentration between 0.1 - 0.5 M and acid gas concentration NO2 between 100 - 1000 ppm (191 - 1910 mg/m3), SO2 between 500 - 2500 ppm (1310 - 6530 mg/m3) were investigated. The mass gas flow rate of 20.646 (kg/m2.min) at 25?C and the absorption rate were determined by measuring the NO2 and SO2 concentrations in the inlet and outlet streams of the absorptioncolumn. The absorption rate of SO2 increases with the decrease of temperature of absorbent (urea solution) and with the increase of the urea concentration. The presence of NO2 in the effluent gas stream lowers the absorption rate of SO2 in urea solution due to the fast reaction of NO2 with urea as compared with SO2. The absorption rate of NO2 decreases as the urea concentration exceeds 0.4 mol/l and for NO2 gas concentration of 100 ppm due to the decrease the diffusivity of the gas. The experimental data were analyzed using dimensionless analysis to find the correlation of mass transfer coefficient in the packed column Sh (H / dp)1.2 = 4.19*10−2 *(G' dp / μg)0.87 (μg / ρg DAB)0.60 The results confirmed the hypothesis that the absorption is accompanied with chemical reaction. Also it is found the increasing the temperature of absorbent solution the absorption rate of two gases is decreases. The mass transfer coefficient models are in good agreements with the Kramer ' s equation.

KEYWORDS

Sulfur Dioxide Removal, Nitrogen Dioxide Removal, Column Absorption, Removal of Acid Gases, Air Pollution Prevention

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References

[1] T. Denmead, B. Macdonald, I. White, G. Bryant, D. Griffith, A. Kinsela and M. Melville, "Links between Emissions of Nitrogen and Sulfur Gases from Acid Sulfate Soils: Field Evidence," 19th World Congress of Soil Science, Soil Solutions for a Changing World, Brisbane, 2010.

[2] P. G. Cheremisionff and R. A. Young, "Air Pollution Control and Design Hand Book," Marcel Dekker, Inc. New York, 1977.

[3] C. M. Hansen, "Control of Sox Emission," Industrial and Engineering Chemistry Product Research and Development, Vol. 16, 1977, p. 266. doi:10.1021/i360063a016

[4] V. S. Soldatov, A. V. Kashinskii, T. A. Korshunova and V. I. Martinovich, "Removal of Nitrogen Dioxide from Air Using Aqueous Carbamide on a Fibrous Ion Ex- changer," Chemistry and Material Science, Vol. 41, No. (Suppl. 2), 2005, pp. 760-763.

[5] U.S.DOE, "Advance Technology for the Control of Sulfur Dioxide Emission from Coal-Fired Boilers," Clean Coal Technology Conference, Knoxville, 1999.

[6] B. H. Potter and T. L. Craig, "Control Sulfur Oxide," Chemical Engineering Programme, Vol. 68, No. 8, 1972, p. 53.

[7] F. S. Chalmer, "Evaluation of Regenerable FGD Process," AIChE Journal, Vol. 23, No. 4, 1977, pp. 538-544.

[8] E. Bekassy-Molnar, E. Marki and J. G. Majeed, "Sulphur Dioxide Absorption in Air-Lift-Tube Absorbers by Sodium Citrate Buffer Solution," Chemical Engineering and Processing, Vol. 44, No. 9, 2005, pp. 1039-1046. doi:10.1016/j.cep.2005.02.001

[9] J. H. Russel, J. I. Paige and D. L. Paulson, "Evaluation of Some Solid Oxides as Sorbent of SOx," Rep Invest-U.S Bur. Mines R1 7582, 1971.

[10] P. G. Gray, "A Fundamental Study on the Removal of Air Pollutants (Sulfur Dioxide, Nitrogen Dioxide and Carbon Dioxide) by Adsorption on Activated Carbon," Gas Separation & Purification, Vol. 7, No. 4, 1993, pp. 213- 224. doi:10.1016/0950-4214(93)80020-W

[11] P. Daniell, A. Soltani-Ahmadi and H. O. Kono, "Reaction Kinetics of the SO2-CaO System-Pore Closure Model," Powder Technology, Vol. 55, 1988, pp. 75-78. doi:10.1016/0032-5910(88)80090-1

[12] EPAU.S Environmental Protection Agency, "Alternative Control Techniques Document-Nitric and Adipic Acid," EPA Publication, No. 450/3-91-026, 1991.

[13] European Commission, "Technical Note on Best Available Technologies Not Entailing Excessive Costs for Heavy Metal Emissions from Non-Ferrous Industrial Plants," Final Report - May 1991, ECSC-EC-EAEC, Brussels Luxembourg, 1994.

[14] S. H. Zhang, L. L. Cai, X. H. Mi, J. L. Jiang and W. Li, "NOx Removal from Simulated Flue Gas by Chemical Absorption - Biological Reduction Integrated Approach in a Biofilter," Environment Science and Technology, Vol. 42, No. 10, 2008, pp. 3814-3820. doi:10.1021/es800200g

[15] G. A. Streuli and P. R. Averell, "The Analytical Chemistry of Nitrogen and It Is Compound, Part I," John Wiley and Sons. Inc, New York, 1970.

[16] D. G. Montgomery, "Design and Analysis of Industrial Experiments," John Wiley and Sons, New York, 1976.

[17] W. Weisweiler and K. H. Deib, "Measurement of Absorption Rate of NO2 and SO2 in Water in a Falling Film Absorber," Chemistry Engineering, Vol. 4, 1981, p. 79.

[18] J. M. Coulson and J. F. Richardson, "Chemical Engineering," Vol. 2, 4th Edition, Pergamon Press, Oxford, 1991.

[19] R. K. Basu and B. K. Dutta, "Kinetic of Absorption of Sulfur Dioxide in Dimethylaniline Solution," Canadian Journal of Chemistry Engineering, Vol. 65, No. 1, 1987, pp. 27-35. doi:10.1002/cjce.5450650106

[20] J. B. Lefers and P. I. Berg, "Absorption of NO2-N2O4 – SO2 in to Dilute and Concentrated Aqueous Solution," Chemistry Engineering Journal, Vol. 23, 1981, p. 211.

[21] R. E. Khoma, M. I. Gavrilenko and V. I. Nikitin, "Interaction of Sulfur Dioxide with Aqueous Solutions of Amides," Zhurnal Obshchei Khimii, Vol. 75, No. 5, 2005, pp. 771-777.

[22] T. K. Sherwood, R. L. Pigford and R. L. Wilke, "Mass Transfer," McGraw-Hill, New York, 1975.

[23] H. Kramers, M. P. Blind and E. Sneck, "Absorption of NO2, SO2, N2O4 by Water Jet," Chemistry