THE DEVELOPMENT OF NOVEL ACTIVATED CARBON COMPOSITES

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THE DEVELOPMENT OF NOVEL ACTIVATED CARBON COMPOSITES

Overview

- CFCMS Manufacture
- CFCMS Characterization
  - SEM & TEM
  - N_2 Adsorption @ 77K
  - SANS/In-Situ Adsorption Experiment
- Single Gas Adsorption Studies (N_2 and CO_2)
- Dynamic CO_2 Separation Studies
- Summary & Conclusions

THE DEVELOPMENT OF NOVEL ACTIVATED CARBON COMPOSITES

MANUFACTURE AND CHARACTERIZATION

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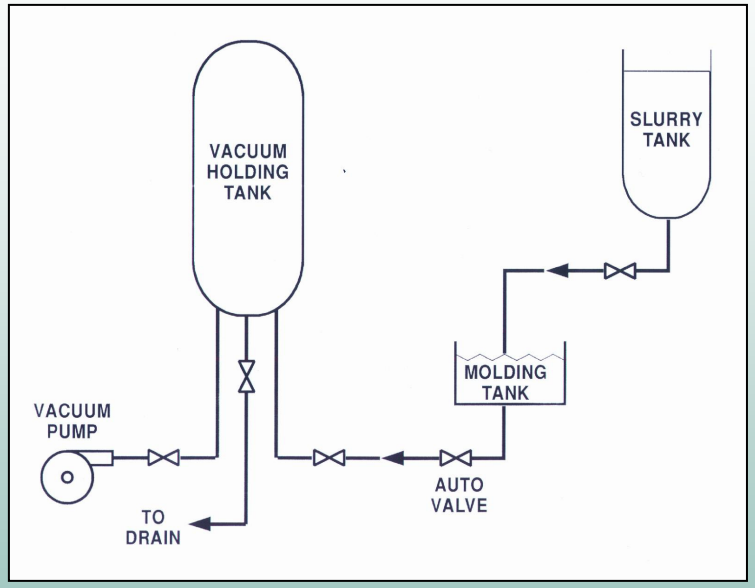
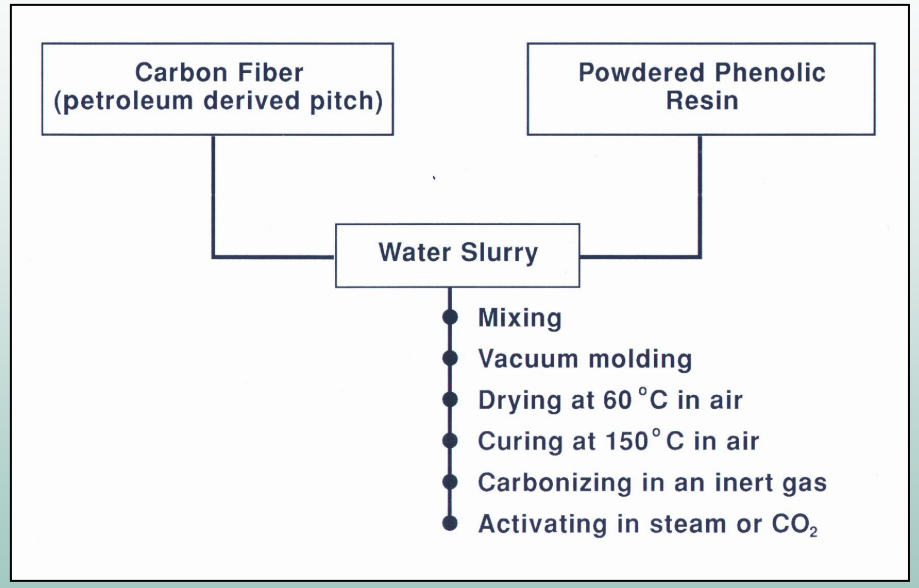
Fabrication is by a Slurry Molding Process

- Isotropic pitch-derived carbon fibers are suspended in water
- Powdered phenolic resin added to form bonding phase
- Product-shaped vacuum filter used to create preform
- Preform is dried, cured, and carbonized to convert resin to a carbon and to bond the fibers



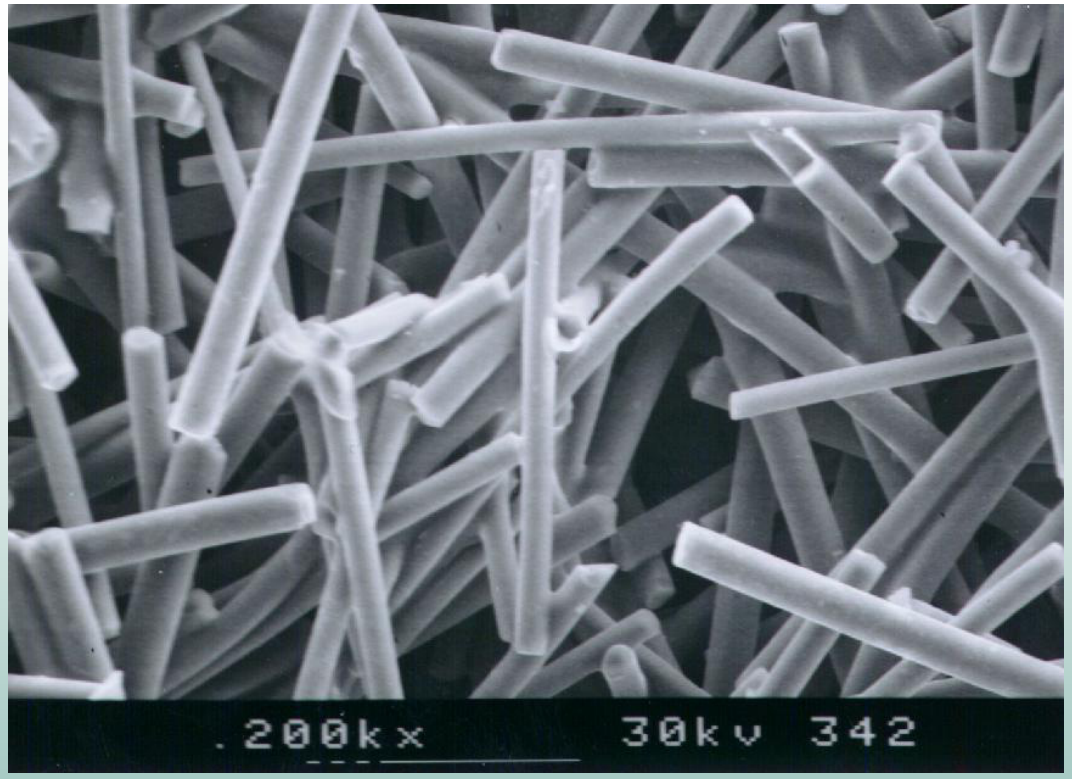
Schematic Diagram of CFCMS Slurry Molding Apparatus



CFCMS Synthesis Route

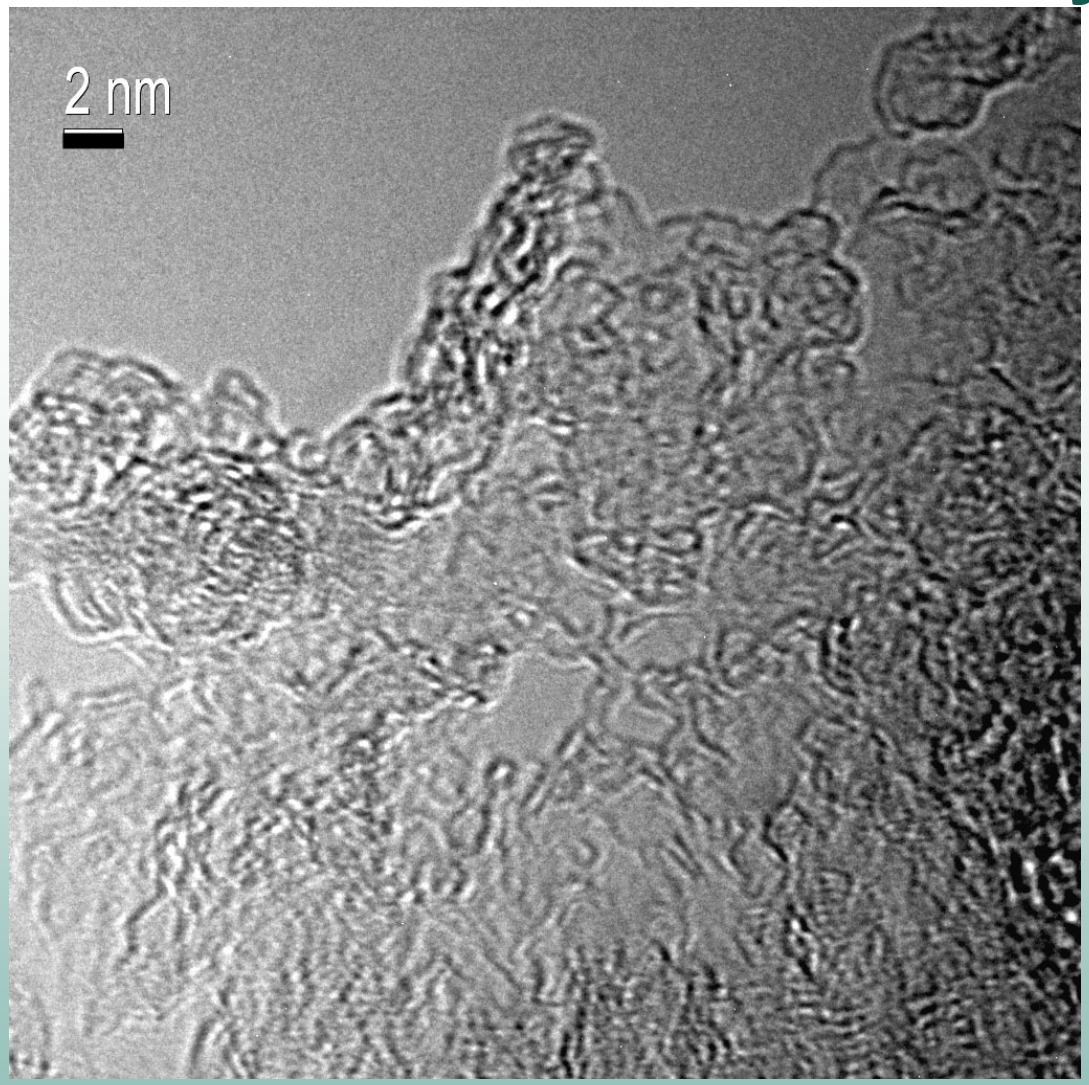
CARBON FIBER COMPOSITE MOLECULAR SIEVE

Monolith Structure



- OPEN STRUCTURE, BUT HIGHLY MICROPOROUS
- RIGID, STRONG, MONOLITHIC
- KINETIC ADVANTAGE DUE TO SMALL FIBER DIAMETER (8-16 μm)
- OVERCOMES PROBLEMS OF GRANULAR ADSORBENTS
- ELECTRICALLY CONDUCTIVE

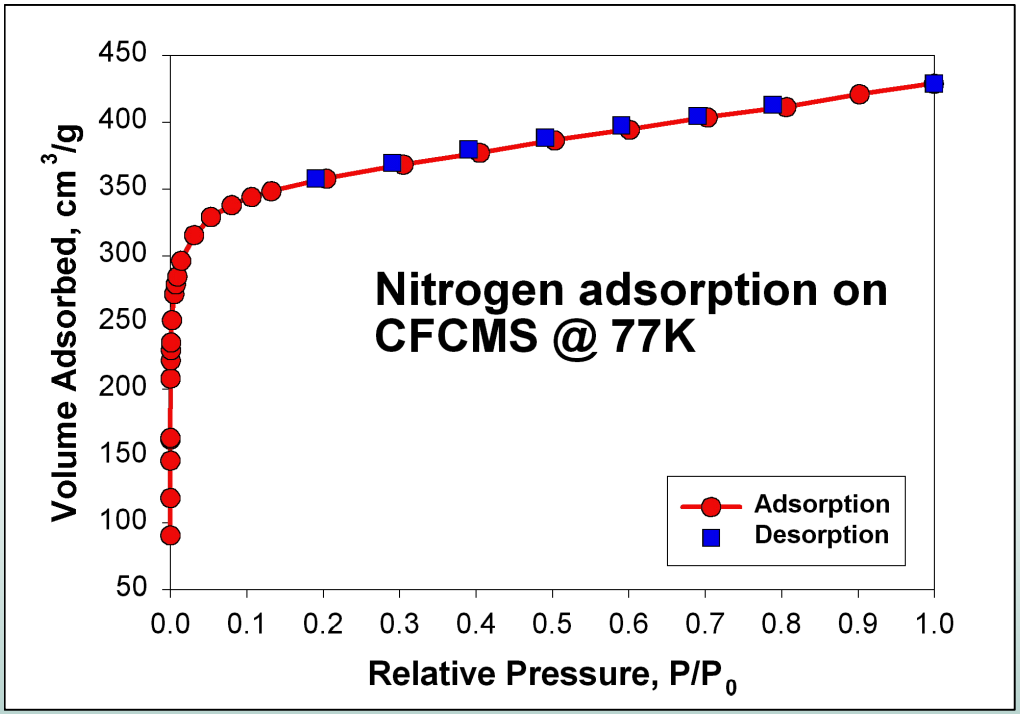
Microstructure of Activated Carbon Composite: TEM Study



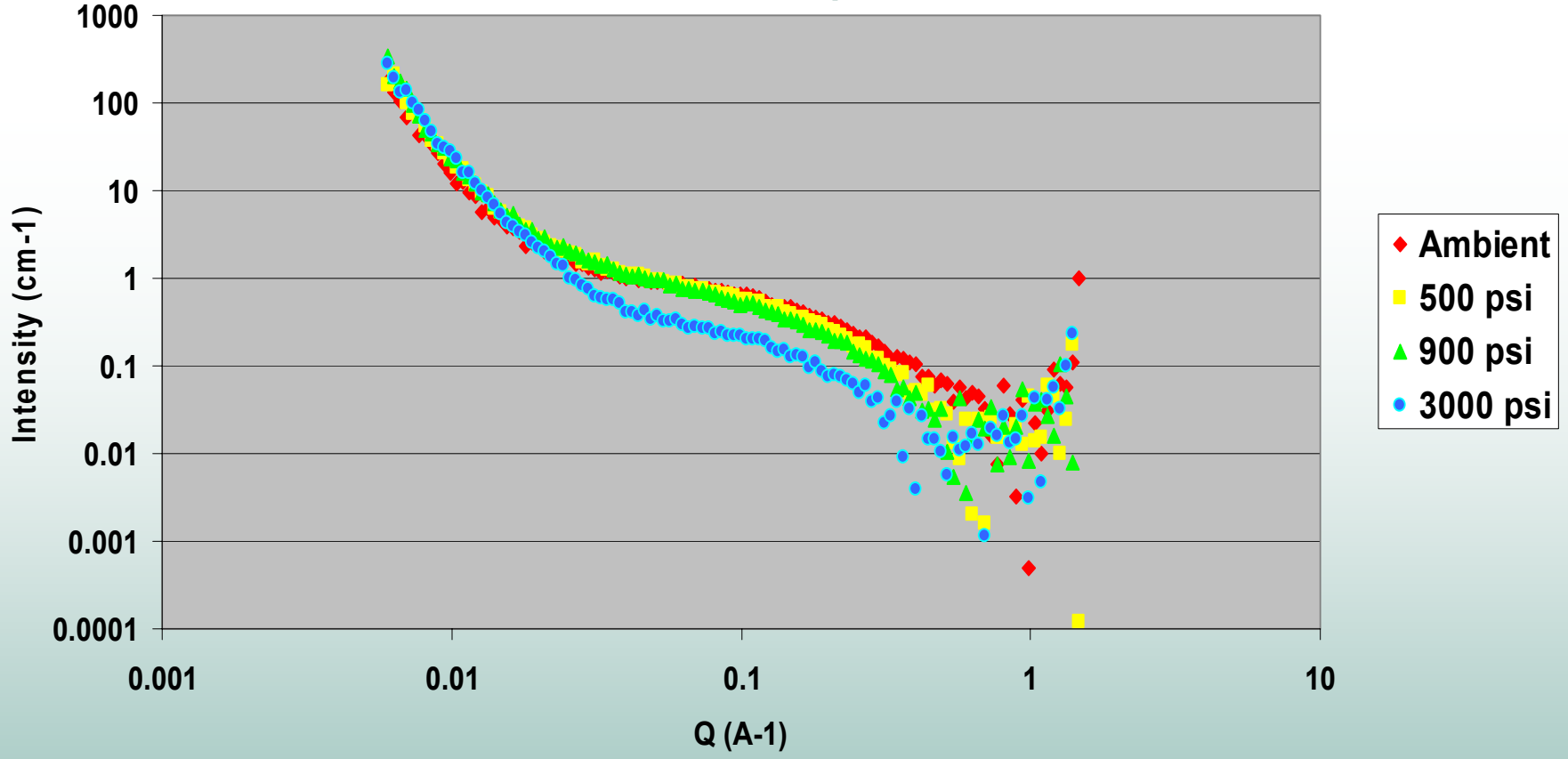
- Graphene layers are distinguishable
- Amorphous structure
- Micropores visible (< 2.0 nm)
- Pore shape is non-spherical
- Micropores are not slit shaped

CFCMS Is Highly Microporous

- Type I isotherm indicative of a microporous carbon
- Large BET surface area, can be > 2500 m^2/g
- Large micropore volume, 0.1 – 1.0 cm^3/g
- Mean micropore size, BET area, and MPV controlled through degree of activation



High-Pressure SANS on Activated Carbon Composite with CD_4



- Low pressure filling occurs in micropore region
- High pressure filling extends to mesopore region

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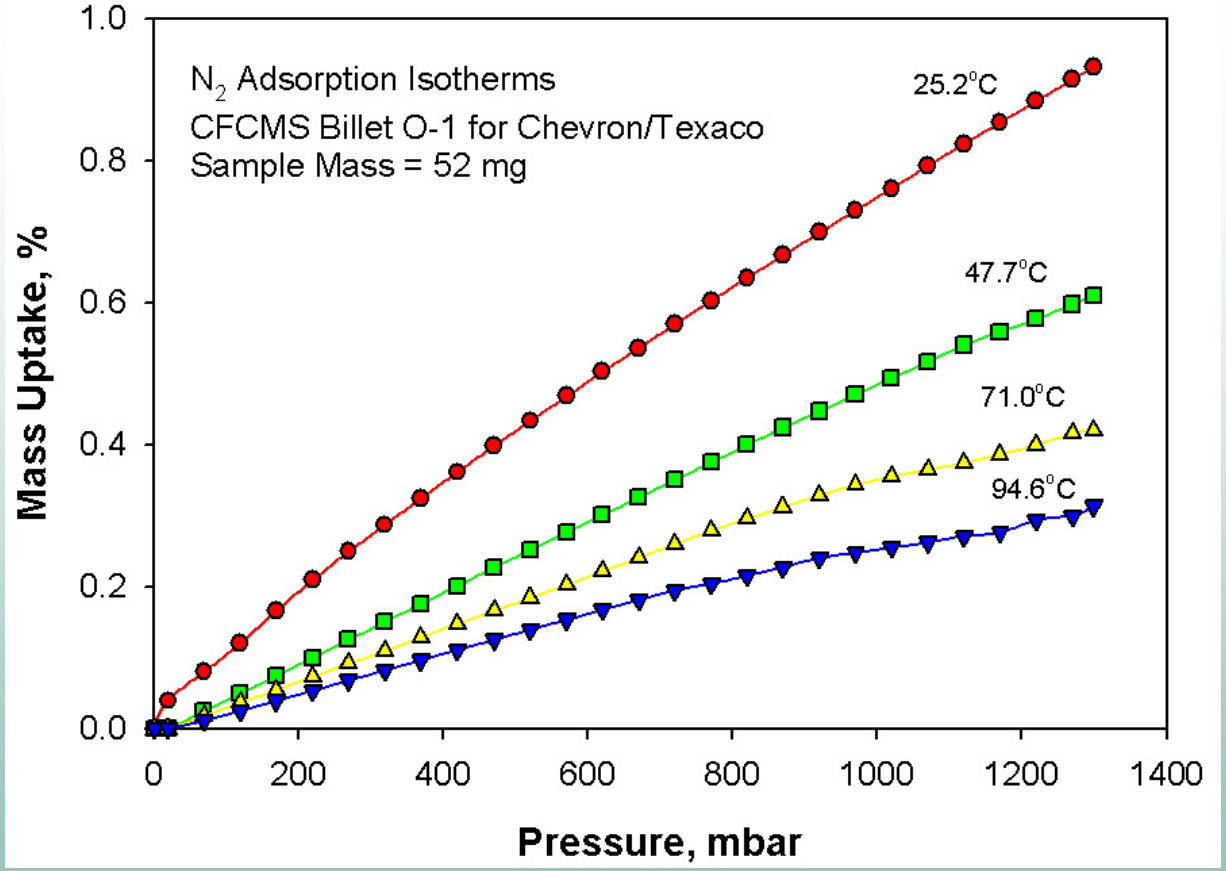
SINGLE GAS ADSORPTION STUDIES

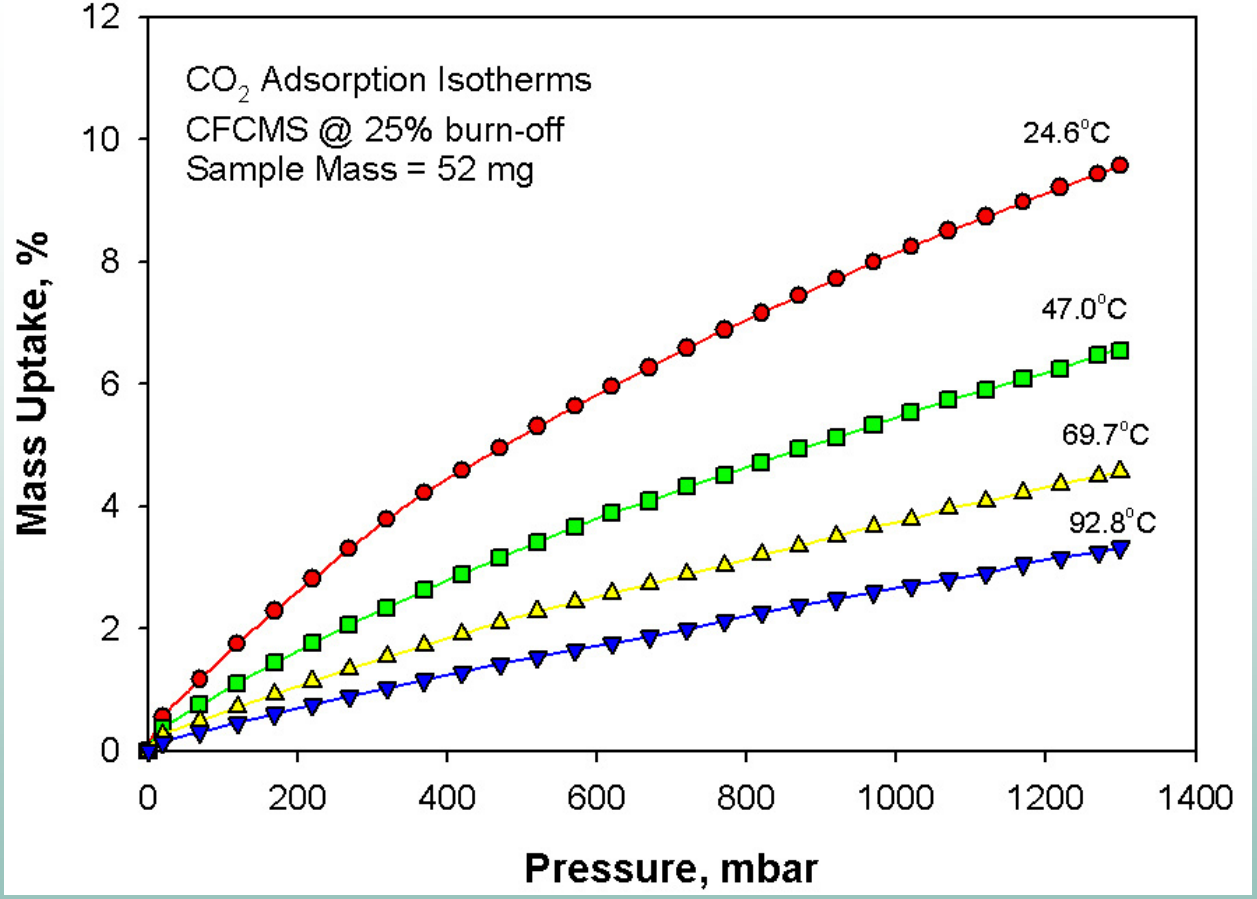
N_2 CAPACITY DETERMINATION

N_2 ADSORPTION ISOTHERMS (0-1300 mb) FOR SAMPLE OF CFCMS @ 25% BURN-OFF

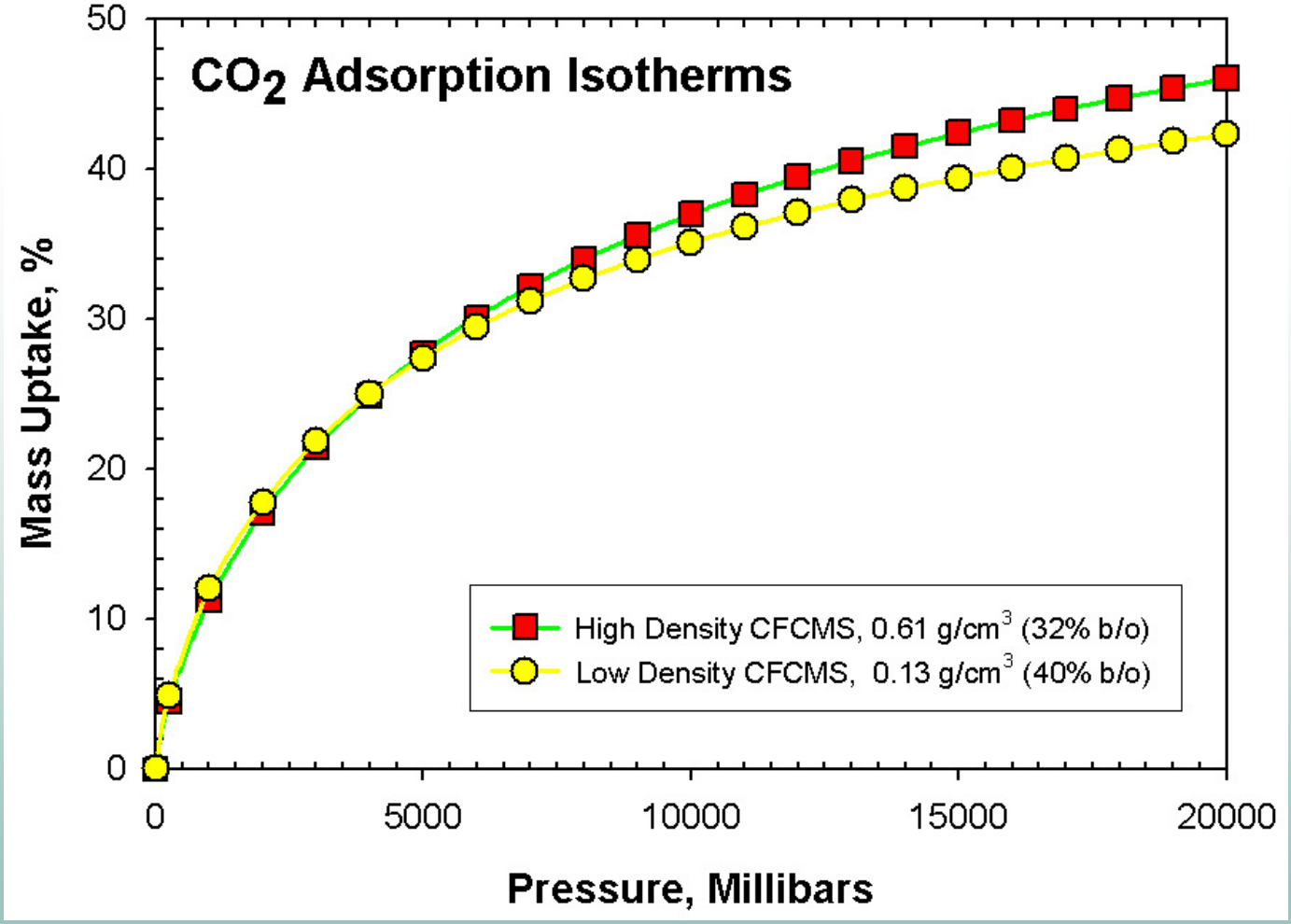


CO_2 CAPACITY DETERMINATION

CO_2 ADSORPTION ISOTHERMS (0-1300 mb) FOR SAMPLE OF CFCMS @ 25% BURN-OFF



High Pressure CO_2 Isotherms



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DYNAMIC CO_2 SEPARATION STUDIES

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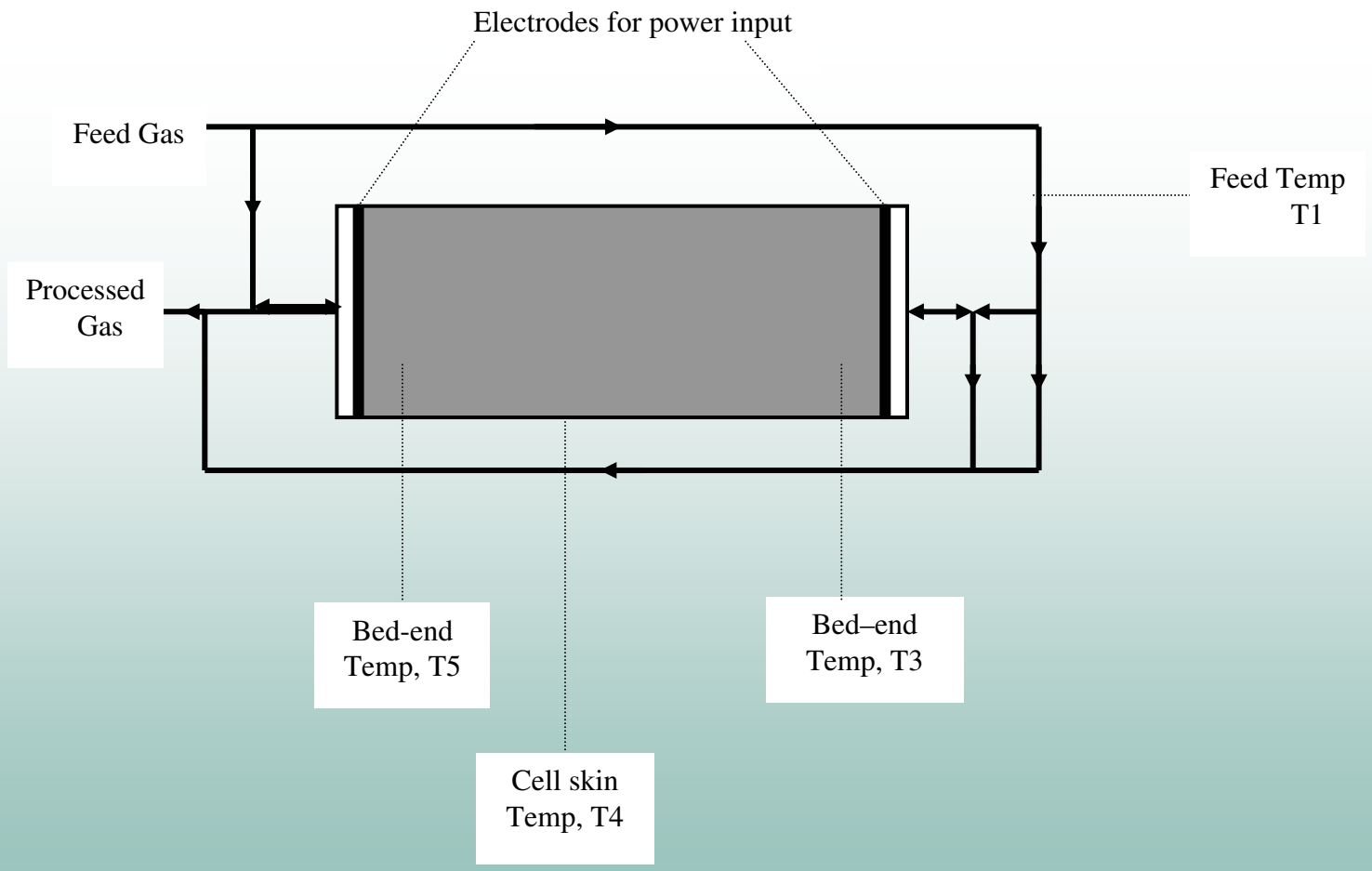
Dynamic CO_2 Separation Experiments

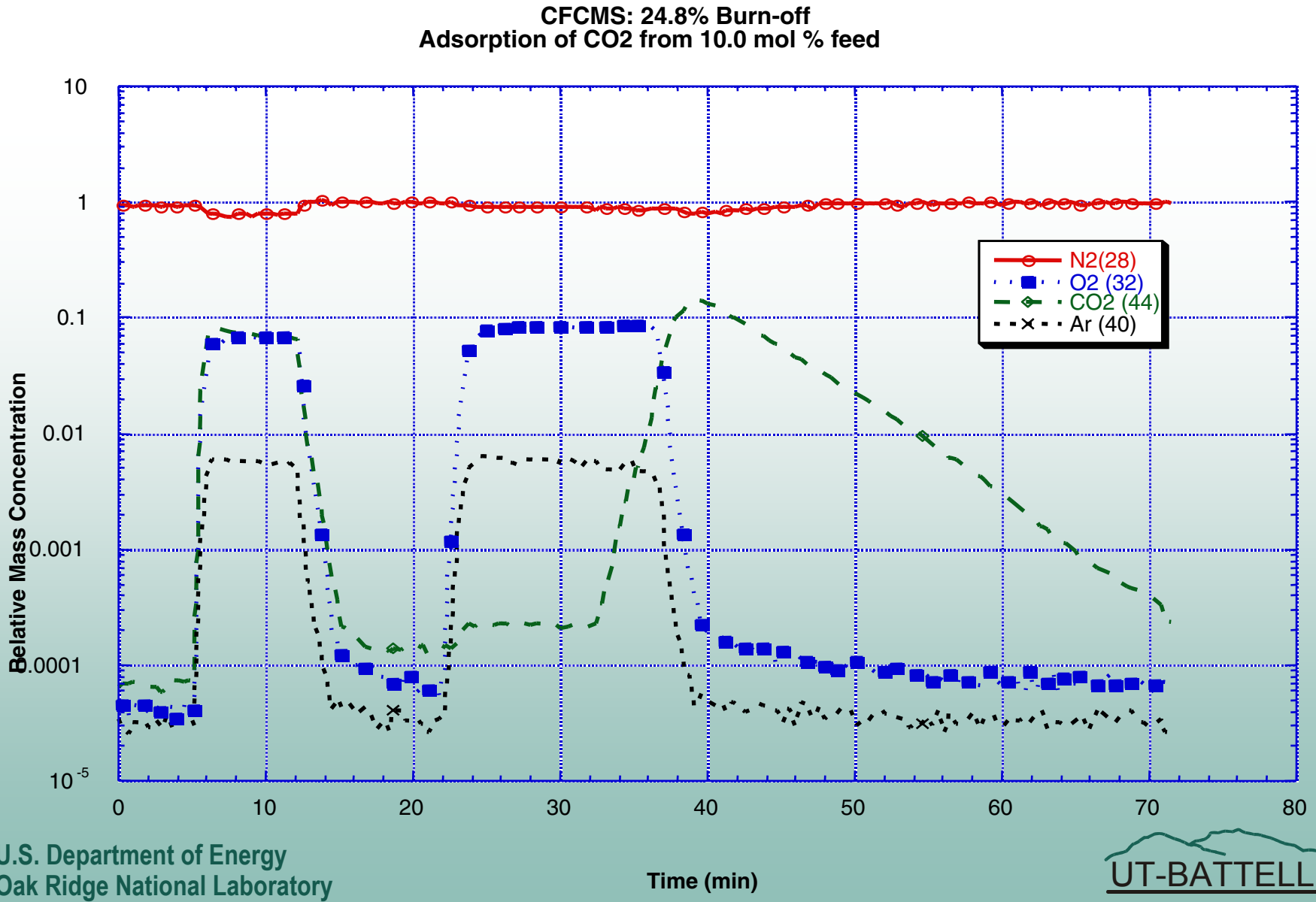
- Dynamic CO_2 adsorption/separation experiments were conducted at ambient temperature and pressure with dry gasses
- Flow rate was 2L/min
- Air (380 ppm)
- 3 mol % CO_2 in N_2
- 10 mol % CO_2 in N_2/O_2
- 19 mol % CO_2 in N_2
- Pure CO_2

CFCMS/ESA CELL

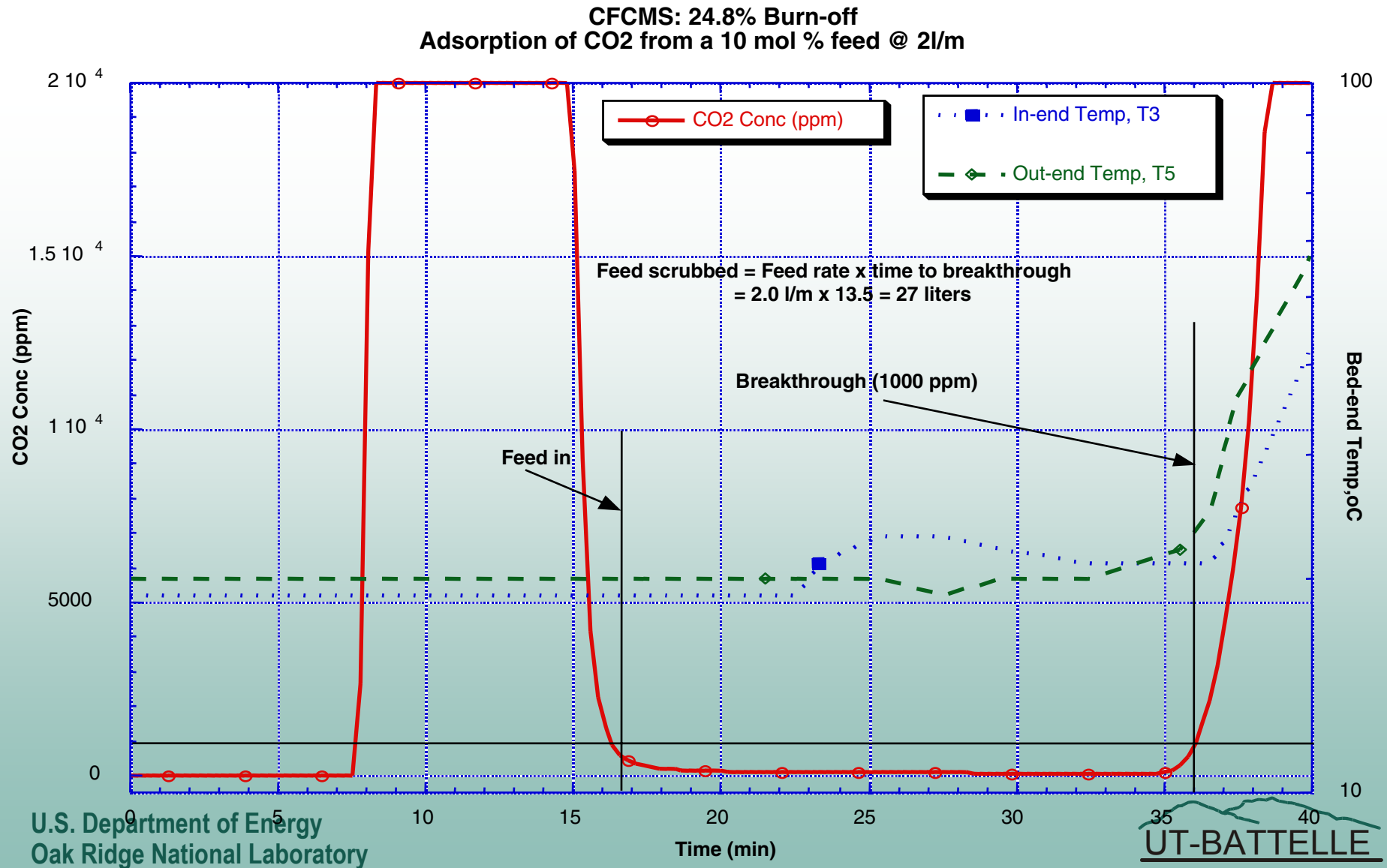
Schematic of the CFCMS Cell Set-up



10% CO_2 Adsorption - RGA-80



10% CO_2 Adsorption



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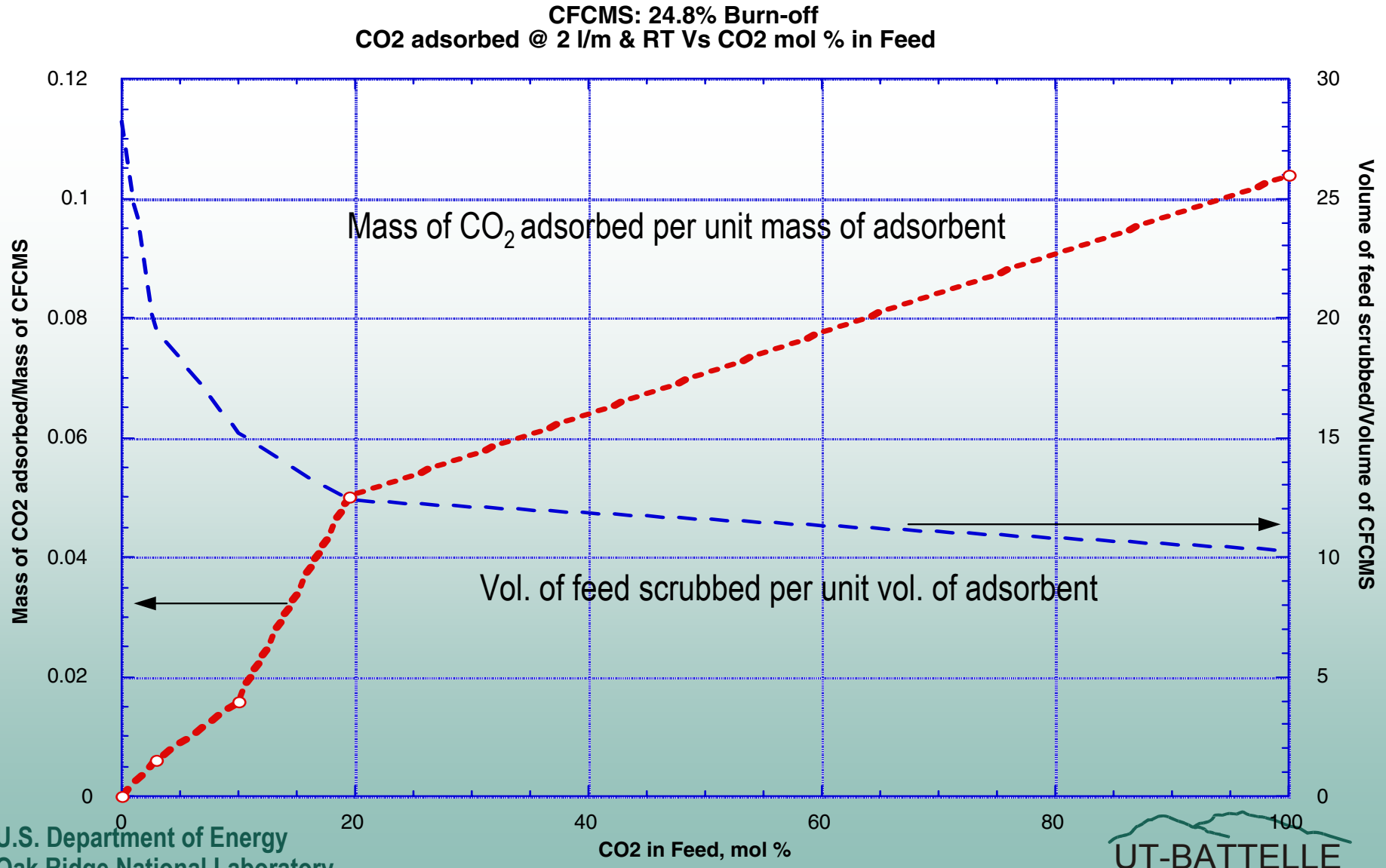
CO_2 adsorbed Vs CO_2 conc. in feed



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CFCMS/ESA can be Applied to Numerous Important Gas Separations

- Removal of contaminant and diluent gases (e.g., H_2S and CO_2) from natural gas
- Hydrogen separation and purification
- Removal of CO and CO_2 from reformate and syngas
- Removal of CO_2 from turbine exhaust streams
- Air separation (separation of oxygen and nitrogen)
- Removal of sulfur compound odorants from natural gas

SUMMARY & CONCLUSIONS

- ORNL HAS DEVELOPED A NOVEL MONOLITHIC ADSORBENT CARBON COMPOSITE MATERIAL CALLED CFCMS
- THE MATERIAL HAS AN OPEN STRUCTURE AND IS PERMEABLE, YET IS REASONABLY STRONG
- WHEN ACTIVATED THE CARBON FIBERS BECOME HIGHLY MICROPOROUS
- ADSORPTION IS ASSOCIATED WITH THE MICROPORES
- CFCMS HAS A STRONG AFFINITY FOR CO_2 ADSORPTION OVER N_2
- THE AMOUNT OF CO_2 ADSORBED INCREASES AS THE CO_2 CONCENTRATION INCREASES IN THE FEED GAS
- WE HAVE DEMONSTRATED THE REMOVAL OF CO_2 FROM AIR (~350 PPM), TURBINE EXHAUST (3-9 % CO_2) AND REFORMATE STREAMS (19-30% CO_2)
- CO-ADSORPTION OF WATER WAS OBSERVED TO BE MINIMAL