Zeolite Degradation: An Investigation of CO_2 Capacity Loss of 13X Sorbent

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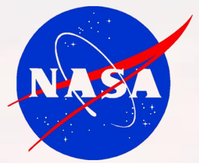
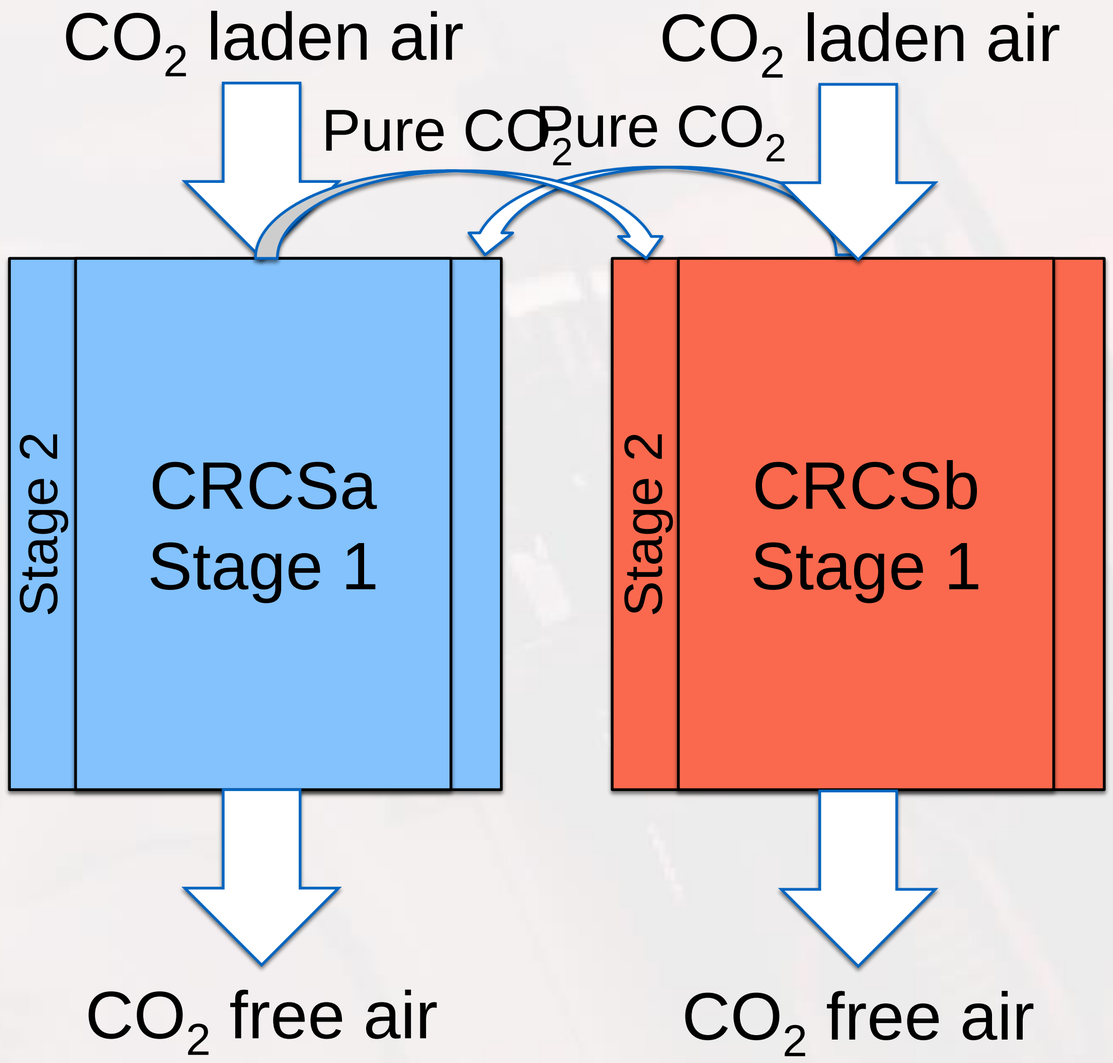


Outline

- Background
- Experimental Method
    - Suspected causes of degradation
- Results and Observations
- Future investigations

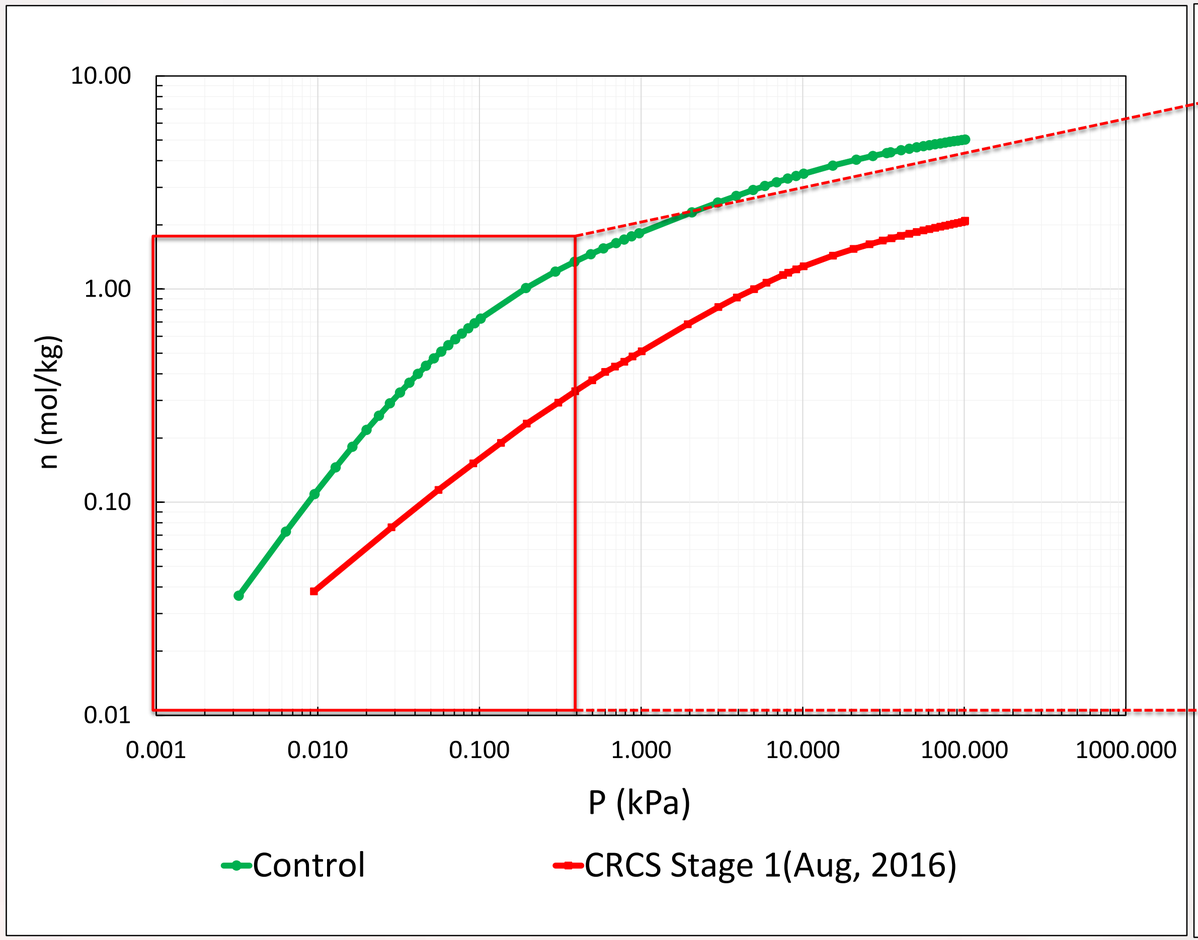
Background

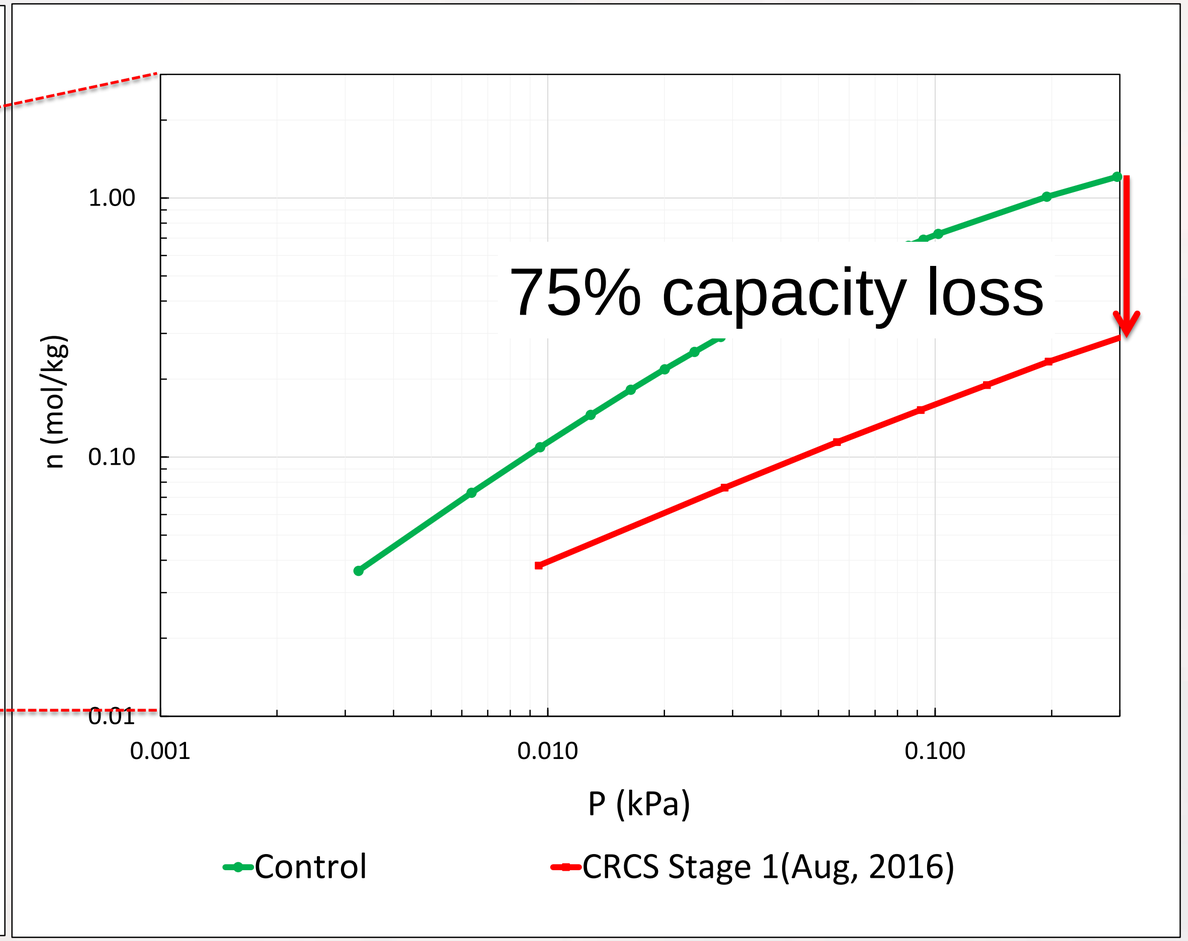
- Carbon Dioxide Removal and Compression System (CRCS)
  - 4-bed molecular sieve system
  - Temperature Swing Adsorption and Compression (TSAC)
  - Stage 1 CO_2 capture at 2600ppm
  - Stage 2 CO_2 storage and compression



Background

- CRCS Stage 1 early CO_2 breakthrough





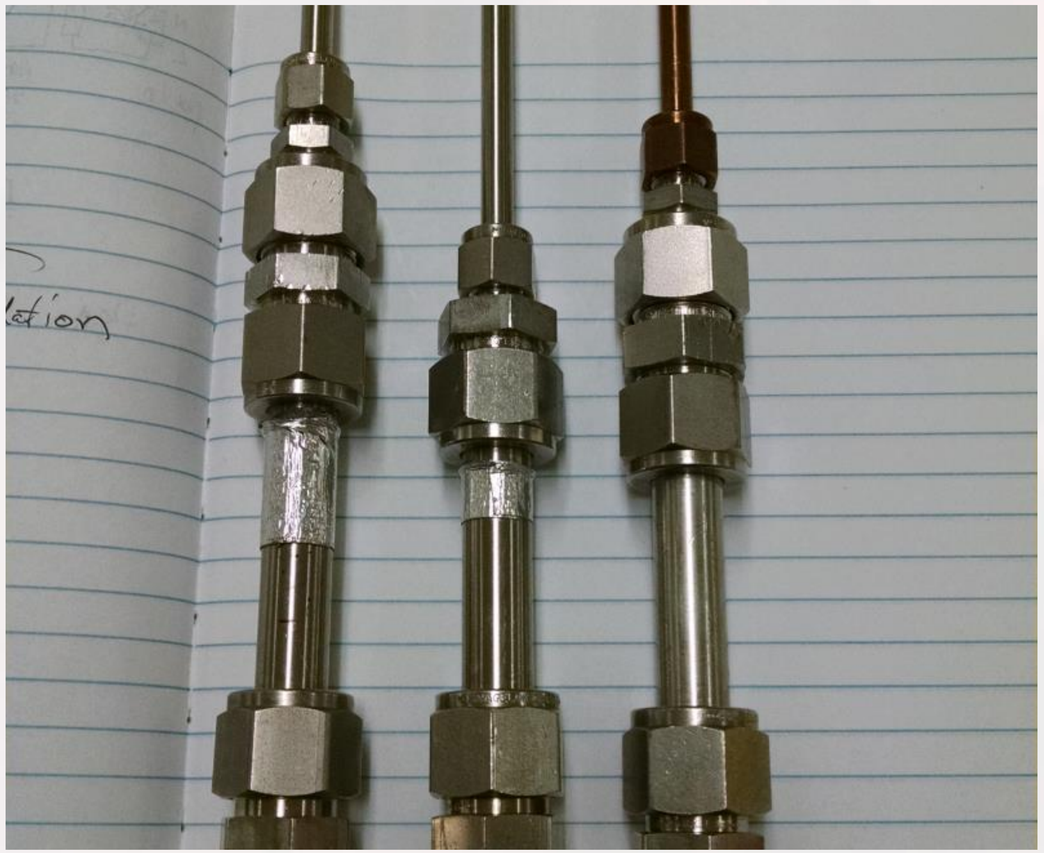
Suspected Causes of Degradation

- Chemical Degradation
  - Lab compressed air source (Pressure Swing Adsorptive (PSA) filtered)
  - Pump Oil
  - Vacuum o-ring greases
    - Krytox LVP, Krytox 240AC
- Physical Degradation
  - Rapid heating
  - Removal procedure via vacuuming

Experimental Cases

- Chemical Contamination
  - Lab compressed air
    - Sorbent loaded into ½” tube cell and exposed to 10SLPM of lab air source for 120 hours
  - Edwards Ultra Grade 19 pump oil
    - Sorbent loaded into ½” tube cell and ~10g of oil dripped into cell onto beads
  - Krytox LVP
    - ~5g of grease applied to inside of ½” tube cell and then loaded with sorbent
  - Krytox 240AC
    - ~5g of grease applied to inside of ½” tube cell and then loaded with sorbent

- All sample cells were then baked out for 16 hours at 280^0C to simulate CRCS bakeout



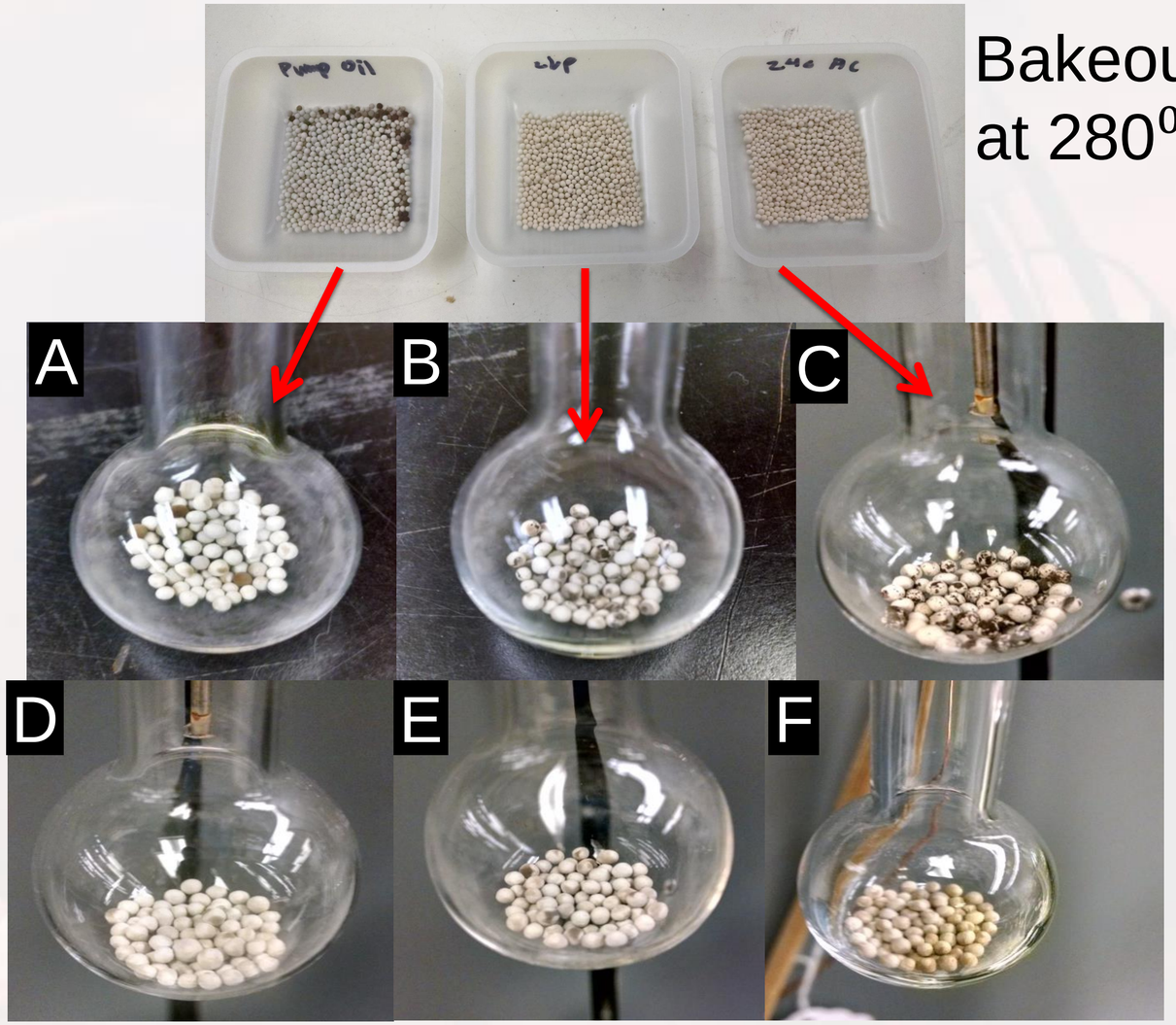
Experimental Cases

- Physical Degradation
  - Cyclic rapid heating (uncontrolled ramp rate)
  - Simulated loading/unloading procedure using vacuum flask

Chemical Contamination

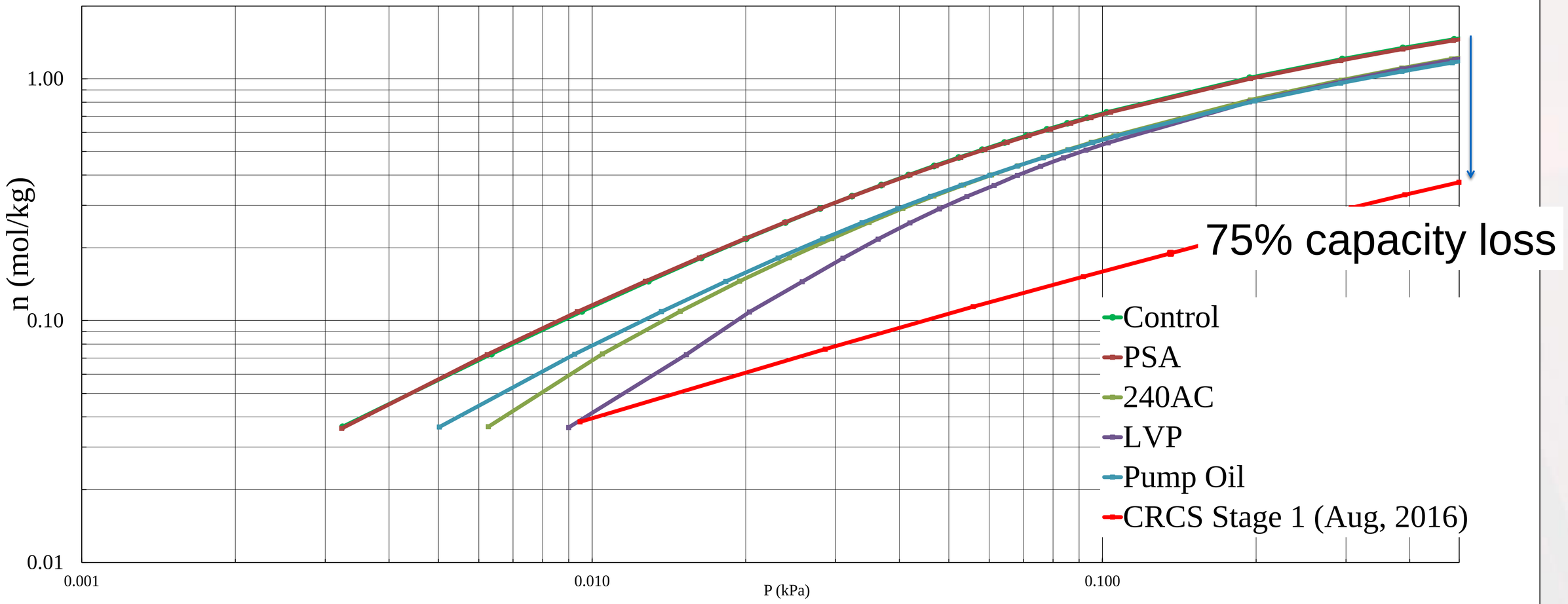
- After simulated system bakeout, all samples activated on ASAP 2020
- 350^{0}C activation temperature

A. Edwards Ultra 19 Pump Oil
B. Krytox LVP
C. Krytox 240 AC
D. Lab compressed air
E. Degraded CRCS Stage 1
F. Control



Bakeout at 280^{0}C

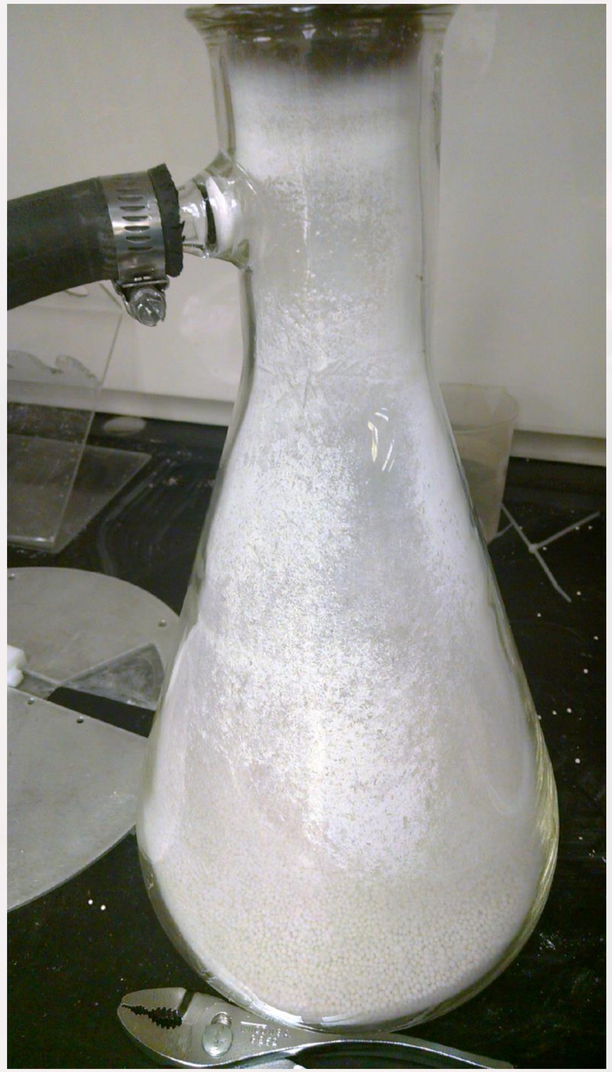
Chemical Contamination



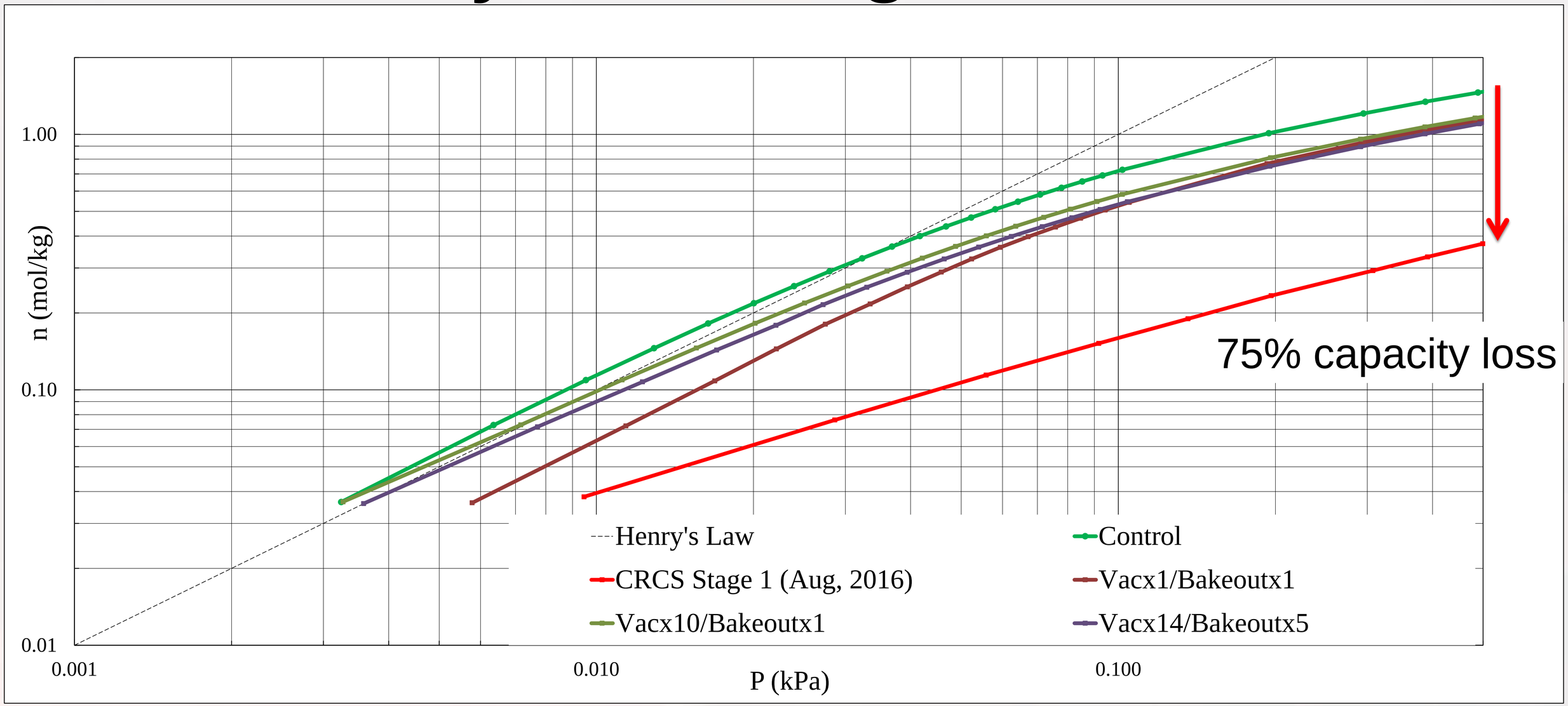
Physical Degradation

Table 1: Physical Degradation Test Matrix

Bakeouts \ Vacuums	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	x	x	x	x	x	x	x	x	x	x				
2											x			
3												x		
4													x	
5														x



Physical Degradation



Results

- **Chemical Degradation**
  - After activation at 350^{0}C, Krytox LVP and 240AC samples exhibited dark speckling
  - Pump Oil contaminated sample also showed color differences
  - PSA shows no detectable degradation
  - None of the contaminated samples showed the type of capacity loss seen by the CRCS Stage 1 sample

- **Physical Degradation**
  - Three analyzed cases of vacuum/bakeout cycling
  - None show the type of capacity loss seen by the CRCS Stage 1

Other considerations

- Possible that a slug discharge of hydrocarbons through the PSA beds during time of CRCS testing contaminated the sorbent
- Micropore structure degradation due to prolonged activation in a humid environment

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