DEVELOPMENT of a LOW COST AUTOMATED SENSOR for the SIMULTANEOUS MEASUREMENT of GAS and PARTICLE-PHASE AMMONIA

Julian Paige, Justin Thaggard, Michael Battiglia, Christopher Hennigan,
Department of Chemical, Biochemical, & Environmental Engineering,
University of Maryland, Baltimore County

Introduction & Project Focus

Ammonia is the most important basic compound in the atmosphere. Ammonia participates in numerous atmospheric chemical reactions including the formation of particulate matter, which has significant implications for air quality and human health. Agriculture is the largest emitter of ammonia; it's been estimated that 25% of the Nitrogen used in fertilizer is lost as Ammonia[1]. However the emissions of ammonia are not predicted well by state-of-the-art models. To provide further accuracy ammonia sensors are used; however the existing systems tend to be very expensive, costing tens of thousands of dollars minimum, which limits their deployment on a widespread basis. This has motivated efforts to develop new methods to measure atmospheric ammonia at a significantly reduced cost. This project is focused on the construction and testing of an automated system to capture ammonia from the gas and particles phases, with subsequent measurement of ammonia in the aqueous phase using UV-Vis spectroscopy to quantify the outcome of the Berthelot reaction.

The Modified Berthelot Reaction

Reagent1: $C_7H_5NaO_3$(Sodium Salicylate), & $Na_2[Fe(CN)_5NO]$ (Sodium Nitroprusside) in 0.5M NaOH. Reagent2: NaOCl in 1M NaOH.
Order: NH_4^+ + Reagent1 + Reagent2
For every mL of NH_4^+ add 0.5ml of each reagent.

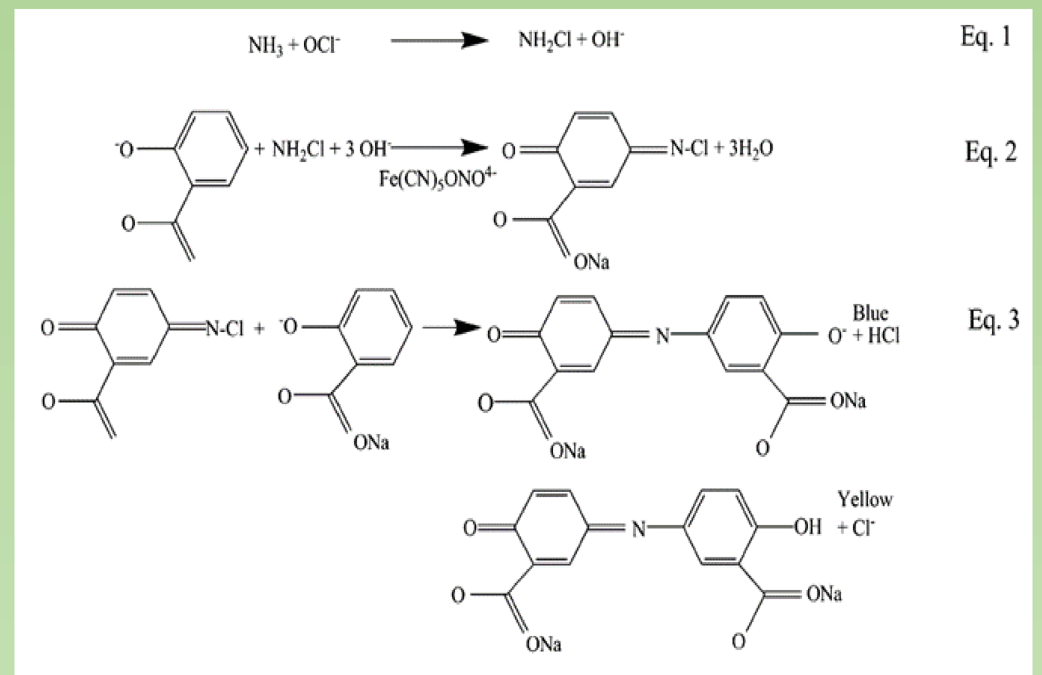


Figure 1. Reaction Pathway, Cogan et al,2014[2]

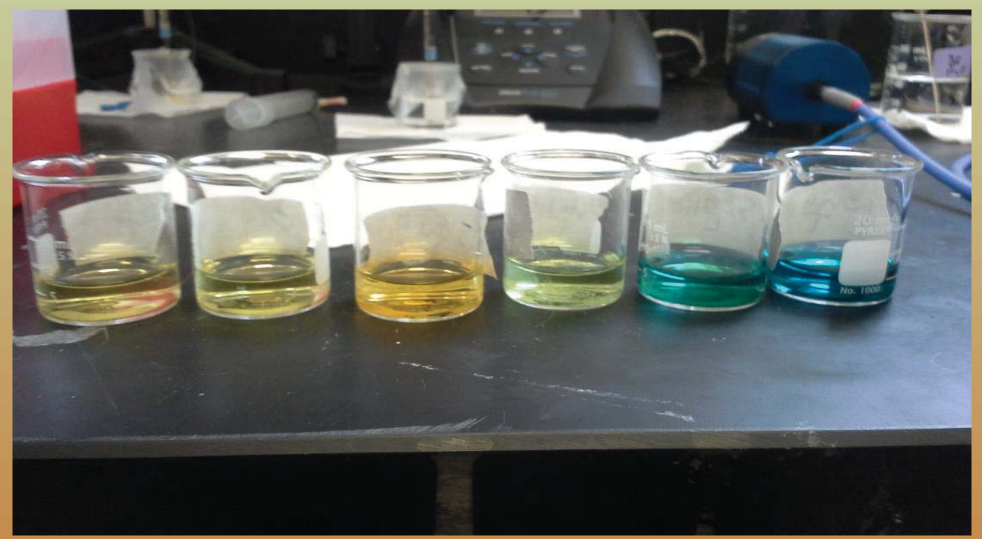


Figure 2. Time and concentration dependent coloration. From left to right: 0.02,0.1,0.5,1,5,10mg/L of NH_4^+ with appropriate ratio of reagent 1 and 2 after 1-2 hours.

Current Sensor System

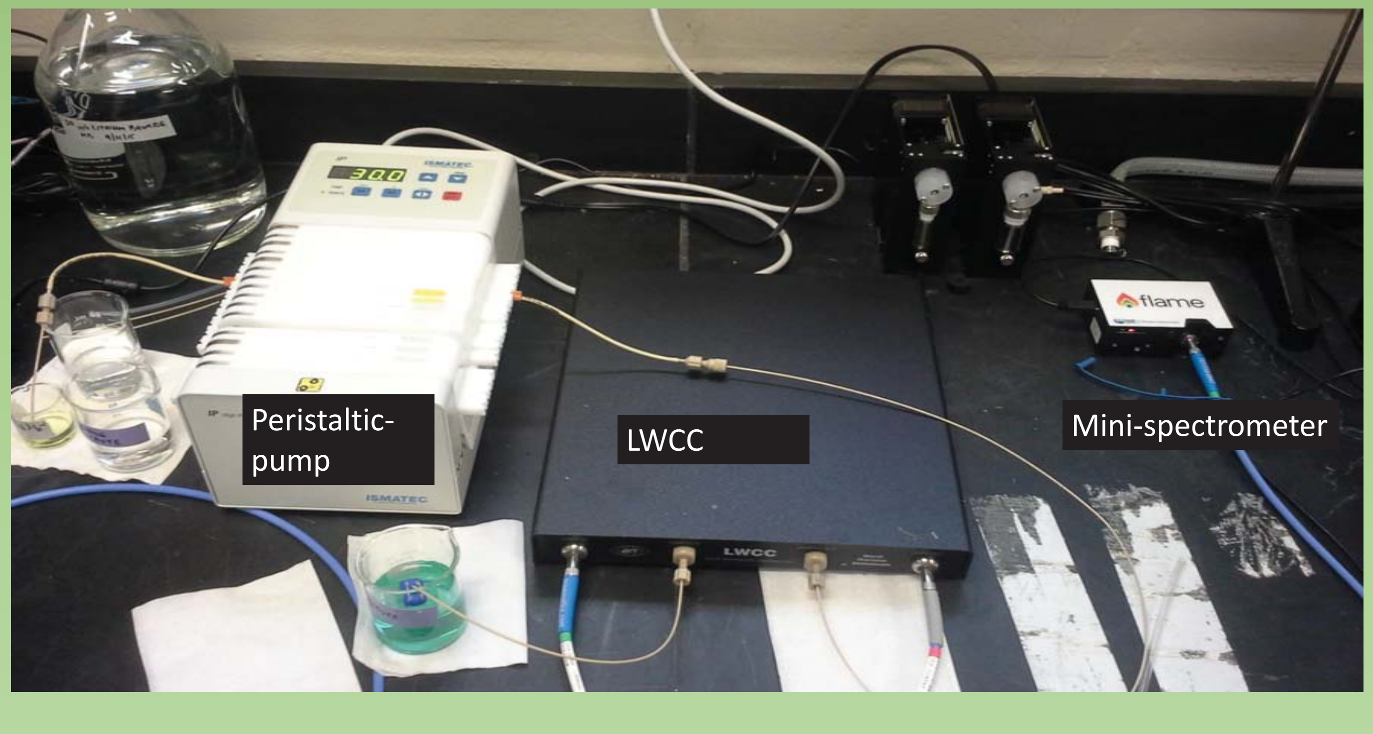
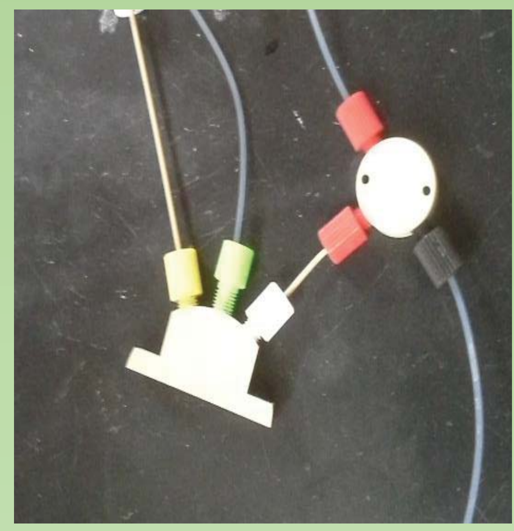


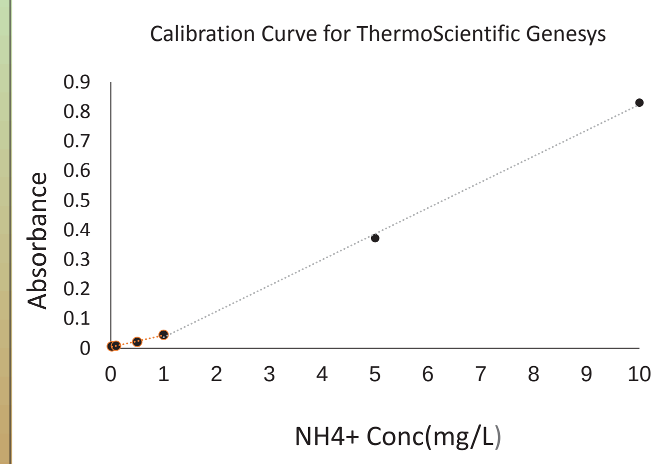
Figure 4.Top: Current set-up for sensor. Sample + Reagents pipetted into beaker, pulled into the peri-staltic pump, and pushed through the Liquid Waveguide Capillary Cell (LWCC). Right: Tungsten-Halogen light source connected to fiber optic cable. Feeds into LWCC then into the miniature spectrometer

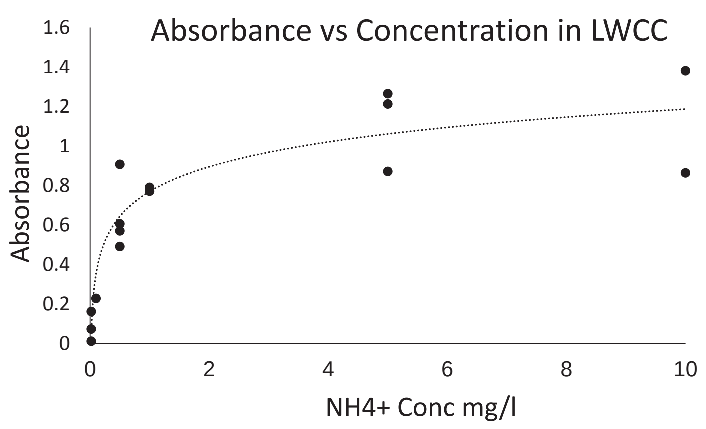
Future Sensor System Components

Figure 6. Left: Mist chamber set up used to create liquid sample from air[3]. Bottom left: syringe pump to be used to fill and empty mist chamber with liquid. Bottom right: reagent mixing system.



Results





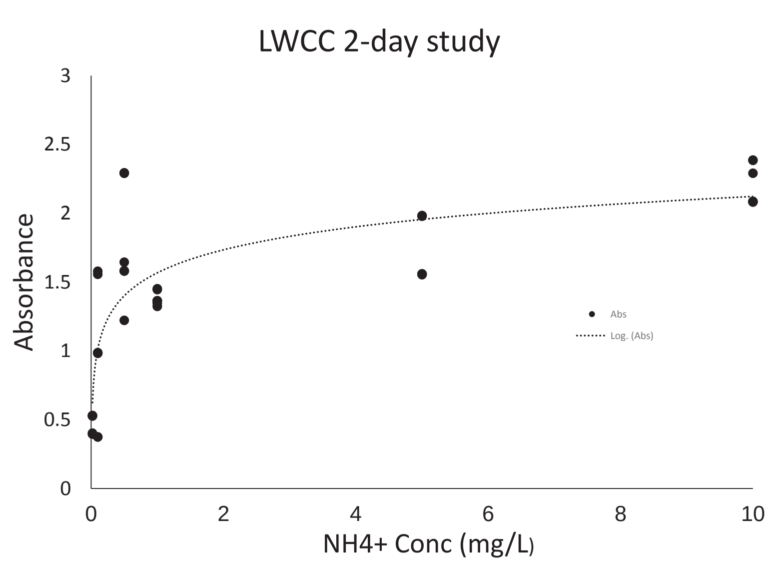


Figure 5. Top left: Serial readings in ThermoScientific Gensys spectrometer at 9mins. Top right: Same test in the LWCC. Bottom Right: Similar test for LWCC, except tested two days after R1& R2 are added instead of 9 mins. Concentrations used: 0.02,0.1,0.5,1,5,10 mg/L

Conclusions

Currently, the LWCC in conjunction with the miniature spectrometer lack the precision provided by the benchtop model spectrometer. Adjusting light settings and equipment specifications is the next step in improving sensor precision. Once this is achieved, further components will be added to the system.

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References

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