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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 NO_2, SO_2 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 NO_2 between* 100 - 1000 *ppm* (191 - 1910 *mg/m^3*), *SO_2 between* 500 - 2500 *ppm* (1310 - 6530 *mg/m^3*) *were investigated. The mass gas flow rate of* 20.646 (*kg/m^2.min*) *at* 25°C *and the absorption rate were determined by measuring the NO_2 and SO_2 concentrations in the inlet and outlet streams of the absorptioncolumn. The absorption rate of SO_2 increases with the decrease of temperature of absorbent (urea solution) and with the increase of the urea concentration. The presence of NO_2 in the effluent gas stream lowers the absorption rate of SO_2 in urea solution due to the fast reaction of NO_2 with urea as compared with SO_2. The absorption rate of NO_2 decreases as the urea concentration exceeds* 0.4 *mol/l and for NO_2 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* $Sh\,(H/dp)^{1.2} = 4.19*10^{-2}*(G'\,dp/\mu_g)^{0.87}\,(\mu_g/\rho_g\,D_{AB})^{0.60}$ *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*

1. Introduction

The harmful effects of the sulfur dioxide, SO_x and nitrtogen dioxide, NO_x, gases emissions in dense industrial and urban areas receive increasing attention especially where their production exceeds neutralization and dispersion forces [1]. Of the major contributors nitric acid plants contribute the most NO_2 to the environment [2]. The release of SO_x can be controlled by ammonia injection which relies solely on gas phase reaction in the presence of moisture to produce ammonium sulfate solid particles that can be captured by any other particulate collection device [3]. Heterogeneous reduction process of SO_x by hydrogen sulfide into sulfur can be done in the presence of suitable solid phase catalysts. Methane can be used for the reduction of SO_x into hydrogen sulfide on alumina as the catalyst. The hydrogen sulfide produced by this method is captured by amine scrubbing of the reduced gas stream. The higher concentration of sulfide obtained by heating the amine salt may then be easily and economically converted to elemental sulfur via the Claus process [4].

Catalytic oxidation of SO_x with air, via the heterogeneous contact process or the homogeneous chamber process, also serves to improve the collection efficiency of the SO_2. Also the collection of SO_3 by direct absorption into water is extremely efficient and the produced sulfuric acid is a salable commodity [5]. The scrubbing of SO_2 in dilute ammonium hydroxide gives ammonium sulfate that can be a valuable constituent of fertilizer formulations [6]. The Wellman-lord process uses the effective sodium sulfite equilibrium to capture sulfur dioxide from flue gases [7]. Most of the sodium bisulfite produced is converted back to sodium sulfite which can be crystallized out, dried and sold as wood pulping chemical. The citrate process in which much development work has been invested by the U.S Bureau of mines and by Pfizer use an aqueous solution of citric acid to

