3rd International Conference on Recent Innovations in Science Engineering and Management
Sri Venkateswara College of Engineering and Technology,Srikakulam,Andhra Pradesh (ICRISEM-16)
27 February 2016, www.conferenceworld.in ISBN: 978-81-932074-1-3

ABSORPTION PHENOMENON OF (SO_2+NO+NaClO) SYSTEM

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ABSTRACT

Instantaneous absorption of SO_2 and NOwas carried in bubble column with absorbent NaClOat SO_2 concentration range 1000-6000 ppm, NO concentration range 200-900 ppm, and temperatures in the range of 283-325 K. The concentrations range of NaClO solution varied was 0.5-4% w/v. The experimental procedure wasprogressed at atmospheric pressure. Both SO_2 and NO_2absorption efficiencies reduced with increase in reaction time and finally reached zero removal efficiency exhibiting that solutions enhanced to saturate or equilibrium was established.SO_2absorption efficiency improved with increase in NaClO concentration from 0.5% w/v to 4% w/v for stable time of absorption because the dissolved SO_2 reacts with OH^- to form SO_3^{2-}which is then oxidized by ClO^- to form SO_4^{2-}. The NOremoval efficiency forsimultaneous removal of SO_2 and NO showed same trend as that of SO_2 for various concentrations of NaClO. ClO^- formation is more which consumes more OH^- ions rather in the formation of SO_4^{2-} and NO_3^- ions.Optimum operating conditions for maximum NO and SO_2 removal efficiencies were observed as NaClO concentration of 4% w/v, 305 K temperature.

Keywords: Bubble Column, Absorption, SO_2, NO

I. INTRODUCTION

Coal, natural gas and petroleum are the major sources of the energy in Fossil fuels. Combustion of these fossil fuels in the industries such as power plants, incinerators, and boilers results of sulfur dioxide (SO_2) and nitric oxide (NO) emission. The emission of these toxic gases from stationary sources will lead to worsening air quality, causes regional acid rain and photochemical smog.Pre-treatment of the stack gases before releasing to the environment can reduce these toxic effects on living beings and meet stringent effluent discharge limits. There were several individual techniques those were successful in process of removal in elemental sulfur and NO_x from stack gases. In consideration of cost and area numerous techniques had developed for pre-treatment of these gases simultaneously. In this case of simultaneous removal of these toxic gases wet and dry process were highly successful processes. Selective catalytic reduction was the major wet technique adopted for simultaneous removal of SO_2 and NO. ClO_2[1], $FeSO_4$ [2], $NaCi_3$/NaOH[3], $NaClO_2$[4], NaClO[5-7], NH_3[8], Urea [9], Urea/$KMnO_4$ [10], UV/H_2O_2 [11] were some of the resent techinque in absorption phenominon.

This process is concern about removal of SO_2 and NO using sodium hypochlorite as absorbent in experimental scale bubble column. The major coern in this process is to convert iinsoluble NO to NO_2 using aqueous NaClO. Several operating parameters has been studied in this process keeping remaining parameters asfrozen. The major

operation parameters were temparature, intial absorbent concentration, intial SO_2 cocentration, Initial NO cocentration and pH. Effective removal efficency of 91%NO and 99% f $SO_2$was obtained in this process.

II. EXPERIMENTAL

2.1. Experimental Apparatus

The complete experimental setup was shown in **Fig. 1** included with major parts such as a simulated flue gas preparation section, absorption section and analysis section. The volume of the bubble columnwas 150cm^3 which consits of two valve, one is consern about injection of gas stream in liquid phase and another one was for outlet to analysis and by pass section.

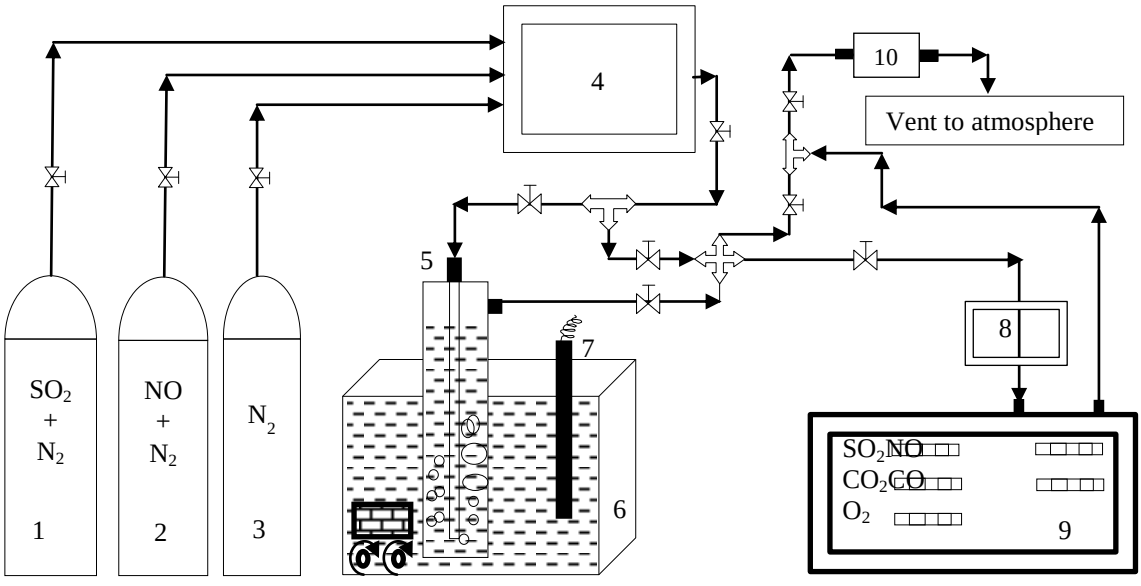
2.2. Reagents

The NaOCl used in the experiment was analytical reagent (AR) grade (99.00 % accuracy, Fisher Scientific Pvt. Ltd., India). Buffering agents (Elico India Pvt. Ltd. India)

2.3. Experimental Procedure

There gas cylinders containing SO_2 with balance N_2 (1), NO with balance N_2 (2) and N_2 were conected parallely to the gas mixing chamber (4) for preparation of gas stream so that the concentration will reach the similar concentration in flue gas exhaust. These gas cylingers were atttached with pressure regulatorswhich shows cylinder pressure and column pressure. This section was named as preparation of fabricated gas stream.

After the gas stream simulation section the gas was proceeded to absorption with use of bubble column (5) covered with water bath with temperature control (6) in which heater (7) is provided for heating of the process. The gas stream was injected in the the column and the absorbed gas stream was proceeded to analysis section.



1.SO_2 + balance N_2 gas cylinder, 2.NO + balance N_2 gas cylinder 3. N_2 gas cylinder,4. Gas mixing and pressure releasing chamber, 5.Bubble column,6. Water bath with temperature control,7.Heater, 8.Silica column, 9.Multi flue gas analyser, 10. Gas Flow meter

Figure 1. Schematic diagram of experimental set-up

ISBN: 978-81-932074-1-3

In the analysis section the gas stream was initially dried with help of silica column (8) and further this gas stream was analyzed with multiflue gas analyzer (9). Before the abosrbtion process initillaly the gas stream was bypased through T-joint and cross-joint present after gas mixing chamber through silica column to analyzer for analysis of gas stream. The absorbed gas was sent to atmoshere through gas flow meter (11) which measures amount of gas flow through out the process.

III. RESULTS AND DISCUSSION

3.1. Effect of Reaction Time

The variation in removal efficiency relating to time was determined in this process by measuring the absorbed gas stream within regular time interval of 10 min maintaining the flow rate, temperature, absorbent concentration, SO_2 concentration, NO concentration and pH of the solution as constant. The change in removal efficincy of NO and SO_2 with respect to time was shown in Fig. 2. This provideseefficeincy of absorbent in SO_2 and NO absorption for anessential contact time. Till 2h the removal efficiency of both SO_2 and NO was maintainted constant and then the garph tend to decrease. From the results it has shown that the optimum time in the process for a 4% w/vNaOCl was 2h with SO_2 concentration 6348.13 ppm, NO concentration 1804.12 ppm, pH of 5.3 and temperature of 313 K. The saturation time at these conditions was determined as 260 min for NO and 350 min for SO_2. The time lag between saturatio of both gas is due to dissolution of SO_2 in water, it means SO_2 will further soluble in water even though hypochlorite species in liquid solution were saturated.

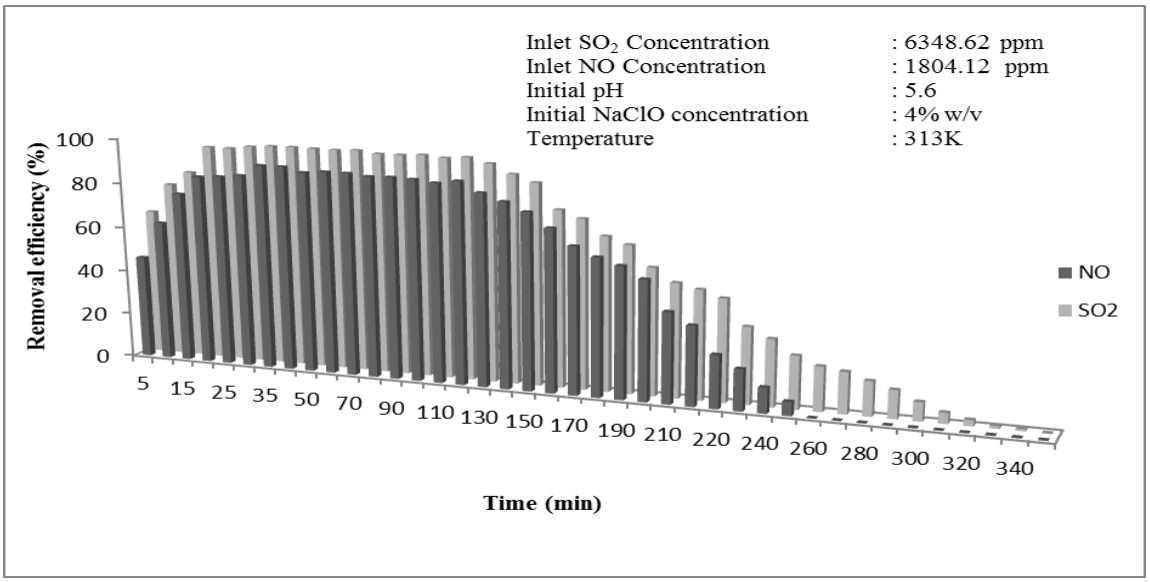


Fig. 2.Effect of time on removal of NO and SO_2.

3.2. Effect of Initial SO_2 Concentration

The initial concentration variation of SO_2 has been studied under the constant parameters such as flow rate of the gas stream, reaction temperature, absorbent concentration, reaction time; initial NO concentration and initial pH of the solution. This study examines the reactive tendency of absorbent on NO with variation in SO_2 concentration. There was slight decrease in a NO removal with increase in SO_2 concentration. The constant operating parameters in this process were 4% w/v NaOCl with reaction time 2 h, as initial NO concentration was 1804.12 ppm, initial pH of 5.6 and temperature of 313 K.

3.3. Effect of Initial NO Concentration

The change in initial concentration of NO has been studied under the constant parameters such as flow rate of the gas stream, reaction temperature, absorbent concentration, reaction time; initial SO_2 concentration and initial pH of the solution. This study explains the reaction capability of NaOCl on SO_2 with variation in NO concentration. There was similar trend has been observed as of effect of initial SO_2 concentration such that decrease in a NO removal with increase in SO_2 concentration. The constant operating parameters in this process were 4% w/v absorbent with reaction time 2 hours, as SO_2 concentration was 6348.13 ppm, initial pH of absorbent 5.6 and reaction temperature of 305 K.

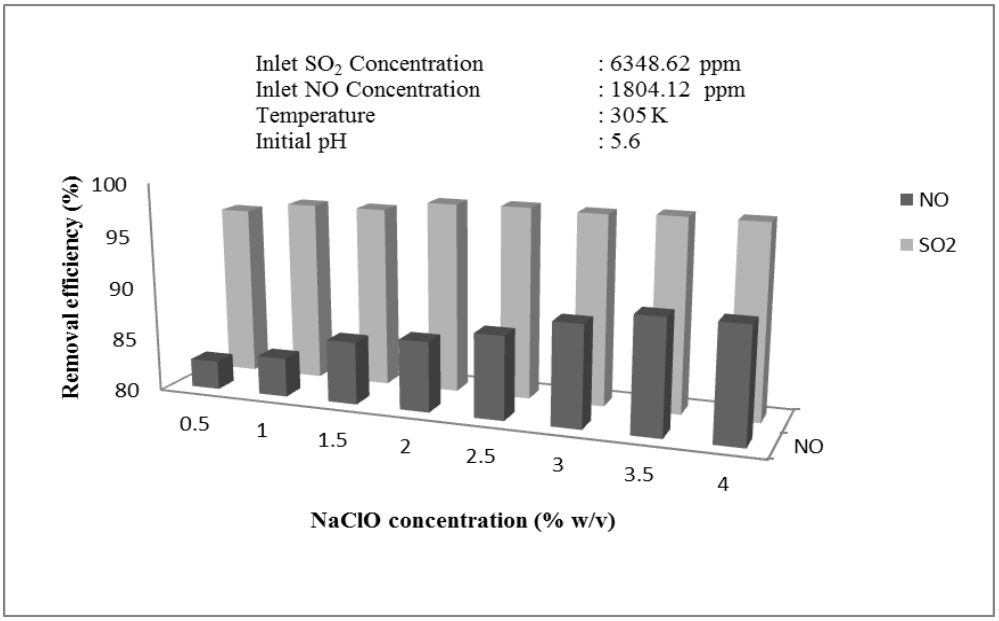


Fig. 2.Effect of NaOCl concentration on removal of NO and SO_2.

3.4. Effect of Absorbent Concentration

The change in SO_2 and NO removalwith respect to absorbent concentraion was studied with constant parameters such as reaction time 2h, SO_2 concentration 6348.13 ppm, NO concentration 804.12 ppm, pH of 5.3 and temperature of 313 K to study efefctivenes and expectant requirement of absorbent for the process. The range of NaClO during the process was 0.5-6% w/v. The change inremoval efficency with respect to concentration range was shown in Fig. 3. From the data the optimistic absorbent for the process was obtained as 4% w/v. The supreme removal efficiency 91% has been acquired for NO and 99% for SO_2 in this process. Standarg oxidation of SO_2 and NO in the liquid stream to produce acidic intermediatese such as HNO_3, HNO_2 and H_2SO_4 was the major operation carried out in the process. The presence of hypochlorite ions help in conversion of NO to NO_2.

3.5. Effect of Absorbent Temperature

Effect of reaction temperature holds the requred amout of temperature for the process. The cahng ein reaction temperature with constant parameters such as reaction time 2h, SO_2 concentration 6348.13 ppm, NO concentration 1804.12 ppm, pH of 5.3 and absorbent concentration 4% w/v was shown in Fig. 3. The change in removal efficiency of SO_2 and NO with the temperature range of 283-325 K was considered in this process.

During the experimentation maximum removal efficeiency was observed at 305 K. Initaially the removal increases with increase in temperature till 305 and then decreases, hence 305 K was optimum temperature for this process. Initial increase is due to presence of vacant hypoclorite ions in the reactor and decrease is due to dissolution of absorbent in liquid phase.

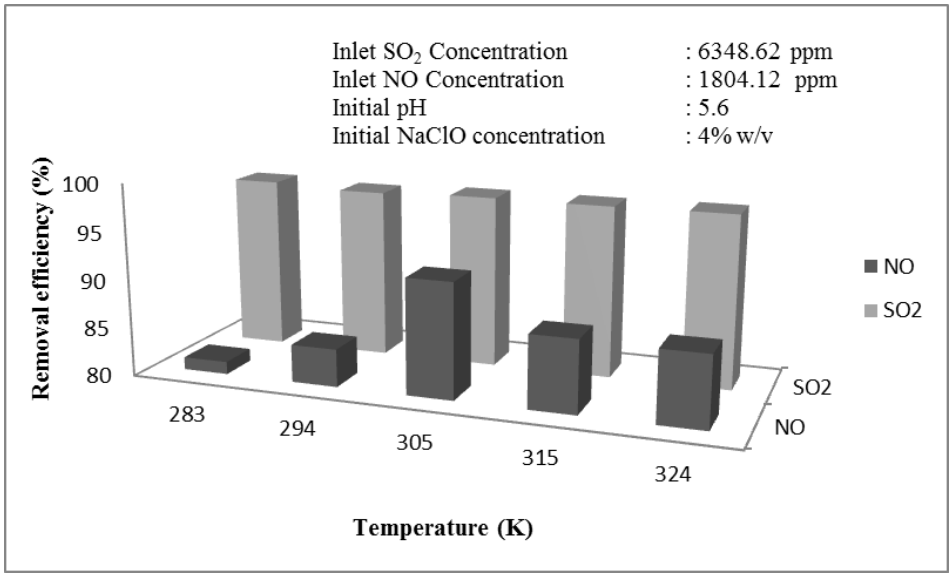


Fig. 3. Effect of absorbent temperature on removal of NO and SO_2.

3.6. Effect of Initial pH

The effect of initial pH of NO has been examined keeping flow rate of the gas stream, temperature, concentration, time, initial SO_2 concentration and initial NO concentration as constant. The operating parameters were reaction time 2h, SO_2 concentration 6348.13 ppm, NO concentration 1804.12 ppm, temperature 305K and absorbent concentration 4% w/v This study accomplishes the optimum pH of the solution containing NaClO for simultaneous removal of SO_2 and NO. The Optimum pH obtained in the process was given as 5.6.

V. CONCLUSIONS

NaClO was shown an effective removal efficiency of both SO_2 and NO in bubble column absorption. The optimum results for removal SO_2 and NO with use of NaClO as absorbent in bubble column were process temperature 305K; absorbent concentration was 4% w/v NaClO and pH of 5.6. The change in initial concentration of SO_2 and NO also measured to observe the reactive tendency absorbent with these gases. Maximum removal efficiencies of 99% for SO_2 and 85% for NO were obtained under optimal experimental conditions. The saturation time for the process was determined as 260 min for NO and 350 min for SO_2 with experimental conditions; SO_2 concentration 6348.13 ppm, NO concentration 1804.12 ppm, temperature 305K and absorbent concentration 4% w/v and pH 5.6.

VI. ACKNOWLEDGEMENTS

Authors are thankful to Department of Chemical Engineering & Technology, Indian Institute of Technology, (Banaras Hindu University) and Ministry of Human Resourse Devolopment (MHRD) for providing necessary facilities and help during the course of the work.

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