Removing Acid Mist in Flue Gas Emissions

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***Abstract*—Air pollution can be very harmful to human or biodiversity. In order to overcome this problem, this study has been conducted which aiming to study the removal hydrobromic acid by using NaOH solution and to investigate the effect of concentration of NaOH toward acid gas. This research will be focused on removing acid mist which is hydrogen bromide acid. Major acid removal is by using the scrubbing method. This study performed a gas chromatography analysis to tracing the compound in the gas sample. Hydrobromic acid mist will be remove by using 1M, 2M and 3M concentration of NaOH and different time contact which 10min, 20min and 30min each concentration. Based on the analysis higher concentration of NaOH will removed higher content of hydrogen bromide gas mist. For removal of hydrogen bromide using 1M NaOH solution after 30 min the percent of reduction is 75.6%. secondly for removal using 2M NaOH the results shows percent of reduction after 30min is 84.7%. lastly for the 3M NaOH remove 89.1%. Based on the data, it shows that 3M of NaOH with the longer contact times which is 30min can't remove 100% of Hbr acid mist, so its required higher concentration of NaOH solution.**

Keywords*— *acid mist, hydrogen bromide, sodium hydroxide scrubbing method, Absorption, gas chromatography.

1. INTRODUCTION

Air pollution occurs when large of acid mist emission including particulate and biological molecules are introduced into the atmosphere. This air pollution can cause diseases, allergies or death of humans, besides it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution[1].

Major industries with exposure to strong inorganic acid mists include those that manufacture phosphate fertilizer, isopropyl alcohol, ethyl alcohol, sulfuric acid, nitric acid, and lead batteries. Exposure also occurs during copper smelting, and pickling and other acid treatment of metals. Minor uses of sulfuric acid include applications in petroleum refining, mining, metallurgy, and ore processing, in the synthesis of inorganic and organic chemicals, synthetic rubber and plastics, in the processing of pulp and paper, the manufacture of soap and detergents, cellulose fibers and films, inorganic pigments and paints, and in water treatment. Exposure to strong inorganic acid mists containing sulfuric acid may occur by inhalation, ingestion, and dermal contact. Exposure depends on many factors including particle size, proximity to the source, and control measures such as ventilation and containment[2].

Recent studies show the way to remove this acid mist is scrubbing method. Scrubbing method is a common name given the unit operation known as gas absorption. In this process, mass is transferred from the gas phase into a liquid for the purpose of removing material from the gas stream[3]. Wet packed scrubbers can achieve extremely high contaminants removals and can operate at a variety of loads. This method can achieve simultaneously removal of variety of contaminants as well as provide a measure of gas cooling and particles emission control. Gas absorption will play a very important role in controlling pollutants to bring industry into compliance with the requirements of the clean air[4].

Spray tower scrubber performance based on cement dust particle removal efficiency has been described. The approach focused on the design of a scrubber system for the collection of dust particle sizes that are emitted from cement production processes. To promote maximum gas–liquid surface area and residence time, a number of wet scrubber designs have been used, including spray towers, venturi, plate towers, and mobile packed beds[5]. Because of scale buildup, plugging, or erosion, which affects flue gas desulphurization dependability and absorber efficiency, the trend, is to use simple scrubbers such as spray towers instead of more complicated ones. The configuration of the tower may be vertical or horizontal, and flue gas can flow concurrently, counter currently, or cross currently with respect to the liquid. The chief drawback of spray towers is that they require a higher liquid-to-gas ratio requirement for equivalent toxic gas removal than other absorber designs[6].

The hydrobromic acid gas is heavier than air and can travel to low lying or confined areas. Containers of hydrogen bromide may explode when heated. Solid hydrogen bromide (HBr) shows three crystalline phases at low temperature and ambient pressure[7]. The lowest temperature form solid phases have an orthorhombic ordered structure. With increasing temperature, solid phase transforms to mixture phase at 90 K, then to gas phase at 114 K, and gas and mixture phase are orientation ally disordered. Phase transitions at high pressure have been investigated experimentally[8]. At room temperature, gas phase transformed to solid phase at 13 GPa. Furthermore, HBr was considered to decompose into Br_2 and possibly H_2 after hydrogen-bond symmetrization.

The scope of this research is to find the suitable base solution to remove the acid mist content in flue gas emissions. The types of acid mist used in this research are hydrobromic acid gas. While the base solution used in this research is sodium hydroxide solution. The used of NaOH in this research is not exceed than 3 molar. The acid mist and the base solution need to be contacted in a scrubber bottle through the absorption process[9]. The study will use wet scrubber method to remove the acid mist gas Hbr . the aim of this research is to To identify suitable solution to remove acid mist and to study the efficiency for the acid mist removal.

2. METHODOLOGY

2.1 Experiment design

Scrubber systems are a diverse group of air pollution control devices that can be used to remove some particulates and/or gases from industrial exhaust streams[10]. In this research small scrubber bottle was used to act as scrubber mechanism for the gas absorption to happen in order to treat acid gas.

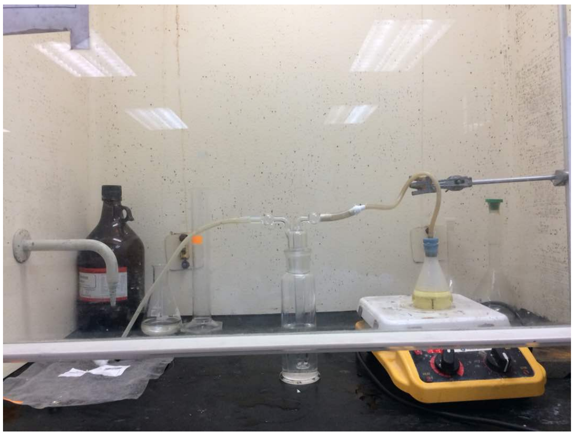

Figure 1: experimental set up

Figure 1 shows the experimental set up for treating hydrogen bromide acid in lab scale. The gas will flow to the 250 ml scrubber botlle filled with various concentrations of 50ml NaOH. The treated gas will flow to the gas bag and will analyse using gas chromatography machine.

2.2 Analytical method

All gases were tested by usin GC of ThermoFinnigan Trace GC. This can be shown by sharp and symmetric peaks high repeatability and reproducibility of retention times and very high precision and accuracy in quantitation based on peak area measurements. The use of Supelco Analytical Carboxen^{TM} 1006 PLOT fused-silica capillary columns with 30m x 0.53mm improved surface inertness, thermal stability and resolution[11].

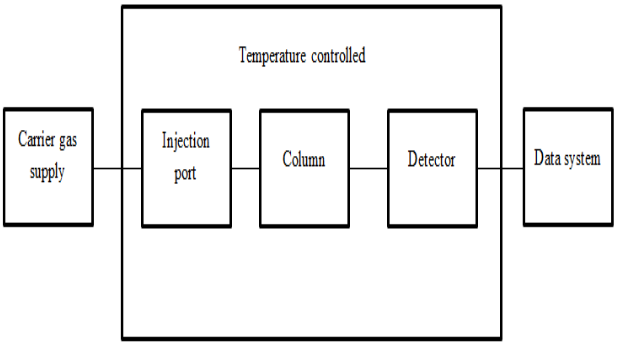

Figure 2: block diagram of gas chromatograph.

Figure 2 shows the block flow diagram of a gas chromatography in order to run the gas analysis. The data acquired was by using Chrom-card data system version 2.3.1. As it moves through the column with the carrier gas, the molecules of each substance present in the sample will distribute between the gas and the liquid. Individual molecules will constantly move between the gas and the liquid in a dynamic equilibrium [13]. While a molecule is in the gas phase it will pass along the column, while it remains dissolved in the liquid it will be stationary. Data of the equipment will shows the peak area of the gases in mvolt unit. Table 1 below shows the appropriate setup of column temperature and oven temperature in the setting of the gas chromatography to acquire a good result.

Table 1: The GC analysis for hydrogen bromide gas.

Acid gas	Column oven	Column flow	Injection temperature	Injection volume
HBr	100ºC hold for 1 minutes, then ramp 180ºC for 4.25 minutes.	4ml/min	100ºC(TCD)	1.0µl

2.3 methods for hydrobromic acid

This 50ml hydrobromic acid liquid form was boil at its boiling point which is 200ºC and the gas was collected in the gas bag. The collected gas was test in the GC to obtain the initial area of peak of this HBr acid gas. The gas was contacted with NaOH with different molar and contacted time. The preparation of NaOH was using a dilution in the chemistry lab.

3. RESULTS AND DISCUSSION

4.

Heating of the hydrobromic acid above its boiling on the heater to ensure the solution is vaporized [14]. The vaporized gas then collected to the gas bag. The solution of Naoh was put in the scrubber bottled, the allowed the vaporized gas to contacted to the naoh solution. After the treated gas was collected, the sample was test by us Hydrobromic acid in the form of liquid was converted to the gas. The initial analysis of hydrobromic acid has been test by the gas chromatography.

In the temperature programming method, the column temperature is either increased continuously or in steps as the separation progresses. This method is well suited to separating a mixture with a broad boiling point range. The analysis begins at a low temperature to resolve the low boiling components and increases during the separation to resolve the less volatile, high boiling components of the sample[15]. Rates of 5-7 °C/minute are typical for temperature programming separations.

$$Naoh + Hbr = Nabr + H_2O \longrightarrow \text{Eq 1}$$

The reaction between Naoh and Hbr is form Nabr and water. the release of the Hbr gas obviously can be treated by this Naoh solution. Sodium hydroxide is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns[17]. It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air. It forms a series of hydrates. The monohydrate crystallizes from water solutions between 12.3 and 61.8 °C. The commercially available "sodium hydroxide" is often this monohydrate, and published data may refer to it instead of the anhydrous compound. As one of the simplest hydroxides, it is frequently utilized alongside neutral water and acidic hydrochloric acid to demonstrate the pH scale to chemistry students [18][19]. Table 2 below shows the data of peak area depending on the molar of NaOH and contacted time between NaOH and acid gas.

Table 2: peak area of different molar of contacted gas.

Molar/ time	0 min	10 min	20 in	30 min
1 molar NaOH	6546	3414	2402	1594
2 molar NaOH	6546	1307	1269	1001
3 molar NaOH	6546	1159	1060	707

The result was plotted in a graph to be more clearly to read the data. Graphic representation is a method to show and represent values, increases, decreases, comparisons to either make predictions or show a report of how certain situation was yesterday and how it is today. It is the visual display of data through charts and graphs.

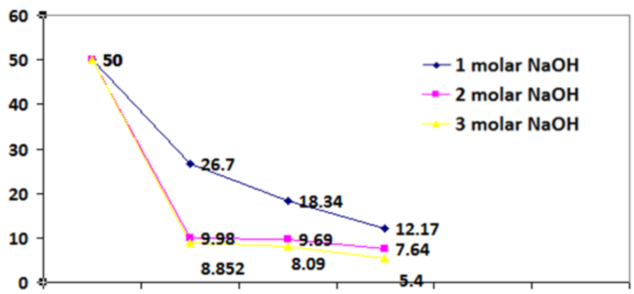

Figure 3: graph of concentration of HBr (ppm) against time contacted in various molar of NaOH.

Based on the Figure 3 plotted result of the area of peak, the higher the concentration of the solution of Naoh the lesser the area of peak. It shows that the 3 molar and above of the NaOH concentration can be used for Hbr gas treating [21][22]. It this plotted graph it shows the inial ppm of HBr is 50 ppm. After the HBr gas was treated using 1 molar NaOH the concentration decreases to 26.7 ppm for first 10 min, 18.34 ppm for the second 20 min and 12.1 ppm for the last 30 min. this result was followed by the 2 molar of NaOH when the initial concentration of HBr is the same which is 50 ppm. The treated gas was reduce the HBr concentration to the 9.98 ppm, 9.69 ppm and 7.64 ppm for the next 10 minutes interval. Lastly the HBr gas was treated by using 3 molar of NaOH concentration, the result show the larger deduction of HBr concentration in ppm which from 50 ppm to 8.85ppm, 8.09 ppm and 5.4ppm respectively to 10 minutes intervals time contacted to the NaOH solution. This study was related to the HBr treatment which is 100 ppm of HBr can be reduced by using 3 molar NaOH to 50 ppm[22][23]. This can conclude that 3 molar can reduced the initial concentration of acid mist to the lower concentration with the shortest time contacted.

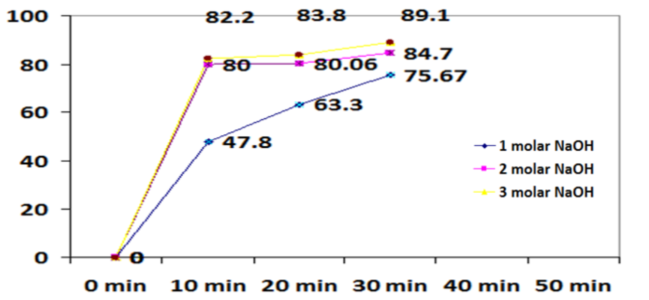

Figure 4: percent reduction of HBr (%)againt time contacted between NaOH

Based on Figure 4, it shows the higher the concentration of NaOH the larger the percent of reduction of this HBr acid gas. Percent is reduction of HBr is dependently on the concentration of NaOh and time contacted between them[24][25]. Based on the result achieved at 10 min of time contacted 3 molar of NaOH shows the largest reduction which is 82.2% whilw 2 molar in second with the value 80% and followed by 1 molar NaOH the lowest with 47.8%. the result was similar with 20 minutes time contacted when the largest reduction shiws with 3 molar of NaOH which is 83.8%, 80.06 % and 63.3% respectively with 2 molar and 3 molar NaOH. Lastly, the result shows after 30 minutes time contacted 3 molar NaOH can increase the percent of reduction to 89.1% which is the greatest reduction of HBr and followed by 84.7% for 2 molar NaOH and 75.67% for 1 molar NaOH. Based on the recent study, this result can be related that 3 molar and above of concentration of NaOH can be the very suitable concentration in treating HBr acid gas[26][27]. This conclude that to achieve the 100% reduction of HBr acid gas is by using the 3 molar and above and by increasing the time contacted between these acid gas and NaOH solution.

5. CONCLUSION

Reduction of Hydrogen bromide gas concentrations in a natural gas stream to values as low as 30ppm can be achieved with physical solvent absorption using NaOH solution as the washing stream. Additionally, NaOH regeneration from an absorption outlet stream can be accomplished through a successive scrubber scheme.

On the other hand, heavy-hydrocarbons removal and condensation stages of a sour gas treatment process can be designed from performing dew point calculations for a natural gas stream. 3 molar concentration of NaOH is suitable to treat 89.1% of HBr. The lesser of this NaOH give lower percent of reduction. To achieved 100 percent of reduction of this acid mist higher concentration is required.

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