Development of a Low-Energy Consumption CO_2 Separation Method

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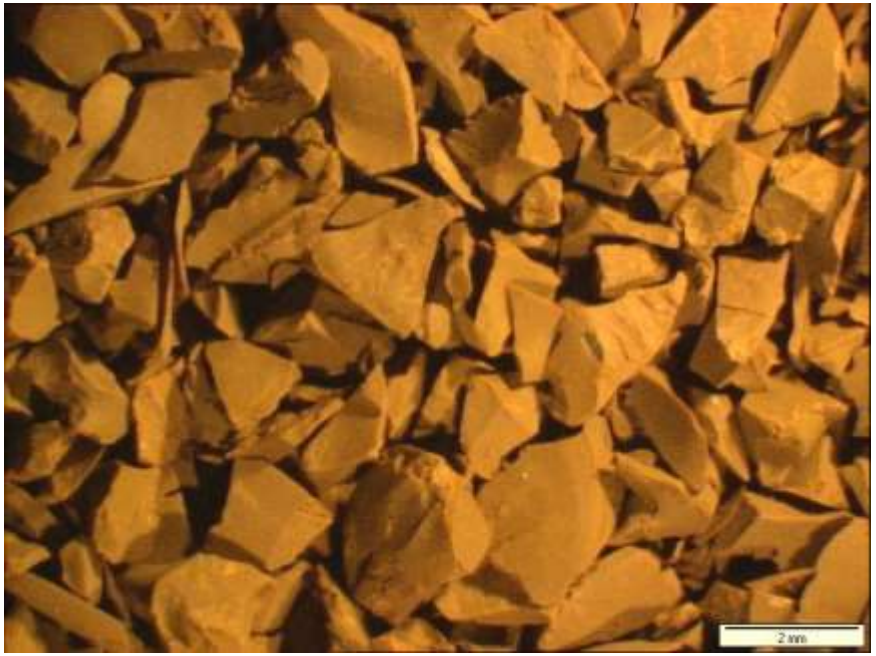
Outline

- Background
- Challenges
- Process
- Results
- Summary

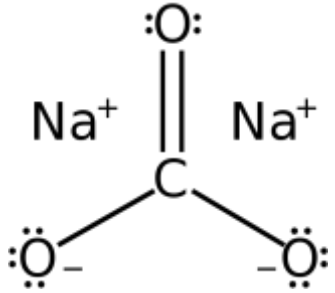
Background

- Many sorbents have been proposed for CO_2 separation.
- As a solid sorbent; alkali metal based sorbents have a great potential for inexpensive CO_2 removal.
- Na_2CO_3/FeOOH was synthesized and compared to K_2CO_3 properties.

Background



Iron Oxide (FeOOH)



Sodium Carbonate (Na_2CO_3, i.e. soda ash)

Background

	Na_2CO_3	K_2CO_3
Molecular Weight (g/mol)	105.9	138.2
ΔH (kcal/mol)	-270.3 exothermic	-274.9 exothermic
ΔG (cal/mol*K)	99.2	57.26
ΔS (cal/mol*K)	33.2	37.32
Cost/lb	$0.27	$1.07

Current Challenges

- Many Co2 removal methods are already employed in industry.
- Current methods are expensive to replace.
- NETL developing a promising new aqueous ammonia system.

Technical Merits

- Use of nanoporous support material for an increased CO_2 sorption capacity.
- Use of catalytic function of the same support material could improve desorption kinetics of CO_2 during regeneration.

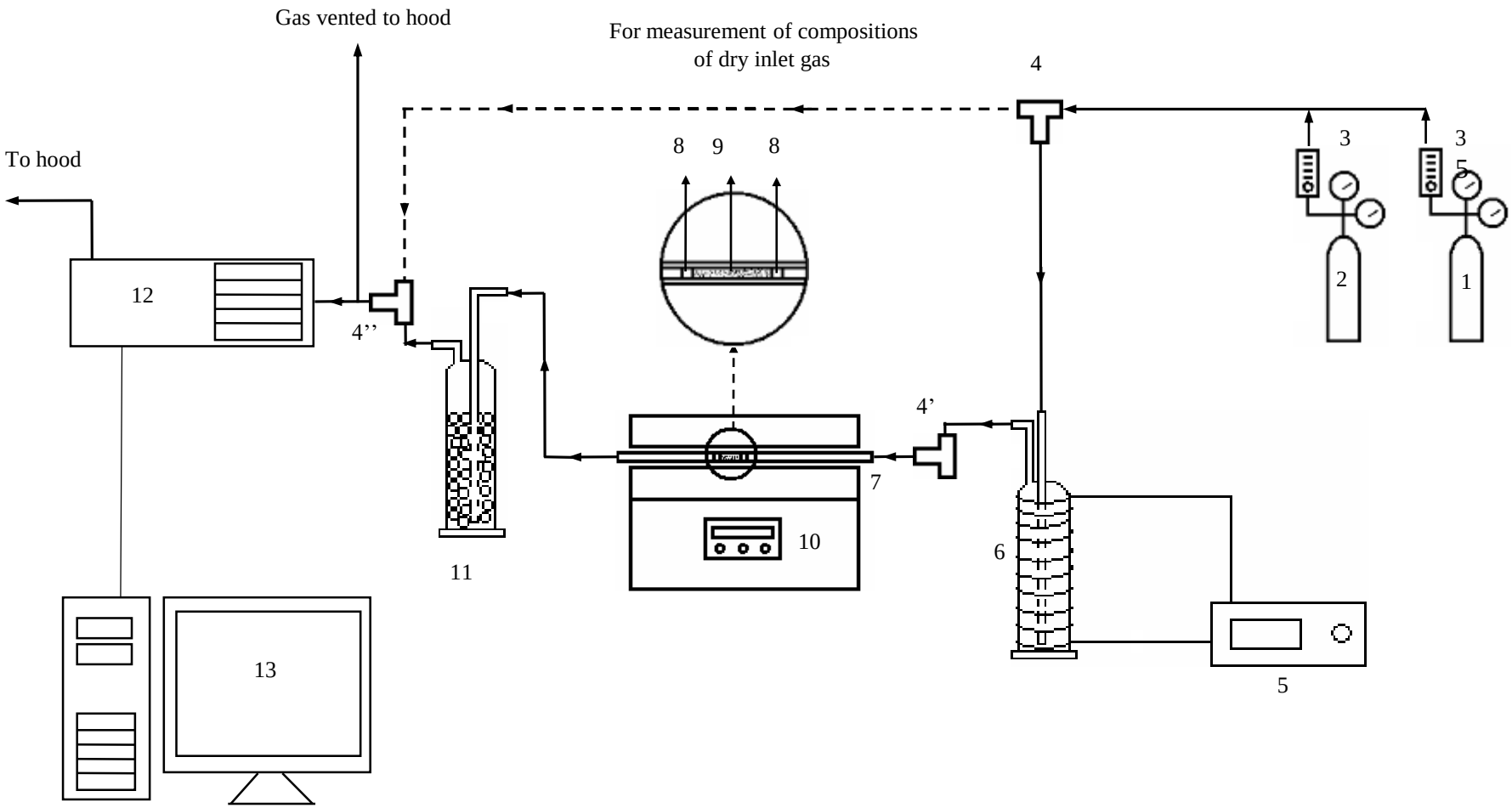
Preparation

- Nanoporous FeOOH was prepared using well known sol-gel and hydrolysis methods.
- 99.5% Anhydrous Na_2CO_3 was purchased from VWR.
- Wet impregnation was used to prepare the solid sorbent Na_2CO_3/FeOOH.

Methods

1. X g of Na_2CO_3 was dissolved in 50mL of deionized water (where X varies from 2.5 -10 g of Na_2CO_3).
2. 10 g of nanoporous FeOOH was then added to the solution and was dissolved over a 24 hr period at 400 rpm.
3. After 24 hrs, the deionized water is evaporated off at 56 C on a rotovap leaving the prepared sorbent behind.

Experimental Set-up

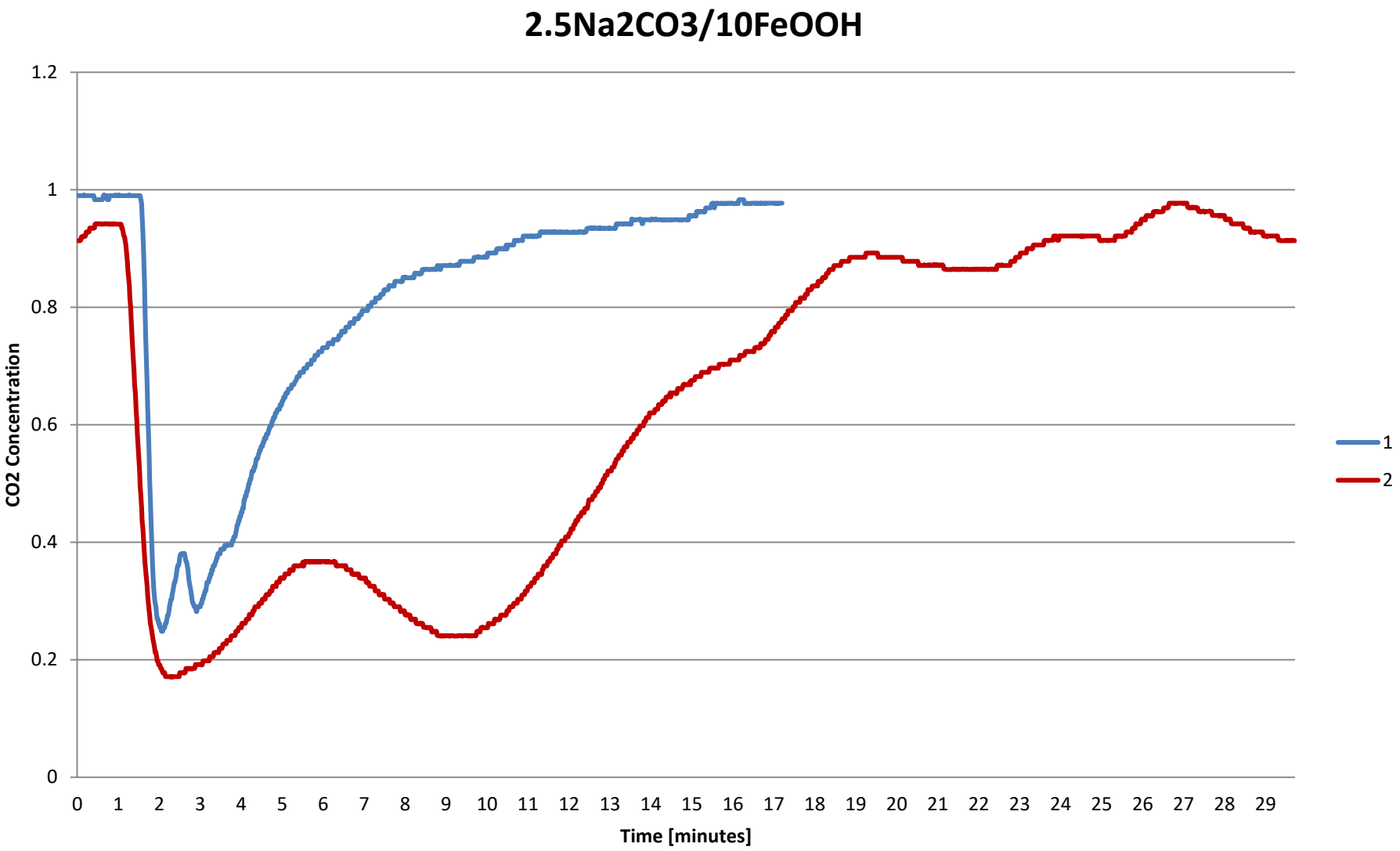


Synthesized Sorbents

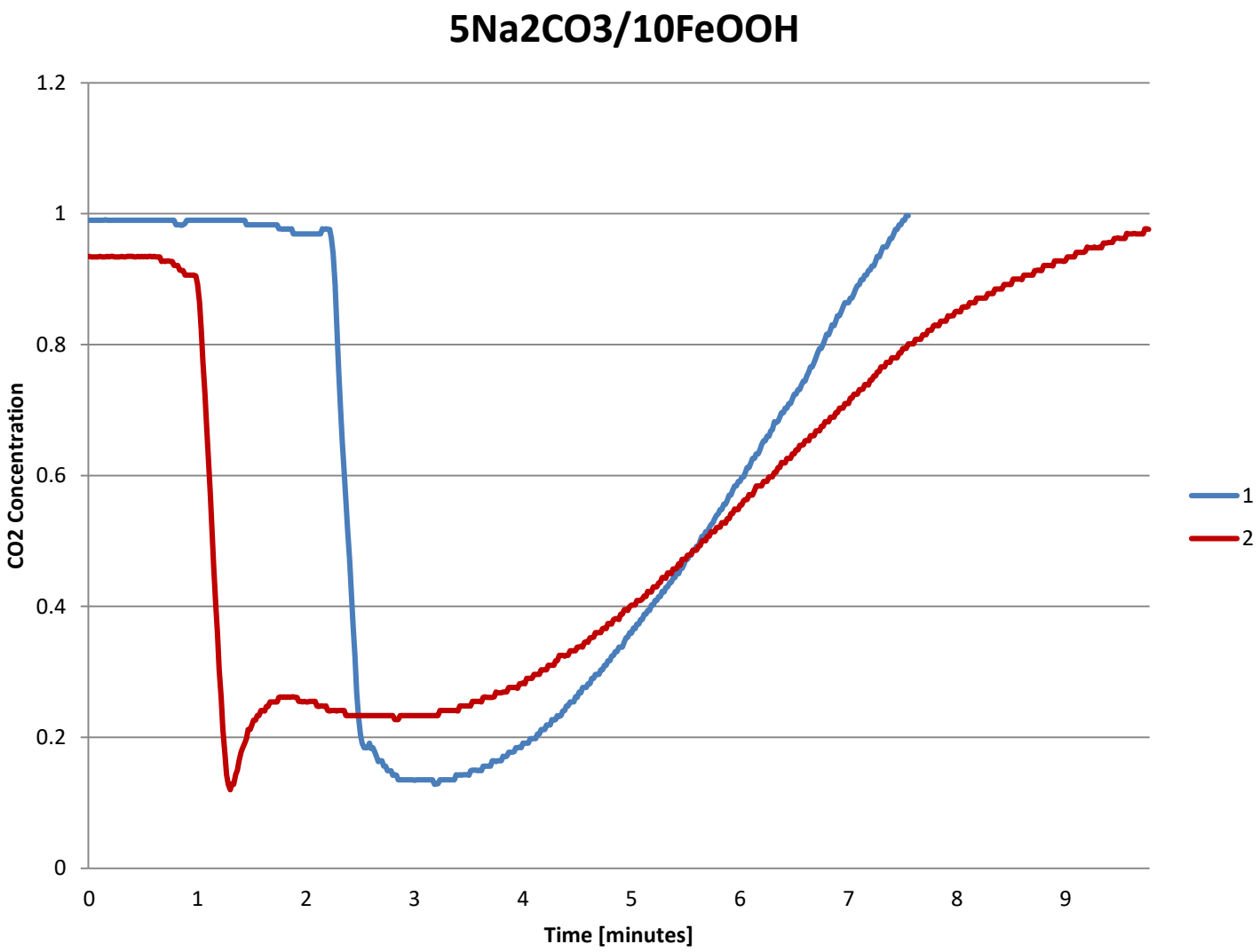
Support Material FeOOH	Sorbent Na_2CO_3
grams	grams
10	2.5
10	5
10	7.5
10	10

- Experiments conducted utilizing a 1% CO_2 gas stream.

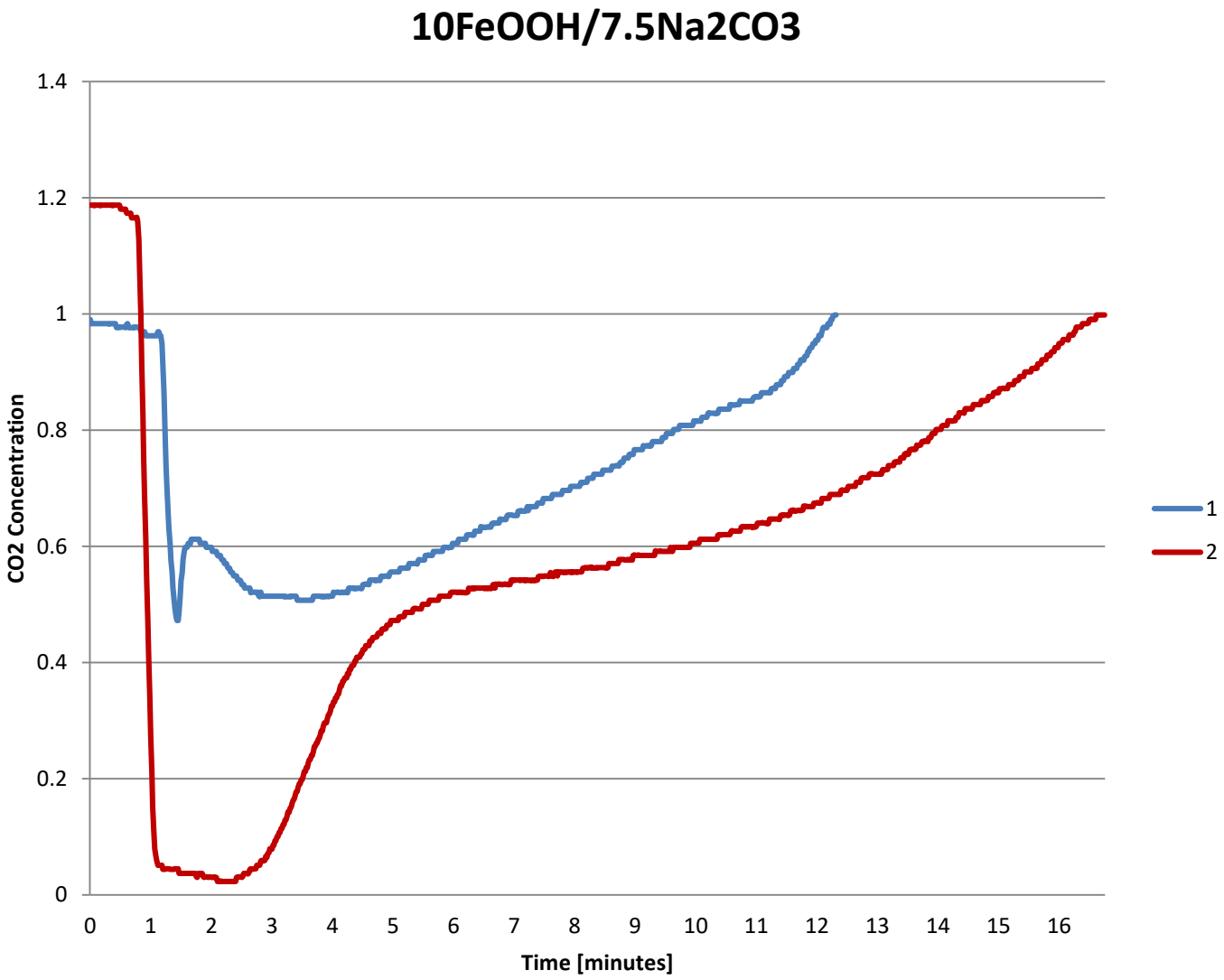
Results


2.5Na2CO3/10FeOOH
CO2 Concentration
Time [minutes]
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
1
2

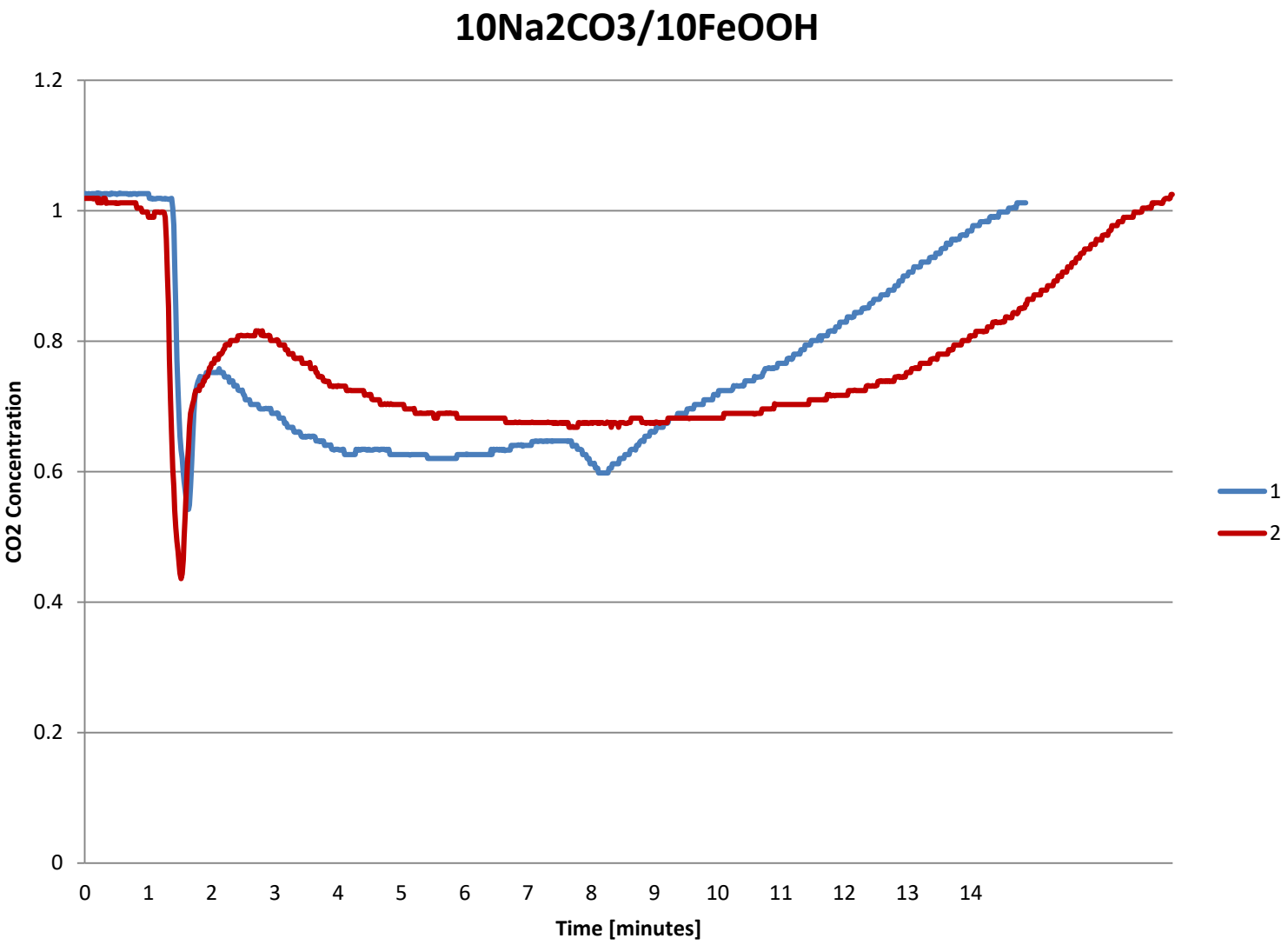
Results


5Na2CO3/10FeOOH
CO2 Concentration
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
Time [minutes]
1
2

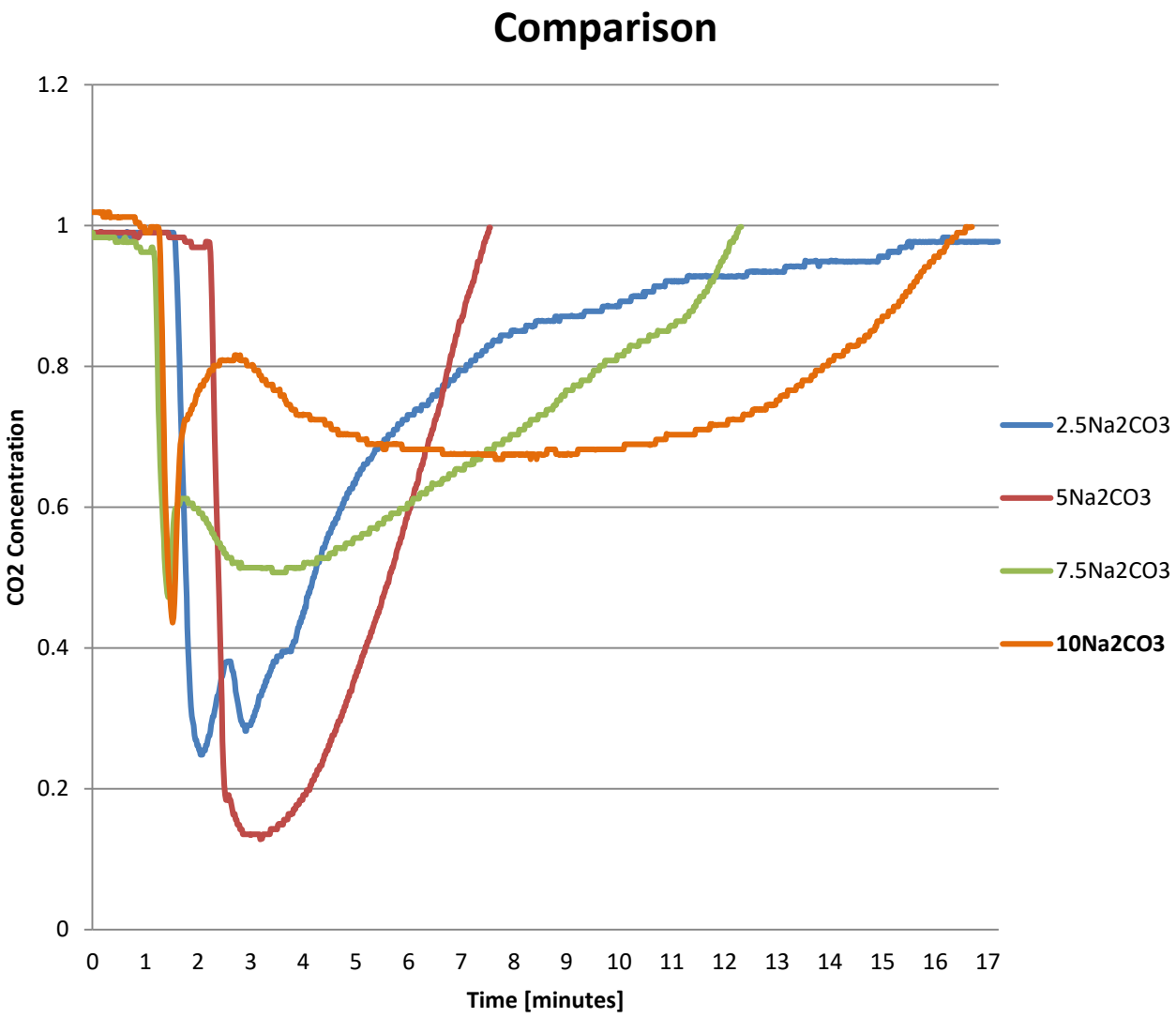
Results


10FeOOH/7.5Na2CO3
CO2 Concentration
Time [minutes]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1
2

Results


10Na2CO3/10FeOOH
CO2 Concentration
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Time [minutes]
1
2

Results


Comparison
1.2
1
0.8
0.6
0.4
0.2
0
CO2 Concentration
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Time [minutes]
2.5Na2CO3
5Na2CO3
7.5Na2CO3
10Na2CO3

Summary

- Based on the above graphs. I believe that the best sorbent choice would be 10Na_2CO_3/10FeOOH.
- This is because it has the largest surface area of Na_2CO_3 available for CO_2 adsorption on the supporting material.
- The adsorption curve also shows that it has the most holding capacity for CO_2.

Summary

- Based on the previously seen properties of Sodium Carbonate and Potassium Carbonate I believe that it would be about 3x more economical to use Sodium Carbonate over Potassium Carbonate for CO_2 removal.

Summary

	Na_2CO_3	K_2CO_3
Molecular Weight (g/mol)	105.9	138.2
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Limitations

- Only Na_2CO_3/FeOOH was synthesized in the lab.
- Due to time limitations a limited number of runs were conducted.
- Limited availability of equipment; not able to use an XRD to verify structure of sorbents.

Further Research

- Further research should be done to determine the exact kinetics of this sorption.
- Mass transfer calculations need to be done to determine the exact amount of CO_2 adsorbed onto the chosen alkali sorbent.
- K_2CO_3/FeOOH needs to be synthesized to in the same lab to compare these sorbents side by side.

Thank you to Professor Maohong Fan and the Chemical and Petroleum Engineering Department for their generous support.

Questions?

References

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