Development of in-situ sensors for CO_2 to fuel process

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Abstract

Conversion of CO_2 into fuel is an interesting and promising field. However, the conversion yield is hard to measure during the conversion process. Here, we have developed two techniques to measure the amount of CO_2 while the reaction is taking place. First method is colorimetry, where a chemical is added to the solution, and it changes color depending on the resulting product. The second method is the atomization of the resulting solution. Thereafter, the results were measured by a gas sensor. The prepare sensors are cost effective and portable to use.

INTRODUCTION

It is a highly desirable goal to convert CO_2 into fuels (such as methanol, ethylene or formic acid) using renewable sources of energy. Stability and poor product selectivity of the catalysts are some of the problems involved.

❖Hence, multiple approaches have been employed to detect such as via electrochemical, optical, or CO_2 sensors.

❖ Meanwhile, an optical sensor does a conversion of a chemical/biological reaction into a light or a color signal.

❖ Amongst these, optical sensors (colorimetric and fluorescence sensors) seem to provide the easiest method to detect the presence of objective analytics in a testing solution.

❖ The colorimetric sensing is easy, speedy, extremely sensitive, and choosy. The recognition is completed in one step without a complicated instrumental setup.

❖ The reason that normal gas sensors are hard to use is that the product is in an aqueous solution. Hence, the second approach is to atomize the solution, and measure using tradition metal oxide sensor.

❖ This project is mainly focused on the detection of harmful carbon dioxide using colorimetric sensors and traditional sensors.

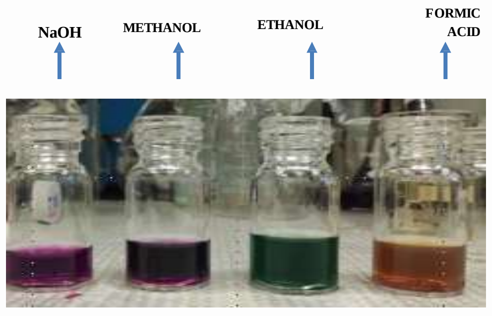
METHODOLOGY

In CO_2 conversion the products are unstable, and the conversion has poor selectivity. Hence, many products can result from the reaction.
The methods for testing are colorimetry, which occur in the aqueous solution by adding Potassium Permanganate . Alternative method is atomizing the aqueous solution using a piezoelectric disk.

RESULTS & DISCUSSION

KMnO4 –Ethanol and Formic acid

Colorimetric investigation of $KMnO_4$ with base of NaOH has seen change in Ethanol and formic acid with different colors.



Potassium Permanganate

KMnO4 –Ethanol

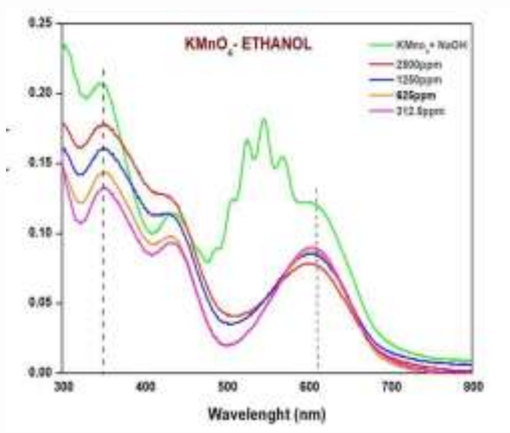
$KMnO_4$+ 2500ppm 1250ppm 625ppm 312.5ppm NaOH

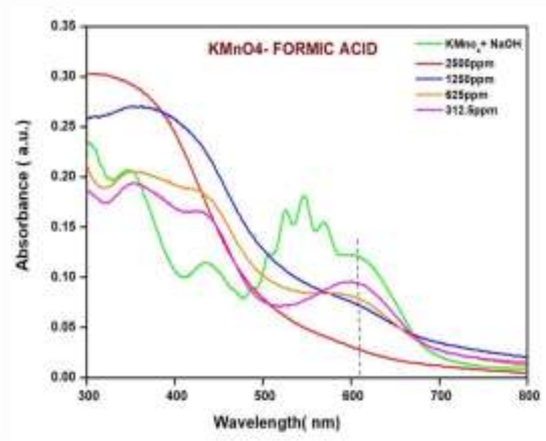
KMnO4 –Formic acid

$KMnO_4$+ NaOH 2500ppm 1250ppm 625ppm 312.5ppm

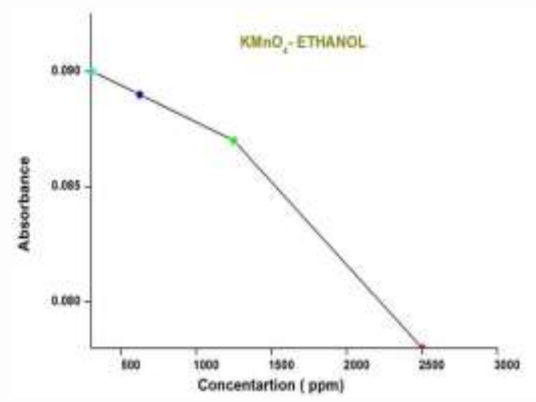
Study of UV Spectrum for Ethanol

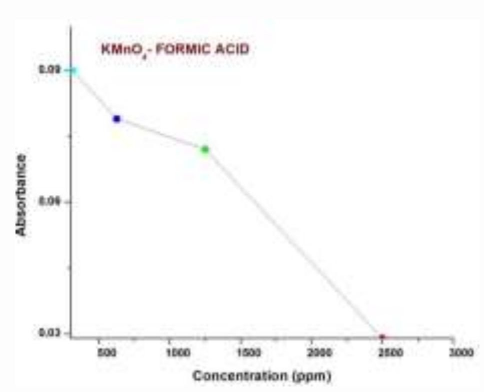
Study of UV Spectrum for





The figures shows the UV spectrum of KMnO4 with varying concentrations of Formic Acid and Ethanol

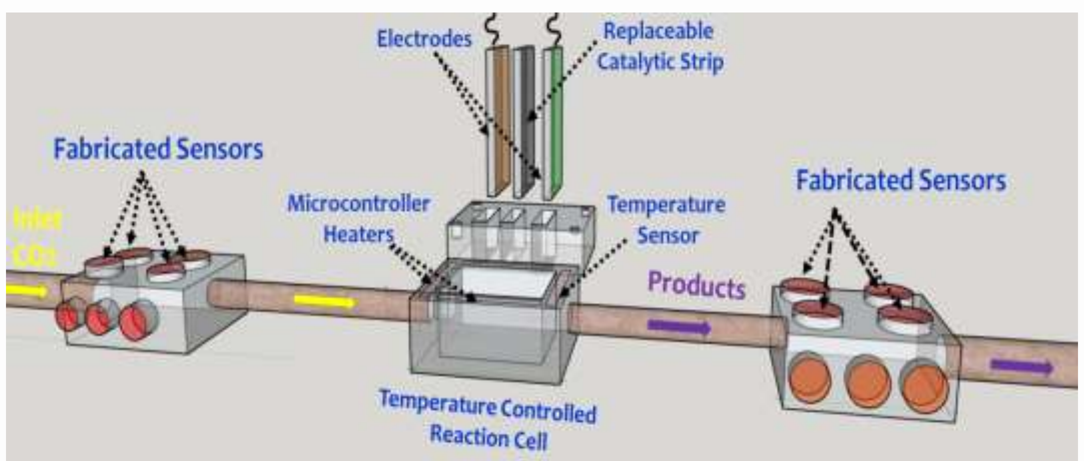


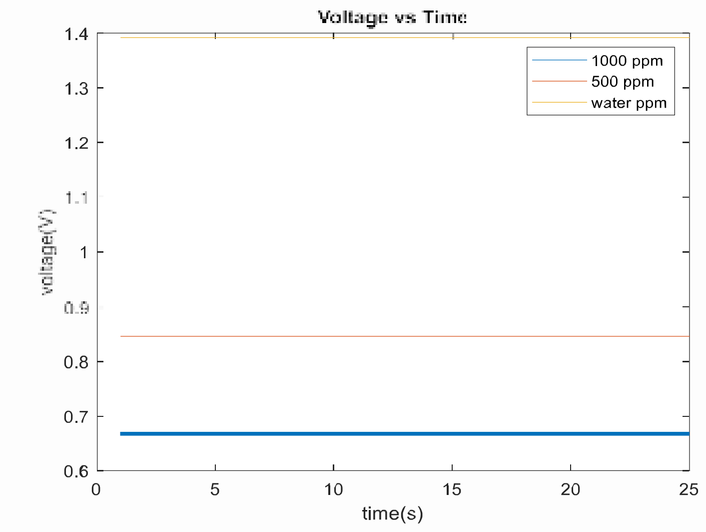


- Change in the pH value and conductivity observed with change in the concentration of CO_2.
- Colorimetric study of $KMnO_4$ with base of NaOH has seen change in Ethanol and formic acid with different colors.
- With the decreasing in the concentrations of Ethanol & Formic acid, the absorbance values increased.

Atomizing –Methanol

- A commercial gas sensor with layer of Tin Dioxide (SnO_2). Sensitive layer was used to detect the atomized solution.
- Three tests were done: one with pure water, others with 1000 ppm and 500 ppm.





- The figure shows the sensor signal while different concentrations of methanol was being released.
- This experiment was not investigated thoroughly, since the effect of moisture on the sensor has not been taken into consideration. However, the preliminary results are promising.

BENEFITS TO QATAR

This project is mainly focused on the detection of fuels that result from CO_2 conversion. CO_2 is a greenhouse gas with the biggest impact on global warming. Getting useful byproducts while removing CO_2 from the environment, if possible, could result in CO_2 reduction being economically feasible. Hence, incentivizing businesses to remove CO_2 from the environment, and by doing research into the many ways to improve the conversion of CO_2 could be useful and could contribute to Qatar moving into a knowledge-based economy.

CONCLUSION

In conclusion, conversion of CO_2 to fuel is an important research field that can have significant impact on Qatar and the globe at large. This study proposes two conversion techniques: the first is based on colorimetry and the second is based on atomization. Detection in colorimetry is based on color change of the solution, while in the atomization the detection is done by gas sensor. Using colorimetry, $KMnO_4$ with base of NaOH has seen change in Ethanol and formic acid with different colors. Sensor based detection showed promising results although further investigation is required.

ACKNOWLEDGEMENT

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REFERENCES

1. Zhang, P. et al. A high throughput method for total alcohol determination in fermentation broths. BMC Biotechnol. 19, 1–8 (2019).
2. Data, T. MQ-3 Semiconductor Sensor for Alcohol. *Structure* 3–5 (2012).