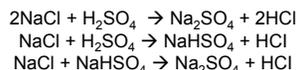


## Introduction

- Field studies have shown that a substantial fraction of sulfate found in cloud water results from S(IV) uptake as SO<sub>2</sub> and subsequent conversion to S(VI) as sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) inside droplets that may contain sea salt (NaCl) particles.
- When sulfuric acid droplets react with NaCl they release HCl, which may contribute to the acidity of the rain. HCl is degassed from NaCl and sulfuric acid via three primary pathways



- The formation HCl has been found to increase with temperature, and assumed to reduce with higher relative humidity. The reduction of HCl with higher relative humidity is assumed not to have any significant effect on above reactions.
- This experiment investigates how much of the HCl produced is dependent on the relative humidity at which the reaction occurs.

## Experimental Setup

- A 10 cm Short path Gas cell Fourier Transform Infrared Spectroscopy (FT-IR) with MCT/D detector and KBr beam splitter was used. (Fig 1)
- Relative Humidity controlled mixing dry and wet air, monitored by sensor before reaction chamber to minimize damage to sensor.
- Background is gas cell with no HCl gas and dry air conditions.
- 2g NaCl and 2mL of 16 M H<sub>2</sub>SO<sub>4</sub> was added to reaction chamber, and RH adjusted and equilibrated through entire setup (Fig 2)

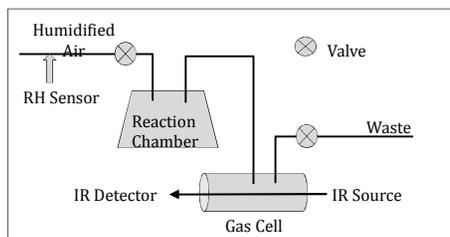


Figure 1 : Schematic of the experiment setup



Figure 2: Picture of flow setup and reaction chamber (left). Picture of NaCl+H<sub>2</sub>SO<sub>4</sub> reaction under controlled atmospheric conditions (right)

## Spectra of Hydrochloric acid

- Spectra of Hydrochloric gas formed after 10 minutes at 30% RH
- Peak at 3780cm<sup>-1</sup> is the OH stretch in water vapor
- Peaks at 2940 and 2800 cm<sup>-1</sup> are HCl in gas phase
- Peak at 1600 cm<sup>-1</sup> is OH bend in water vapor.

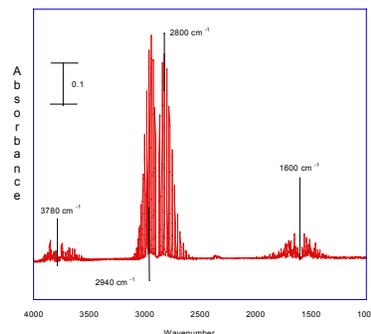


Figure 3: Gas phase IR spectra of HCl

## Rate of Hydrochloric gas production

This is peak area measurements from a reaction completion study. Scans were taken one minute apart. Since scans take one minute to complete, each scan is two minutes apart. After about ten minutes, the reaction reaches an asymptote at 40 units, and thus can be considered complete. So, for the future analyses, a 10 minute delay was taken, and since scans take about a minute to complete, that makes a 11 minute delay. Error bars are taken from three measurements.

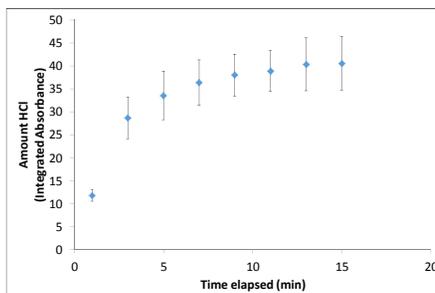


Figure 4: Time lapse graph of the amount of HCl formed measured by integrated absorbance from 3100-2500 cm<sup>-1</sup>.

## Amount of Hydrochloric Gas formed

This graph below shows the average hydrochloric acid formed found by integrated absorbance from 3100-2500 cm<sup>-1</sup>, the amount of HCl formed. The shaded grey area from 30-43 units is the error of the experiment determined by taking an average of five readings of HCl under dry air conditions across the duration of the experiment.

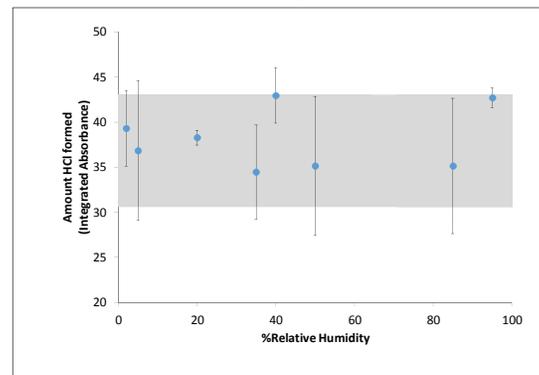


Figure 5: The amount of HCl formed from NaCl and H<sub>2</sub>SO<sub>4</sub> after ten minutes as a function of relative humidity. Amount of HCl is measured by integrated absorbance units.

- The amount of Hydrochloric gas does not vary significantly across 5-95% relative humidity as all measurements are in shaded grey area.
- Error bars are one standard deviation away from the mean of at least three different reactions at the same relative humidity.

## Conclusions

- Hydrochloric is shown to be removed as a gas phase species from reaction of sulfuric acid and sodium chloride.
- Water vapor content does not significantly affect amount or rate of HCl formed on the ten minute timescale.
- In sodium chloride and sulfuric acid reactions, the amount HCl formed is constant and therefore does not have any significant effect on primary pathways which react on the 30 minute timescale.
- Gas cell IR is an effective way to analyze HCl formation reactions

## Acknowledgments

This research was done as part of the Arkansas State University Experiential Learning Fellowship (ELF) Program (NSF grant no. 1060209) research initiative.