DOE-ARRA Geologic Sequestration Training and Research 2011 Yearly Review Meeting

Project DE-FE0001780
SO_2 Resistant, Immobilized Amine Sorbent for CO_2 Capture

University of Akron

Presenter: Chris Wilfong, Department of Chemical and Biomolecular Engineering

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Project Participants

- Principal investigator: Dr. Steven Chuang
- Graduate students: Chris Wilfong, Mathew Isenberg, Uma Tumuluri, Jak Tanthana

Introduction

- Project background
  - Flue gas contains10-15% CO_2 and 500-2000 ppm SO_2
  - Amine grafted sorbent technology for CO_2 capture
- Anticipated benefits
  - High CO_2 capture capacity and SO_2 resistance
  - High stability in flue gas environment
  - Low regeneration energy

Project Objectives

- Primary objective – sorbent development
  - Low cost
  - Greater than1.5 mmol CO_2/g_{sorb} adsorption capacity
  - Less than 10% degradation/100 cycles
  - SO_2 resistant
- Secondary Objectives
  - SO_2 capture
  - Long term sorbent stability, greater than100 cycles
  - Investigate scale-up issues

Project Funding

- Total Project Cost: $386,000
- DOE Share: $300,000
- Non-DOE Cost Share: $86,000
- Cost Share Provider: The University of Akron

Highlights of Project to Date

- Prepared and tested 21 SO_2 capture sorbents.
- Quantified and characterized adsorbed SO_2 with FTIR and MS.
- Determined that presence of SO_2 (i) reduced CO_2 capture about 66% and (ii) increased sorbent degradation about 16% .

Tasks – Overview

Task No.	Task Description	Task Duration	Task Funding
1	Project Management and Planning	12/01/2009 – 11/30/2012	$77,000
2	Preparation of Immobilized Amine Sorbents	3/01/2010 – 11/30/2011	$77,000
3	Determination of CO_2 and SO_2 Capture Capacity and Stability	3/01/2010– 9/30/2010	$77,000
4	Sorbent Characterization	9/01/2011 – 12/01/2011	$77,000
5	Fine-tuning the Sorbents	3/31/2012 – 12/01/2012	$77,000

Project Schedule

Project schedule

	2010				2011				2012			
Tasks	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**
1. Project management	←	—	—	—	—	—	—	—	—	—	—	→
2. Sorbent preparation		←	—	—	—	—	—	→				
3. CO_2 and SO_2 capture capacity and stability		←	—	—	—	—	—	—	—	—	→	
4. Sorbent characterization				←	—	—	—	→				
5. Fine-tuning the sorbent										←	—	→

Discussion – Task 2

- Title – Preparation of Immobilized Amine Sorbents
- Key subtask – find industrial scale chemical sources
- Responsible parties – Chris Wilfong
- Task status – 60% complete
- Major accomplishment –sorbent with greater than 1.5 mmol CO_2/g_{sorb} and less than 10% degradation for 100 cycles, and 0.34 mmol SO_2/g_{sorb}.
- Major problems – sorbent degradation, reproducibility

Sorbent preparation

Silica

A: Amine+enhancer/stabilizer
+immobilizer+ethanol

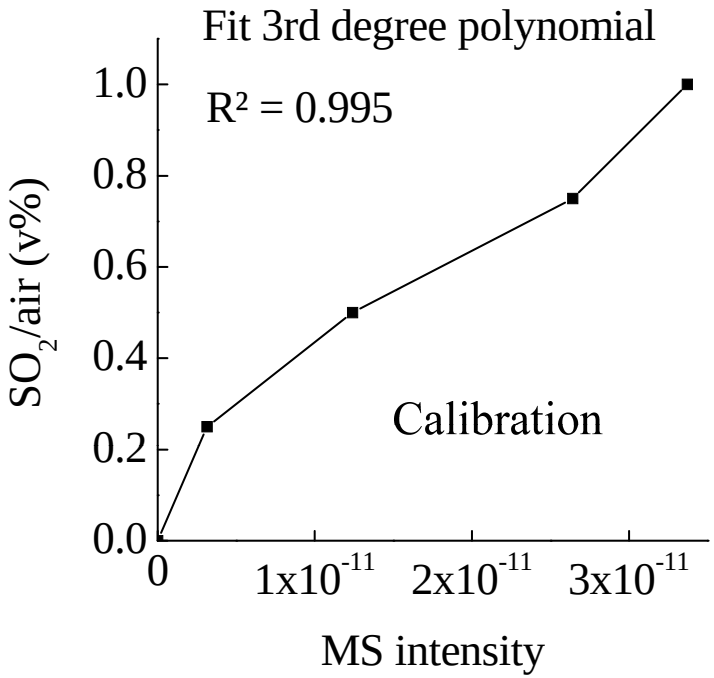
B: Additive+water

Dry

TPSENa, powder

Discussion – Task 3

- Title – Determination of CO_2 and SO_2 Capture Capacity and Stability.
- Key subtask – determine sensitivity of MS to SO_2
- Responsible parties – Mathew Isenberg, Uma Tumuluri, Jak Tanthana
- Task status – 40% complete
- Major accomplishment – increased SO_2 capture capacity of sorbent by 53% and reduced degradation by 17%
- Major problems – sorbent degradation



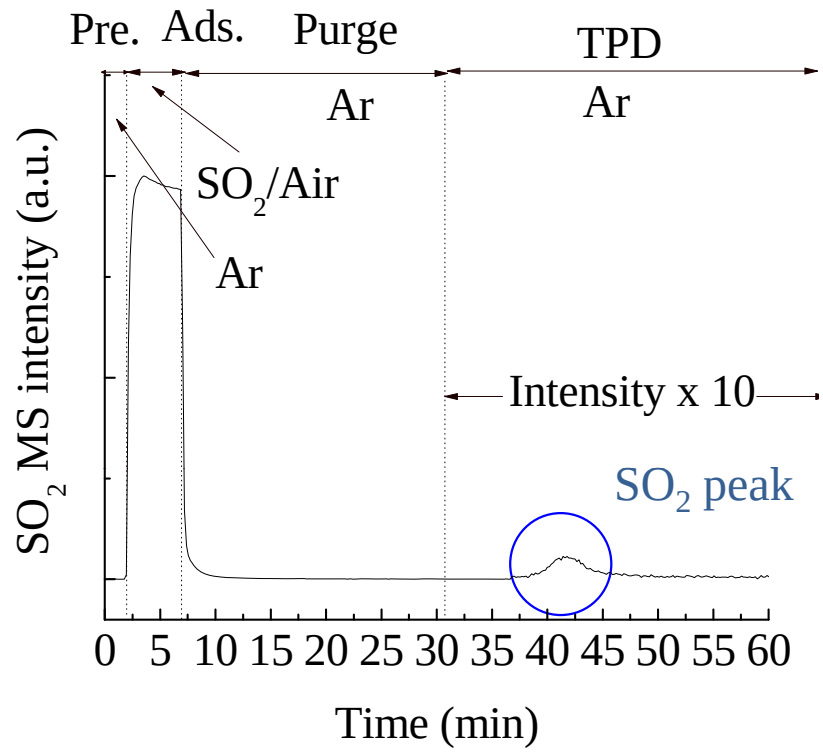


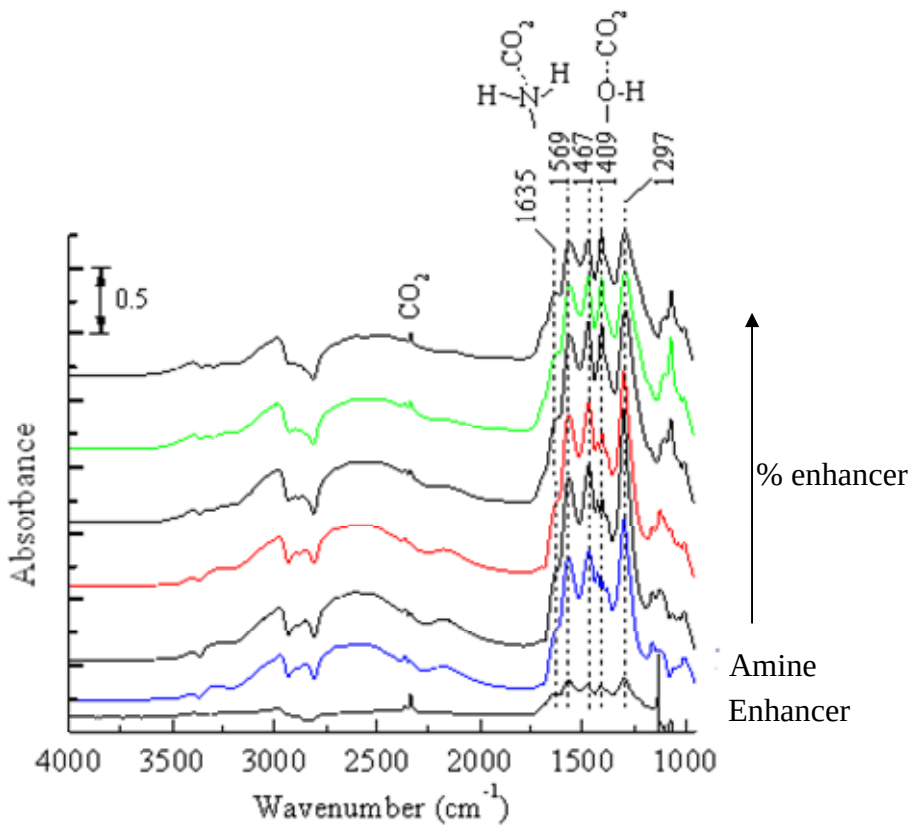
Table 1: CO_2 and SO_2 capture capcities and degradation of sorbents

* Based upon CO_2 capture

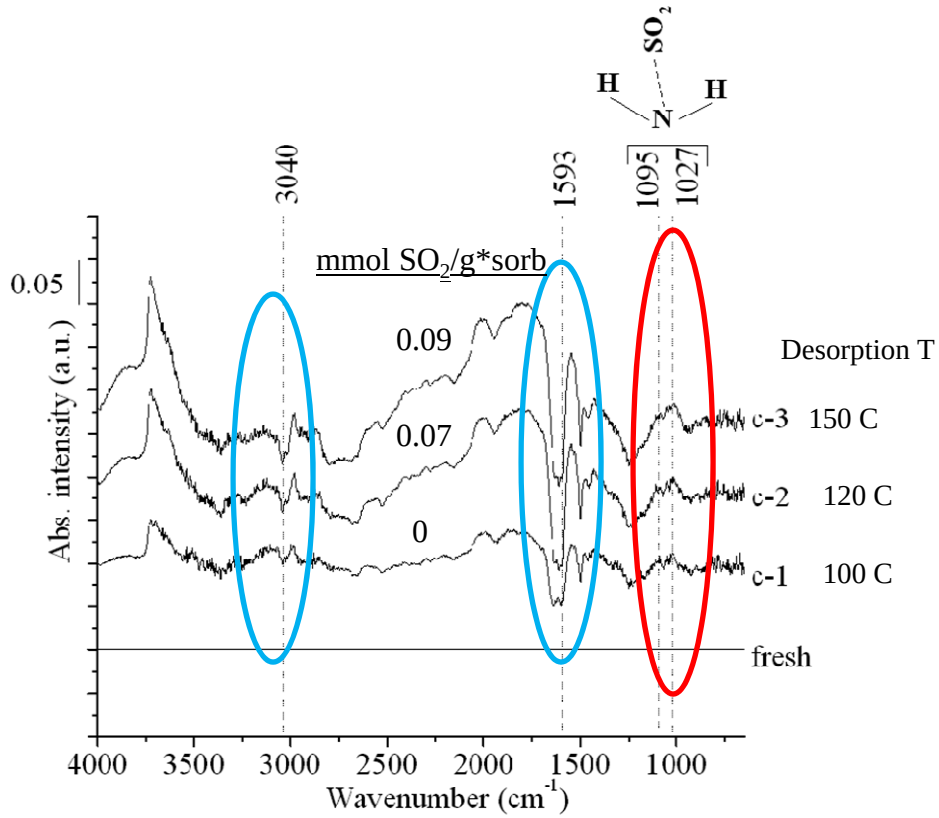
Sorbent	Cycle 1 (mmol-CO_2/g-sorb.)	Cycle 1 (mmol-SO_2/g-sorb.)	% Deg, SO_2 16 cycles
TPSENa>1.5 mmol/g /100 cycles	2.8	0.34	64
TPSENa+1% enhancer/stabilizer	To be determined	0.27	58
TPSENa+5% enhancer/stabilizer	To be determined	0.52	53
TPSENa+E+Na (No SO_2,)	2.2	To be determined	62 *
TPSENa+E+Na (500 ppm SO_2)	0.74	To be determined	72 *

Discussion – Task 4

- Title – Characterization
- Key subtask – identify adsorbed species via IR
- Responsible parties – Chris Wilfong, Uma Tumuluri, Jak Tanthana
- Task status – 40% complete
- Major accomplishment – determined causes of SO_2 sorbent degradation via IR
- Major problems – SO_2 desorption temperature causes amine degradation



CO_2 adsorption onto amine+enhancer/stabilizer film



After heating to desorb SO_2 from amine+enhancer/stabilizer sorbent

Table 2. IR band assignments for CO_2 and SO_2 capture.

Wavenumber (cm^{-1})	Assignment	Species
1569	C=N	adsorbed CO_2; amine
1409	C=O	adsorbed CO_2; additive
1027	S=O stretching	adsorbed SO_2; amine
1095	S=O stretching	adsorbed SO_2; amine
1593	Aromatic N-H bending	amine
3040	Aromatic C-H stretching	amine

Discussion – Task 5

- Title – Fine tune sorbent
- Responsible parties – Chris Wilfong, Mathew Isenberg, Uma Tumuluri
- Task status – 30% complete
- Major accomplishment – established combinatory technique
- Major problems – reproducibility

Fine tuning

- Prepare sorbents with different amines, enhancers/stabilizers, immobilizers, and antioxidants
- Conduct combinatory experiment with varying compositions of all species
- Conduct in-situ degradation experiments
- Test the effect of water on CO_2 and SO_2 capture

Project Milestones

Milestone	Planned Completion Date	Actual Completion Date
Project kick-off meeting	03/31/2010	03/31/2010
Educational program instituted	06/30/2010	06/30/2010
Semi-annual progress report	09/30/2010	09/30/2010
Yearly review meeting	03/31/2011	02/25/2011

Project Milestones-cont'd.

Milestone	Planned Completion Date	Actual Completion Date
Developed sorbent with >1.5 mmol CO_2/g_{sorb} with <10% degradation for 100 cycles, and 0.34 mmol SO_2/g_{sorb}.	03/31/2011	06/01/2010
Increased SO_2 capture capacity by 53% and reduced degradation by 11 percentage points	03/31/2011	02/01/2011
Determined causes of SO_2 sorbent degradation via FTIR	03/31/2011	02/05/2011
Tested >100 sorbent compositions for CO_2, and 21 for SO_2 composition	03/31/2011	02/20/2011

Anticipated Efforts for the Coming Year

- Optimize sorbent composition
- Long term stability testing with CO_2 and SO_2
- Determine the effect of water on SO_2 capture
- Characterize sorbent performance with IR, MS, and NMR.
- Kg-scale testing of new sorbents

Summary

- 42% overall project completion
- Achieved
  - Tested 21 SO_2 sorbents tested and >100 CO_2 sorbents
  - Quantified and characterized SO_2 adsorption
  - Determined effect of SO_2 on CO_2 capture
- Future work
  - Further optimize and test new sorbents
  - Kg-scale sorbent testing

PI Contact Information

- If you have any questions or would be interested in collaboration please contact
- chuang@uakron.edu

Thank you!

Questions?