VALUE-ADDED PRODUCTS FROM FGD SULFITE-RICH SCRUBBER MATERIALS

Vivak Malhotra
Gediminas Markevicius (Ph.D. Student)
Sean Jones (Undergraduate)
Scott Myers (Undergraduate)
Project Manager (NETL): Chuck Miller

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In-kind cost share provided by two power plants burning high sulfur Midwestern bituminous coal

WET FGD SCRUBBER MATERIALS

(data from ACAA CCP 2005 survey)

FGD Wet Scrubber Materials

Sulfate-Rich ($CaSO_4.2H_2O$)

11.975 million tons per year

Currently 9.268 million tons utilized
(mostly in wallboard production,
~ 8.178 million tons)

2.707 million tons must landfilled

Sulfite-rich ($CaSO_3.nH_2O$)

17.700 million tons per year

Currently 0.700 million tons utilized
(mostly in mining, agriculture, roads etc.)

17.00 million tons must landfilled

Enhancing the Utilization of FGD SCRUBBER MATERIALS: Our Approach

HYBRID-MATERIALS

Structural Materials

STARTING MATERIALS:
FGD Gypsum
Natural Byproducts

PRODUCTS:
Structural: Paperless Drywall
Countertops
Decorative Tiles

FATE OF MERCURY

Concentration of Hg:
Variables: Week to Week
Scrubber Water
Limestone

How Product Manufacturing Affects Hg Concentration

MATERIALS FROM SULFITE-RICH SCRUBBER

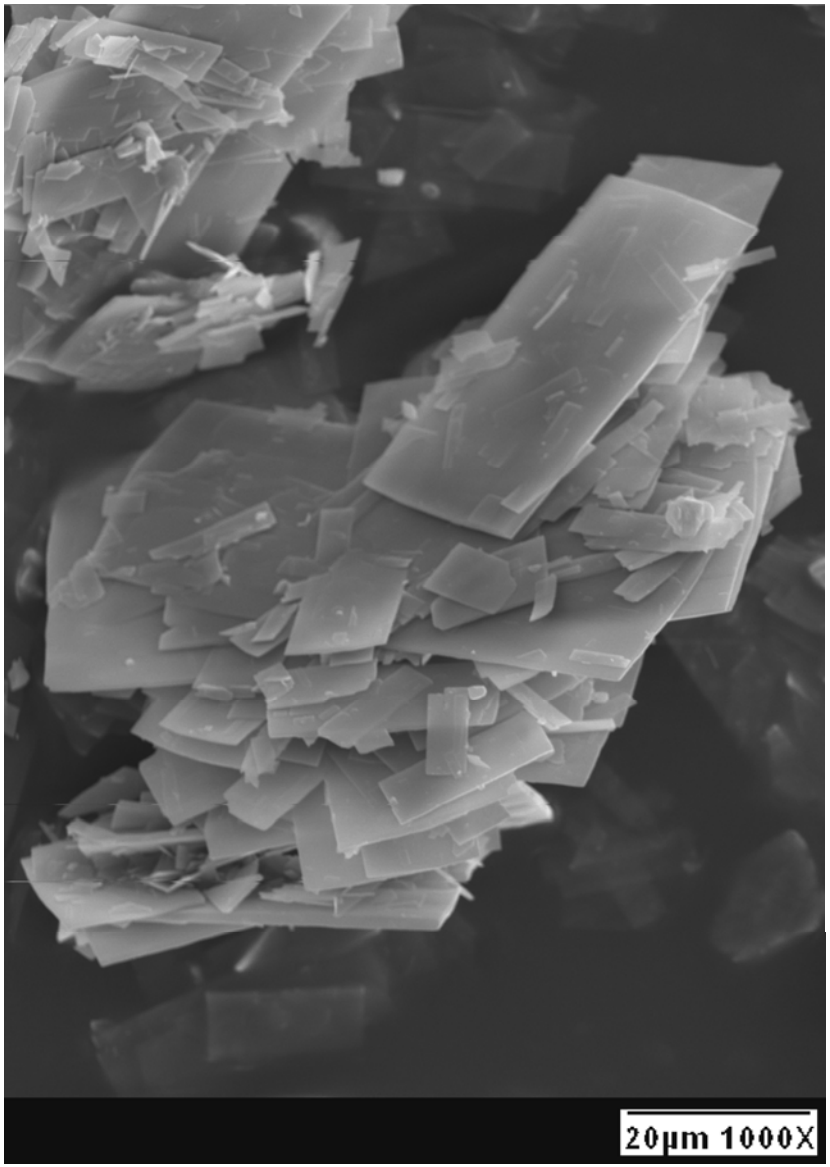
STARTING MATERIALS:
FGD Sulfite-rich Scrubber Material
Natural Byproducts,
Clay Byproducts
Polymers

PRODUCTS:
Wood: Plywood, OSB
Lumber, Metal Molds
Advanced: Automobiles
Interior and Exterior Parts
(Nanotechnology)

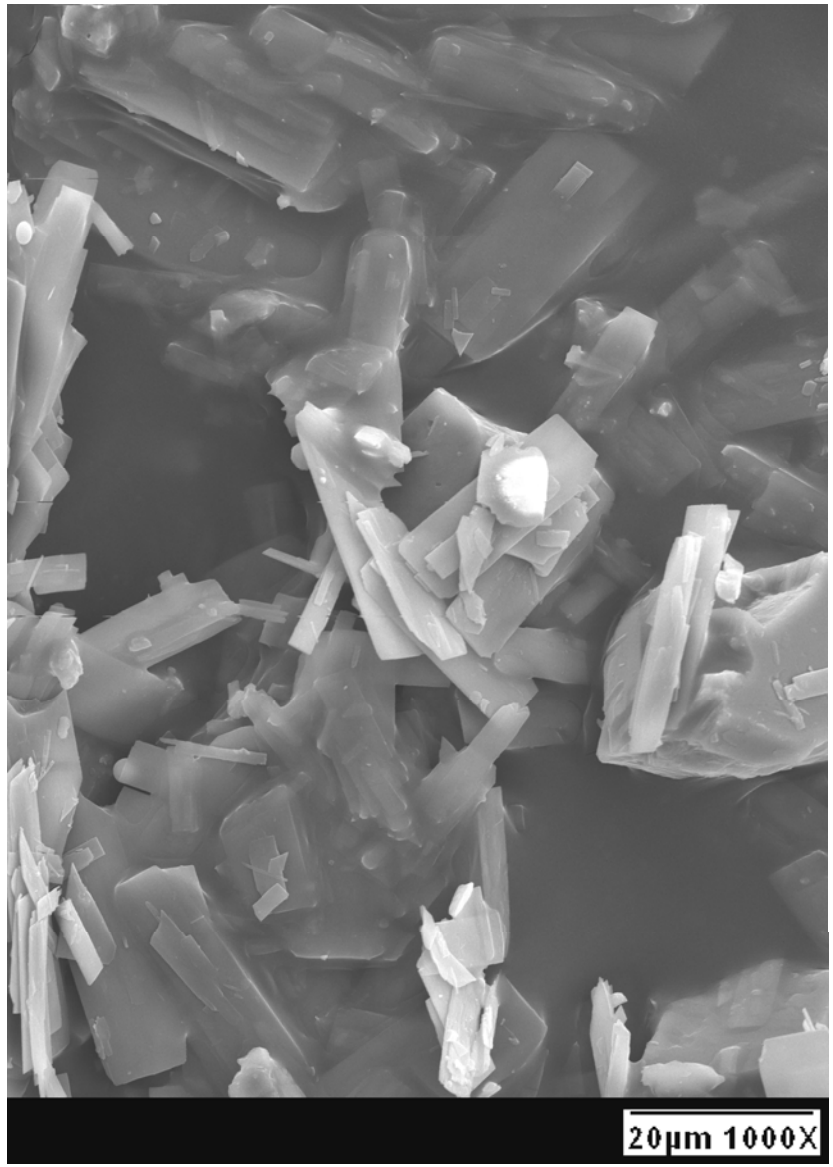
OVERALL GOALS

- Thoroughly characterize, both physically and chemically, the sulfite-rich scrubber materials
- Establish the chemical and physical stability of our raw materials under product manufacturing conditions
- Optimize the fabrication conditions for the development of wood substitute composites
- Generate manufacturing parameters needed for upscaling to a pilot-scale product manufacturing
- Subject the products developed to rigorous performance evaluations

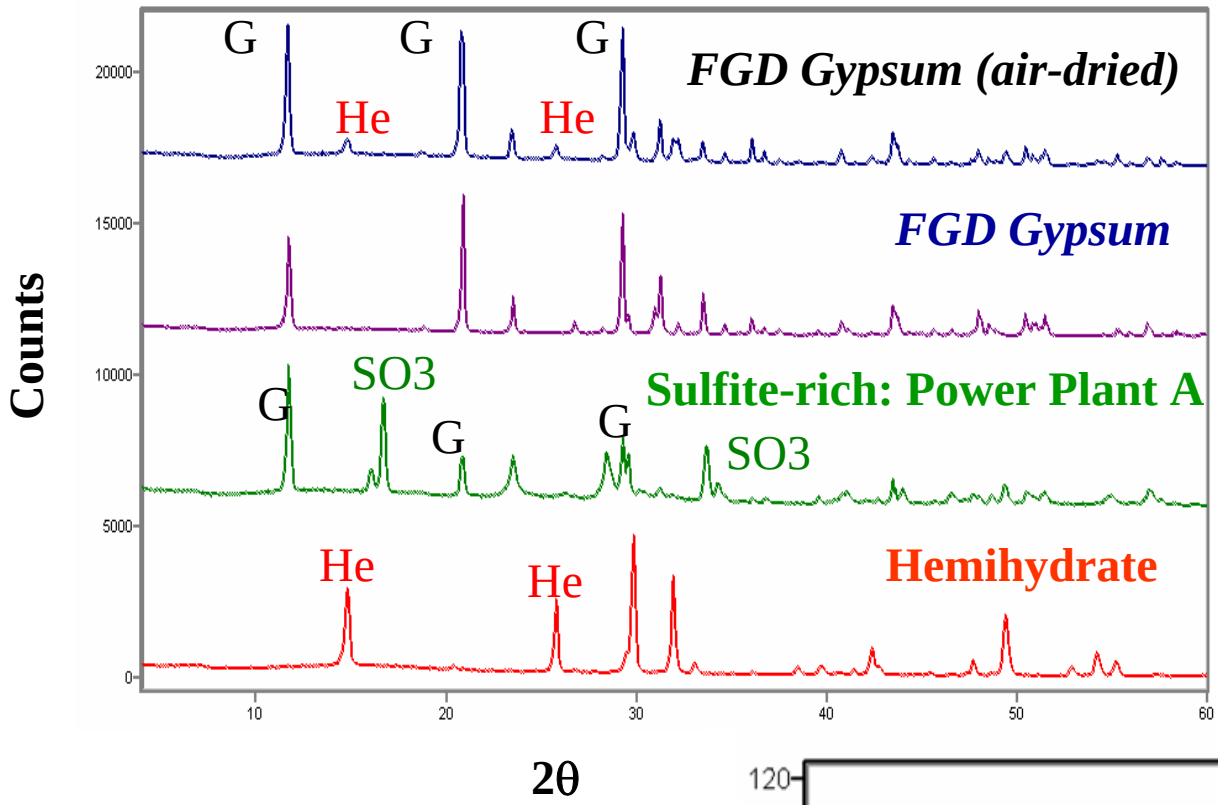
Scanning Electron Microscopy (Physical Structure)



Power Plant A

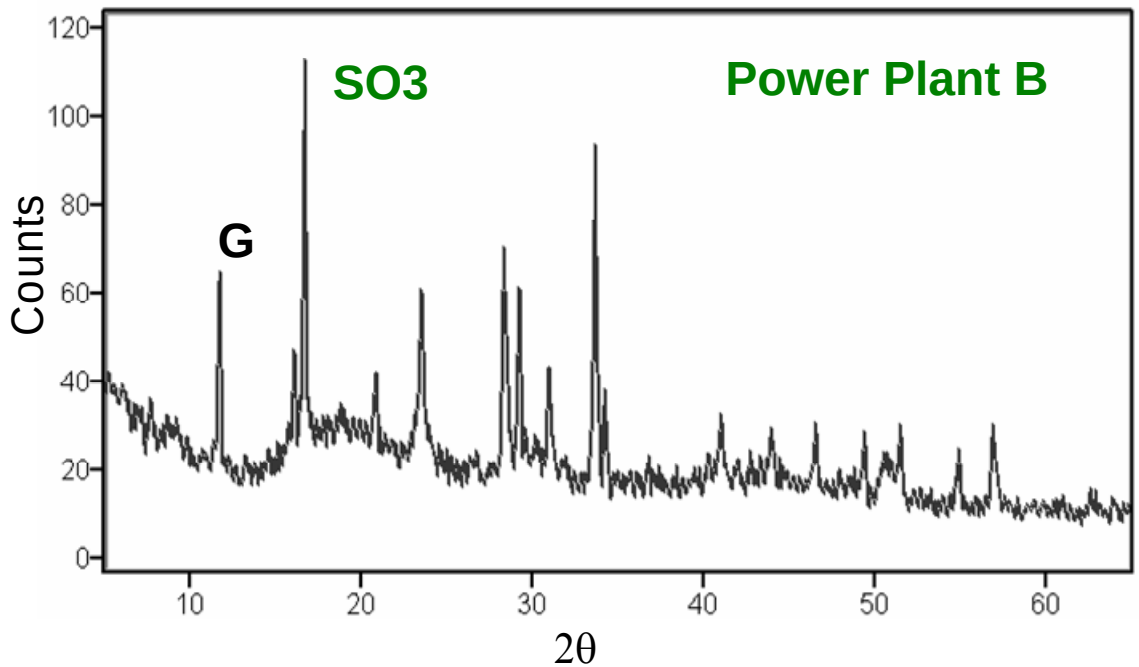


Power Plant B



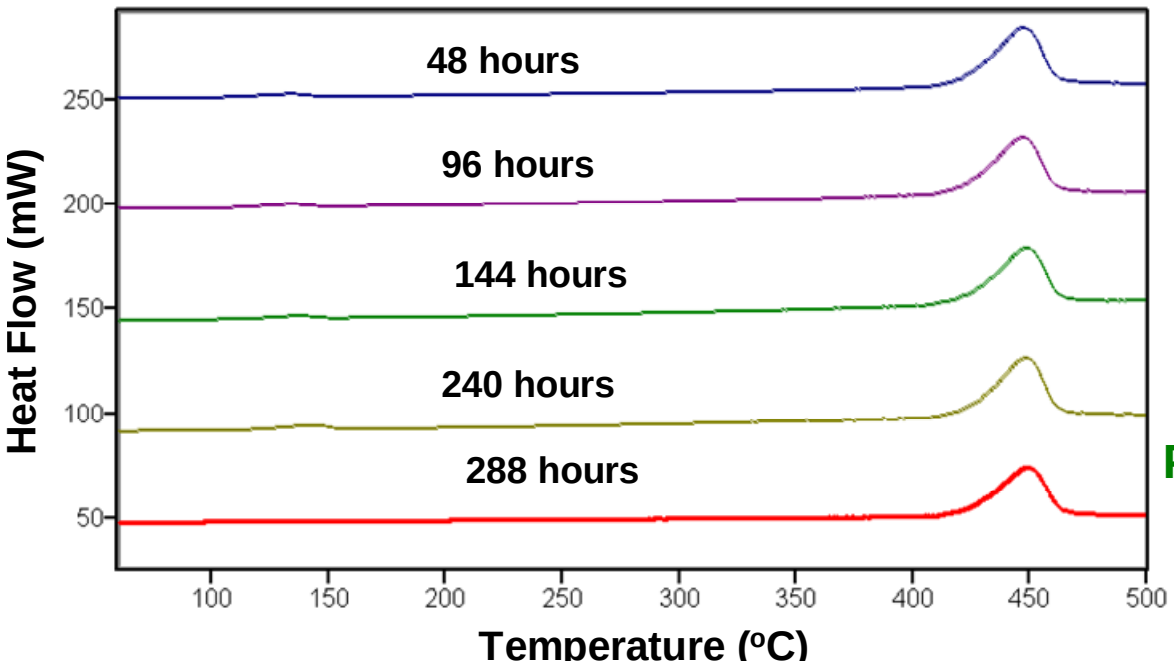
Observed XRD patterns of FGD scrubber materials

G: Gypsum ($CaSO_4.2H_2O$);
He: Hemihydrate($CaSO_4.0.5H_2O$)
SO3: $CaSO_3.0.5H_2O$

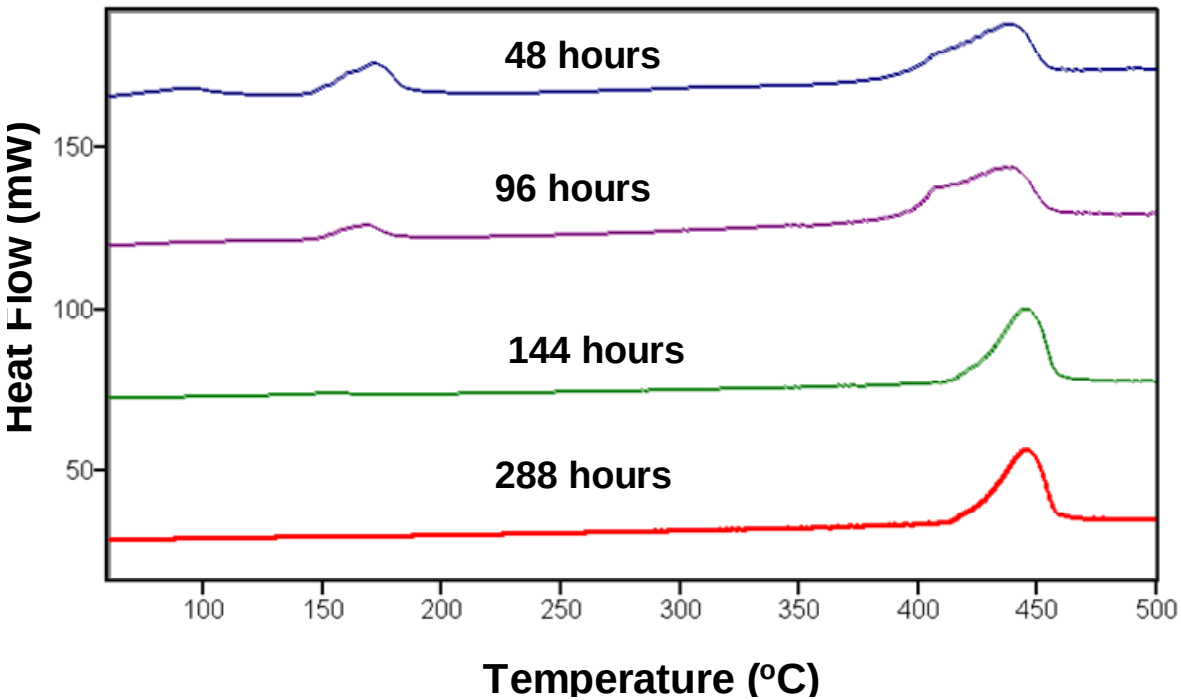


DRYING BEHAVIOR AT AMBIENT TEMPERATURE : Differential Scanning Calorimetry (DSC) Results

(samples dried for various lengths of time before DSC measurements)

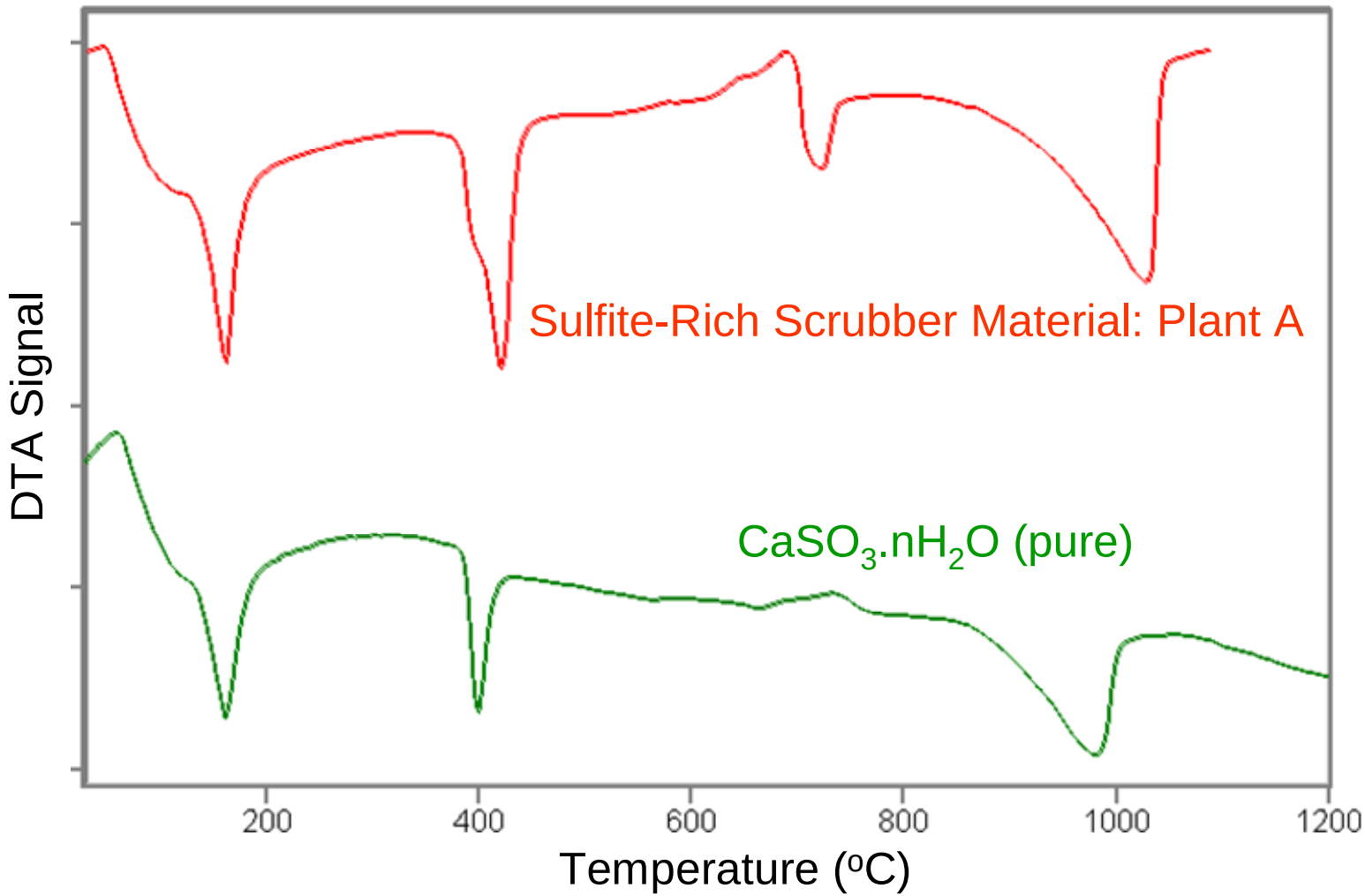


Power Plant A

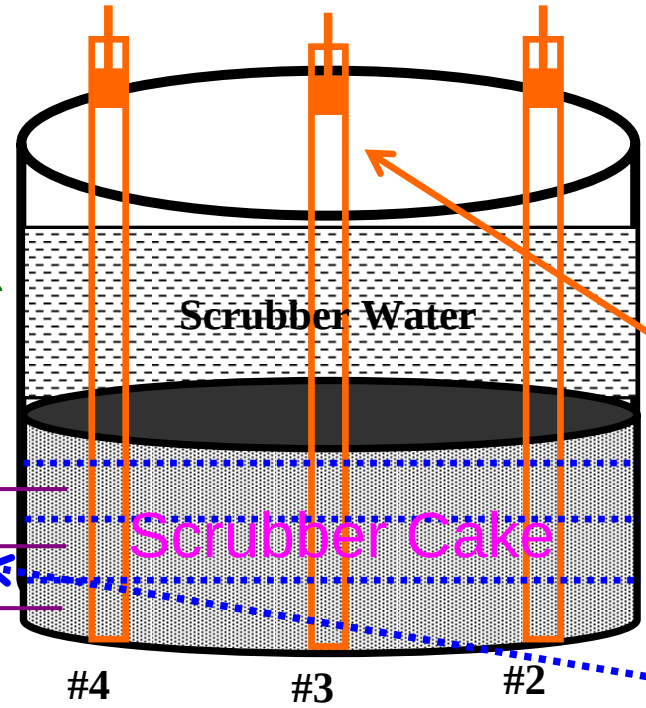


Power Plant B

Differential Thermal Analysis (DTA)



Some Odd Observations: Hg in scrubber materials

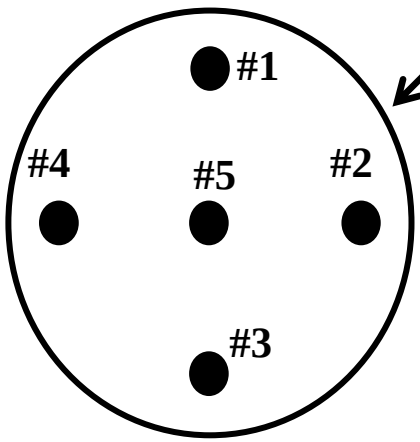


Samples obtained in 5 gallon buckets

Hollow stainless tube-piston system used to extract cores

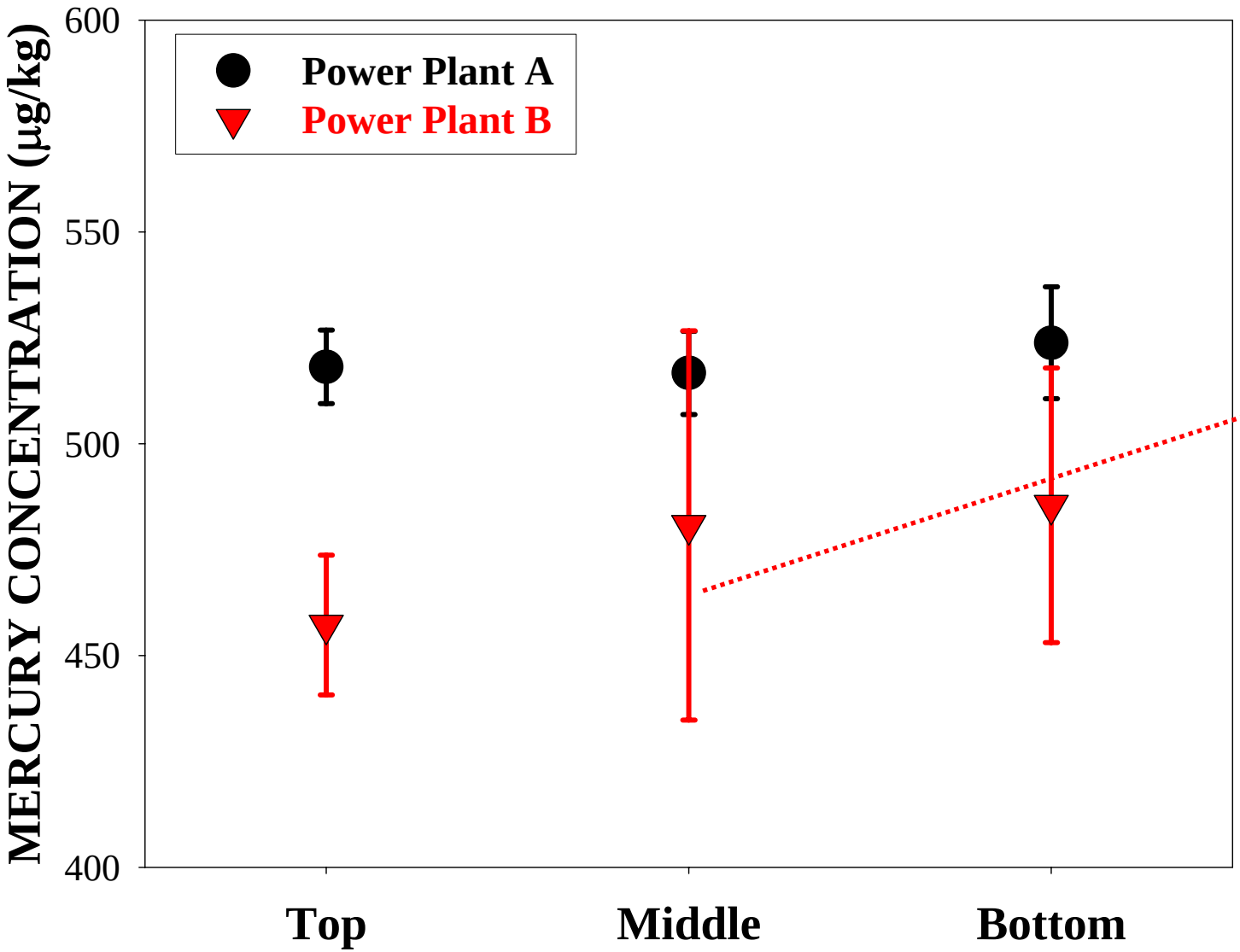
Five cores extracted from each bucket

Cores divided into three parts, i.e., top, middle, and bottom



Markevicius, West, Malhotra, Botha, Miller, ACS Fuel Div. Preprints **52(1)**, 170-172 (2007).
West, Malhotra, and Botha, ACS Fuel Div. Preprints **51(1),** 347-348 (2006).

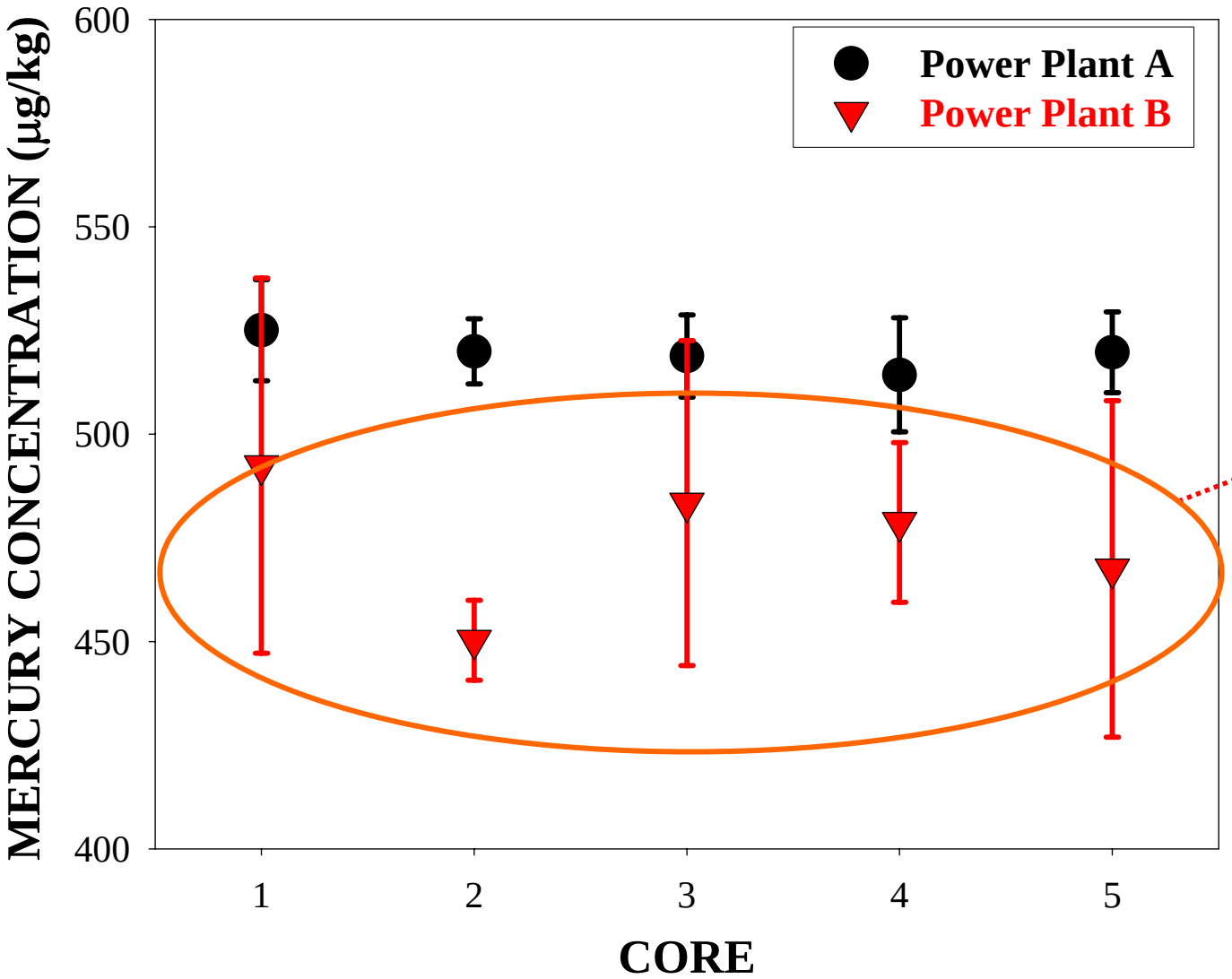
How height from where the samples were extracted controlled the mercury concentration



Note the much larger standard deviations for Plant B

Markevicius, West, Malhotra, Botha, Miller, ACS Fuel Div. Preprints **52(1)**, 170-172 (2007).

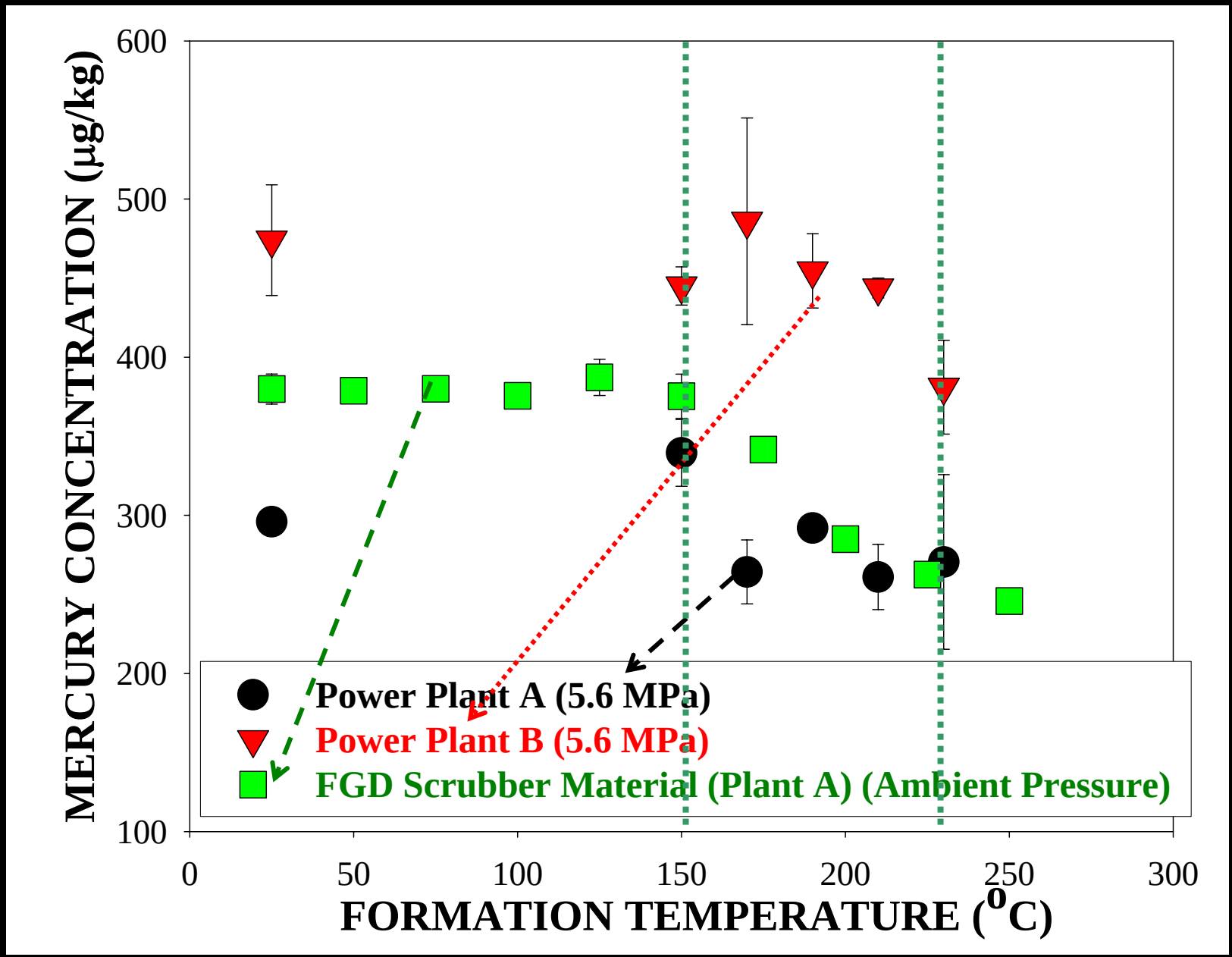
How the location of the samples affected the mercury concentration



Again, note the much larger standard deviations for Plant B

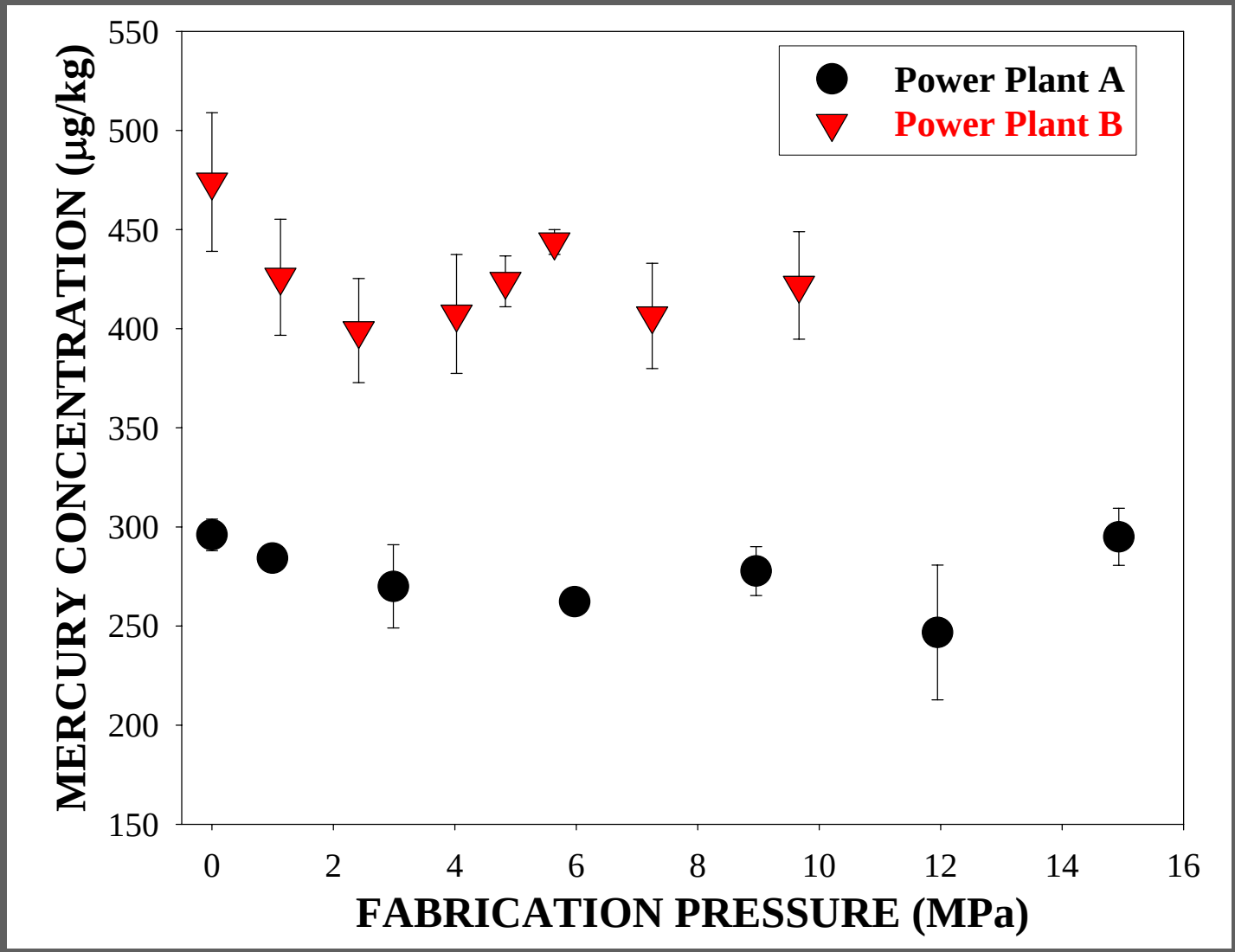
Markevicius, West, Malhotra, Botha, Miller, ACS Fuel Div. Preprints **52(1)**, 170-172 (2007).

How temperature affected the Hg concentration at 5.6 MPa



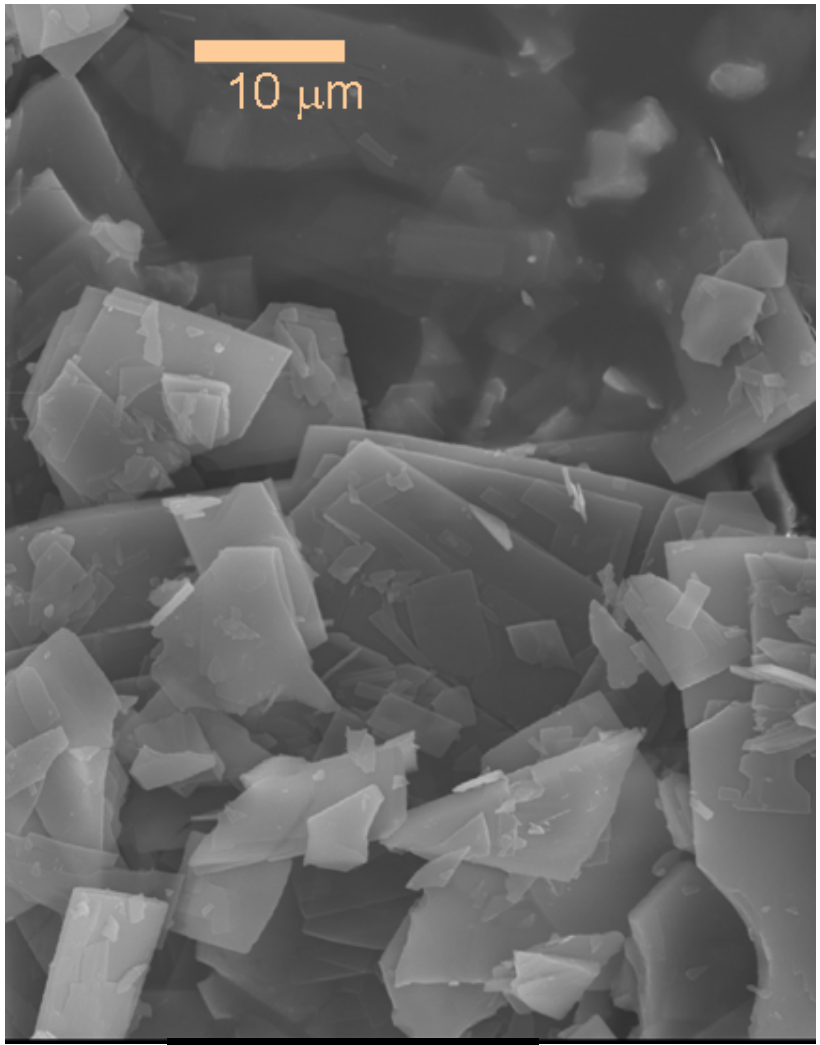
Markevicius, West, Malhotra, Botha, Miller, ACS Fuel Div. Preprints **52(1)**, 170-172 (2007).

How pressure affected the Hg concentration at 210°C

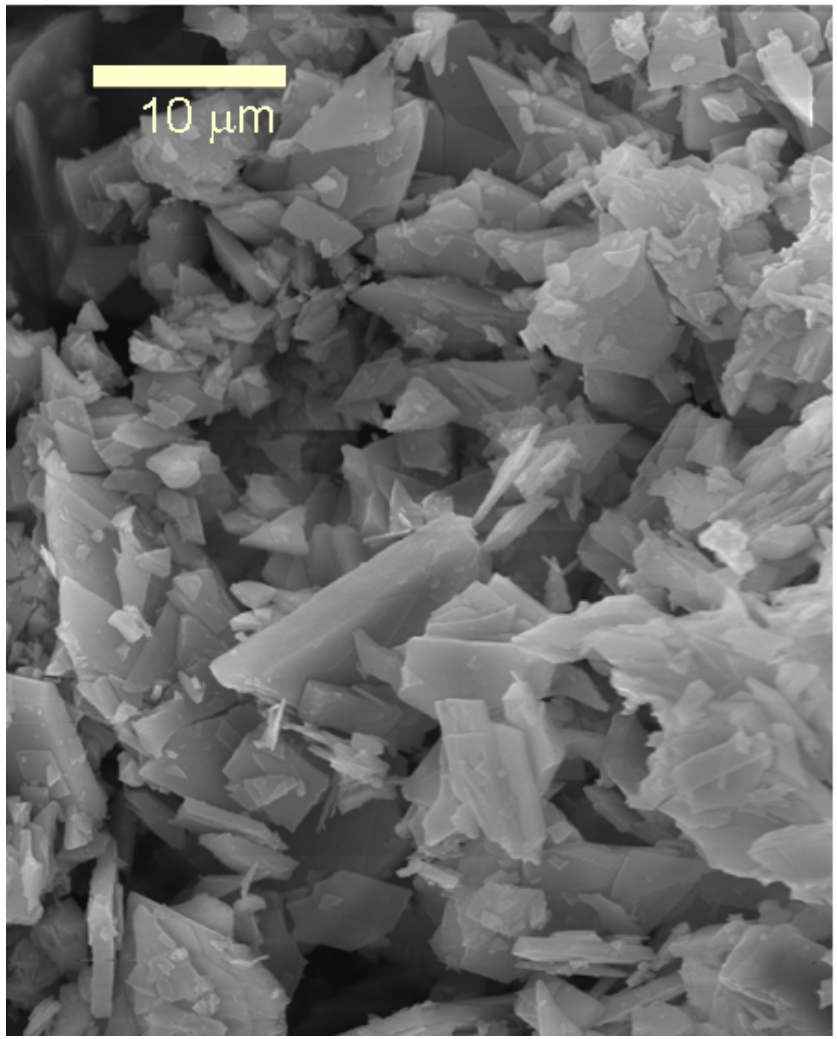


Markevicius, West, Malhotra, Botha, Miller, ACS Fuel Div. Preprints **52(1)**, 170-172 (2007).

Pressure (Scrubber Material: Power Plant A)

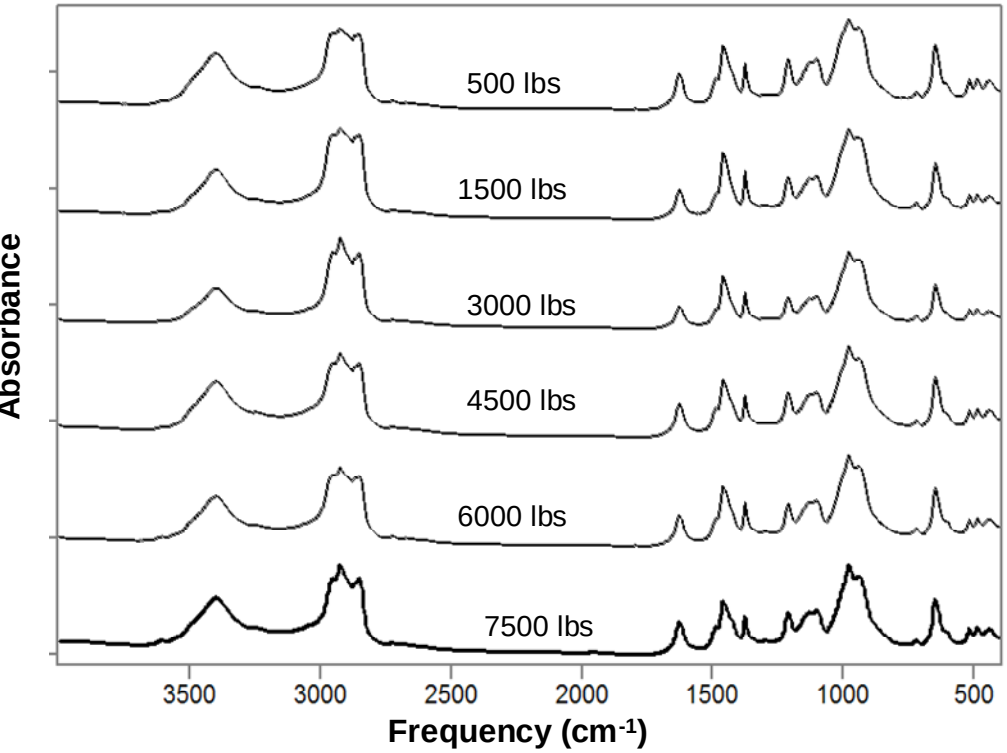


T = 210°C
P = 160 psi

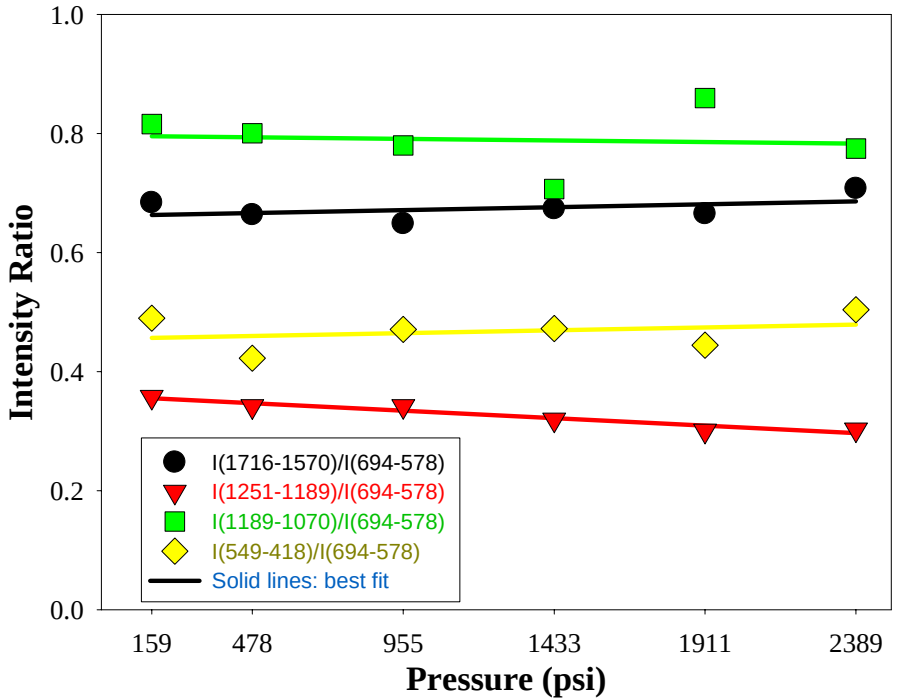


T = 210°C
P = 2390 psi

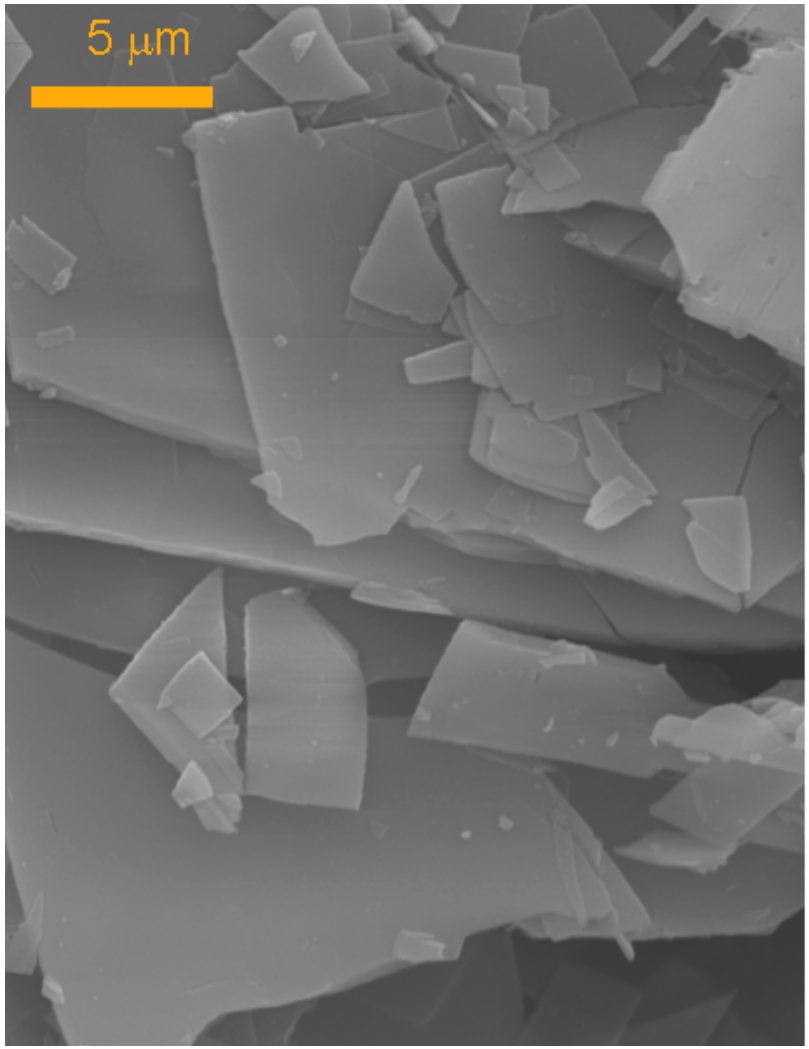
FTIR Spectra of processed scrubber material



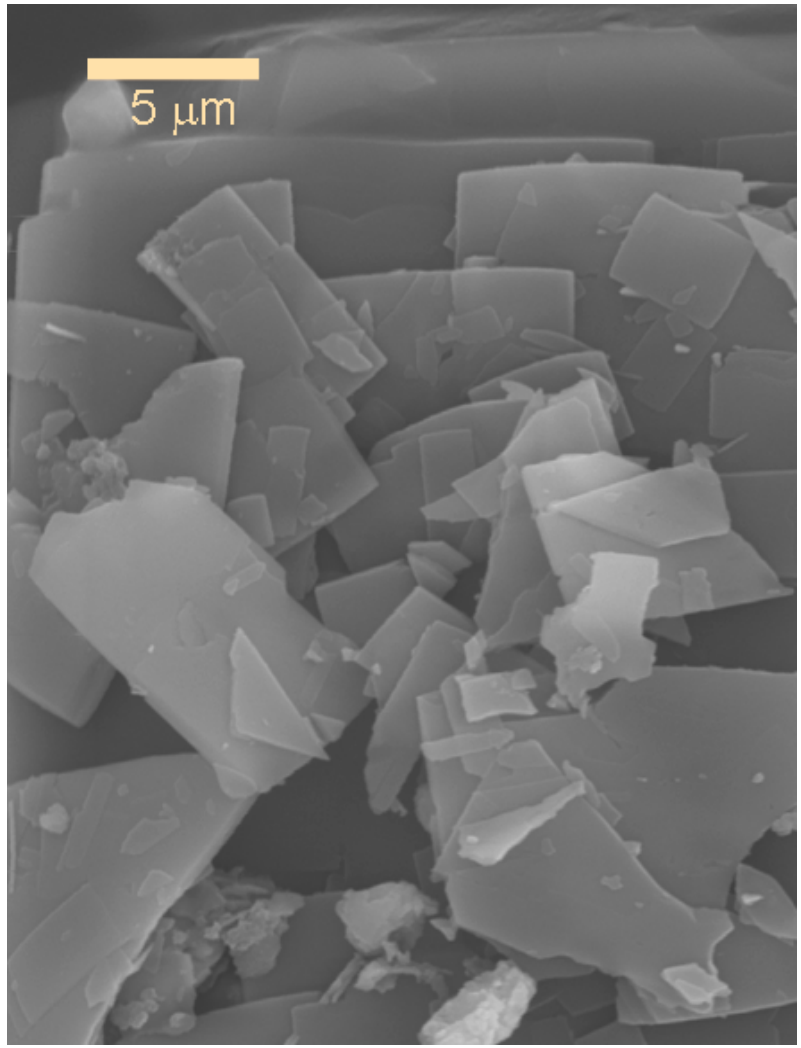
Variable: Pressure



Temperature (Scrubber Material: Power Plant A)

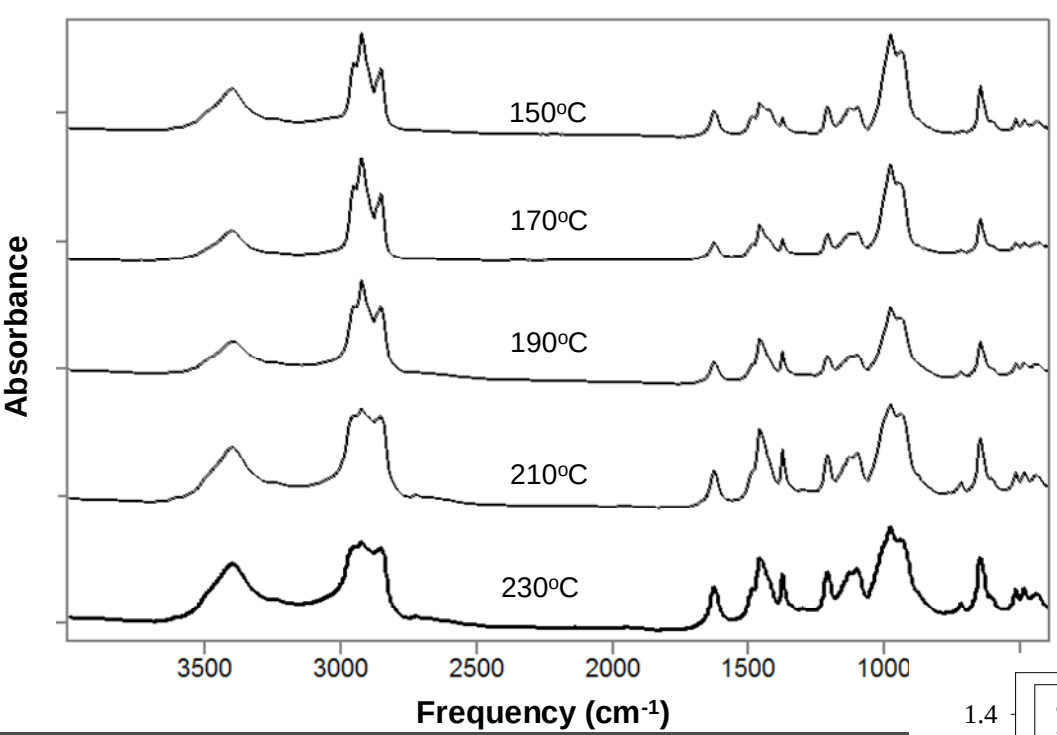


T = 150°C
P = 1115 psi

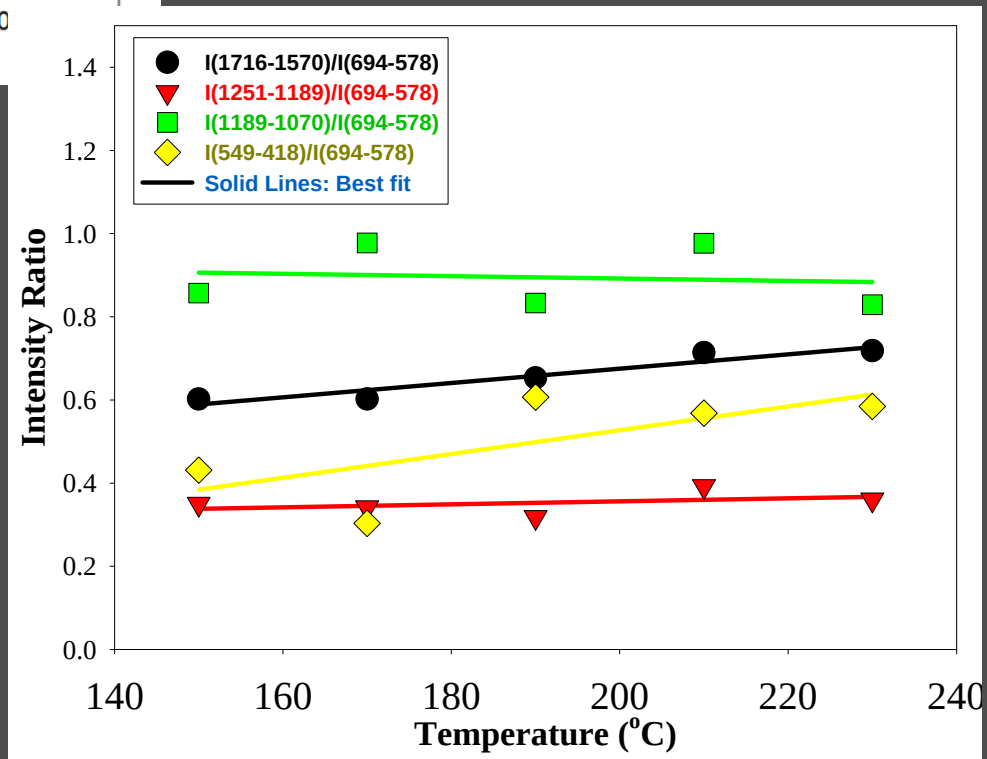


T = 210°C
P = 1115 psi

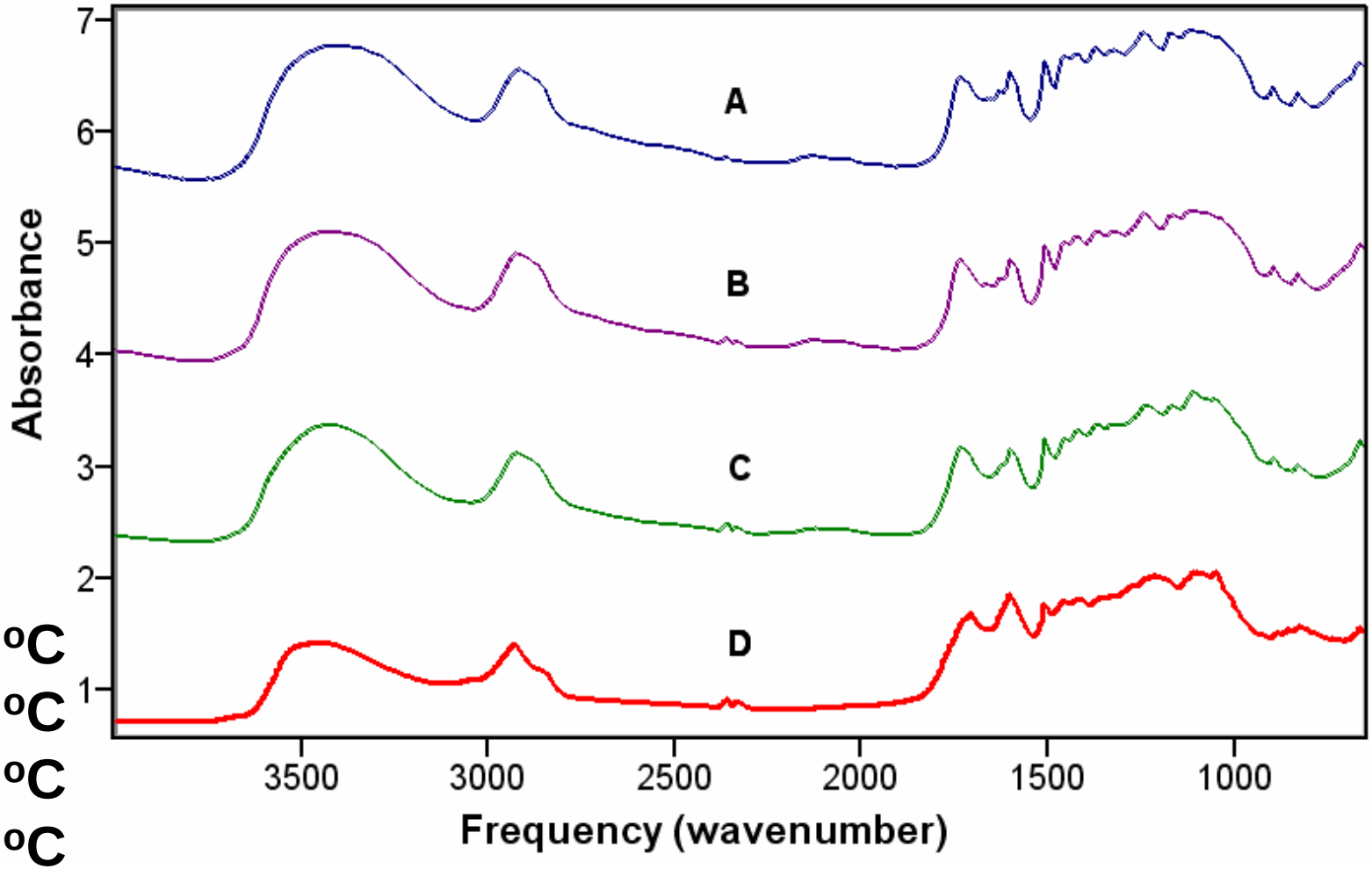
FTIR Spectra of processed scrubber material



Variable: Temperature



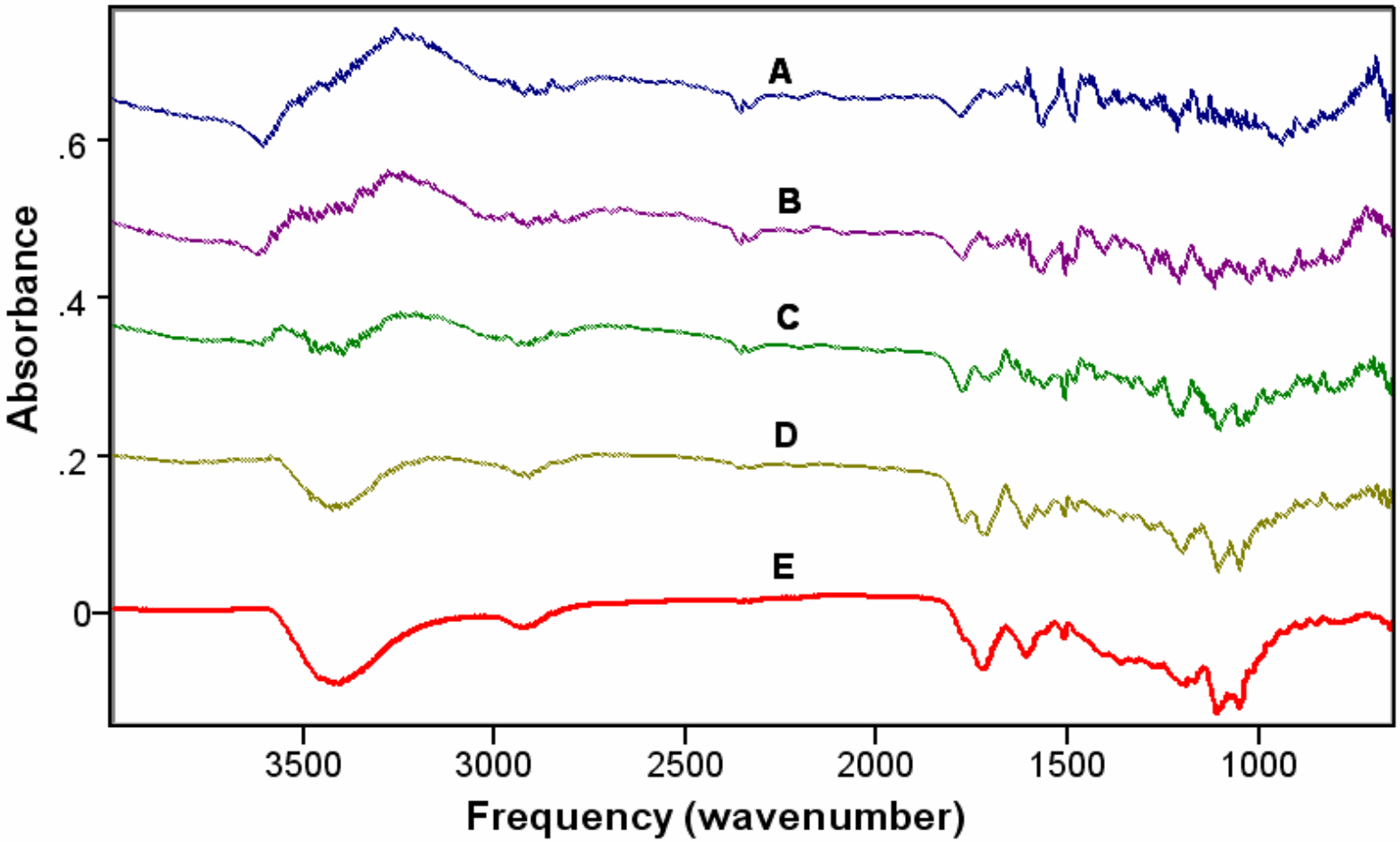
In-situ diffuse reflectance-High Temperature- FTIR (ISDR-HT-FTIR) Measurements: Natural Byproducts

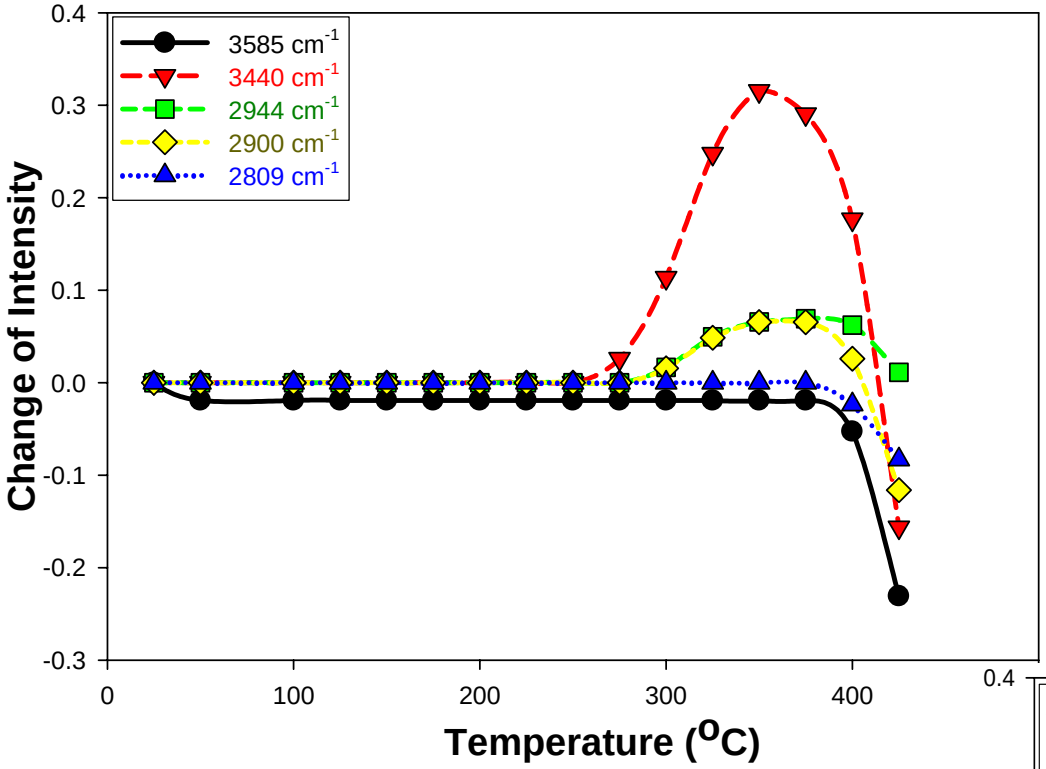


A = 25 °C
B = 150 °C
C = 300 °C
D = 425 °C

In-situ diffuse reflectance-High Temperature- FTIR (ISDR-HT-FTIR) Measurements: Natural Byproducts *Difference Spectra*

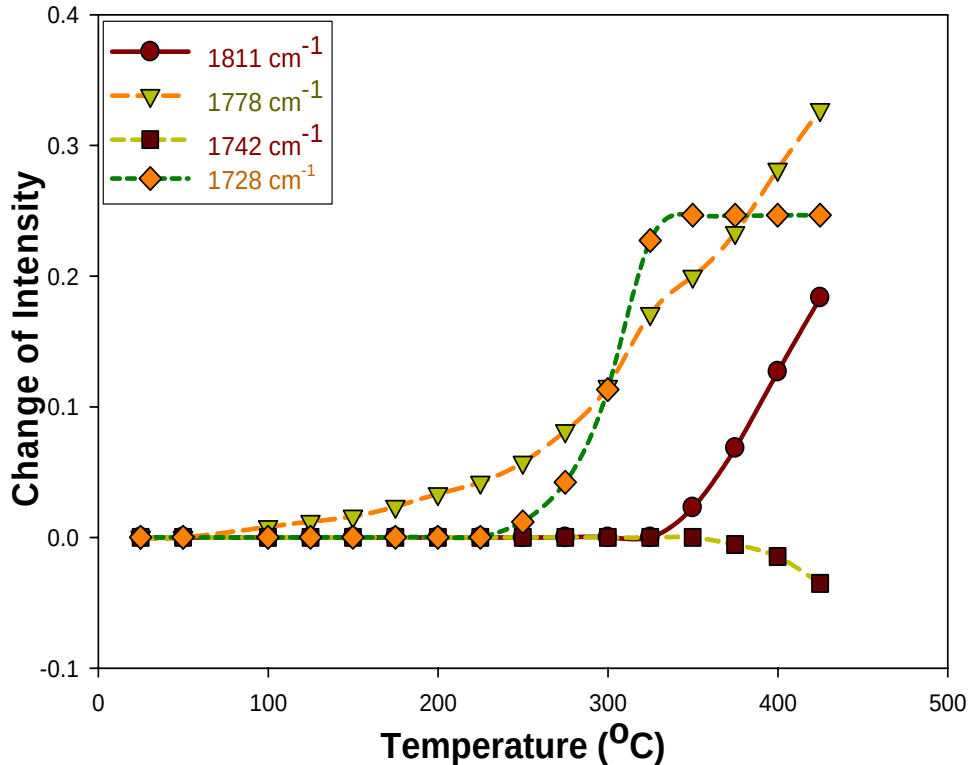
(A) 175^{o}C – 200^{o}C, (B) 200^{o}C – 225^{o}C, (C) 225^{o}C – 250^{o}C, (D) 250^{o}C – 275^{o}C, and (E) 275^{o}C – 300^{o}C





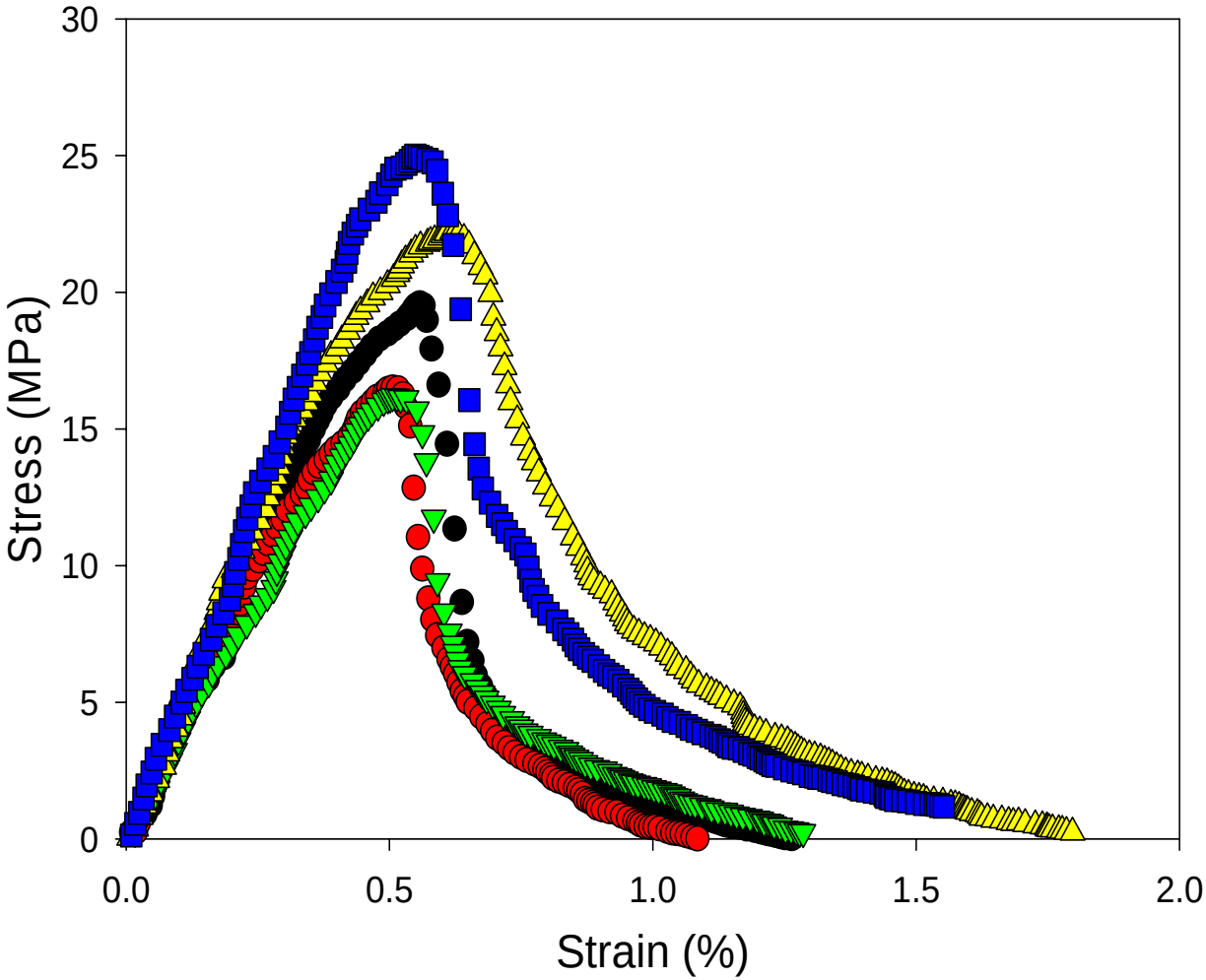
In-situ diffuse reflectance high temperature-Fourier transform infrared (ISDR-HT-FTIR) measurements:

Natural Byproducts



Development of Products to Replace Natural Wood-Derived Materials: Particleboards, Sawdust Boards, Plywood, & OSB

Two Types of Materials Being Developed from Sulfite-rich Scrubber Material

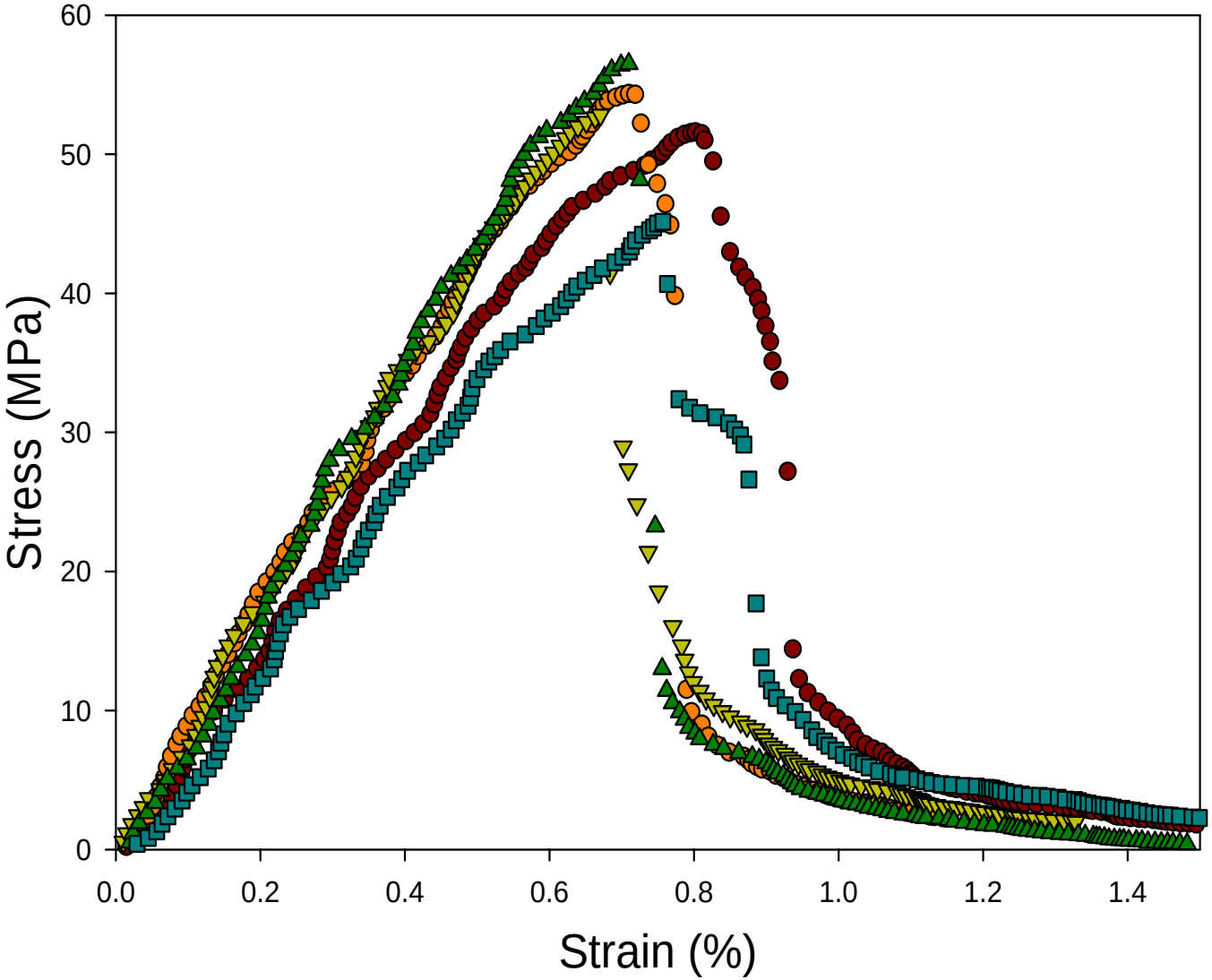


TYPE 1: to replace particleboard, OSB, sawdust board

NO POLYMERS USED

Development of Products to Replace Natural Wood-Derived Materials: Particleboards, Sawdust Boards, Plywood, & OSB

Two Types of Materials Being Developed from Sulfite-rich Scrubber Material

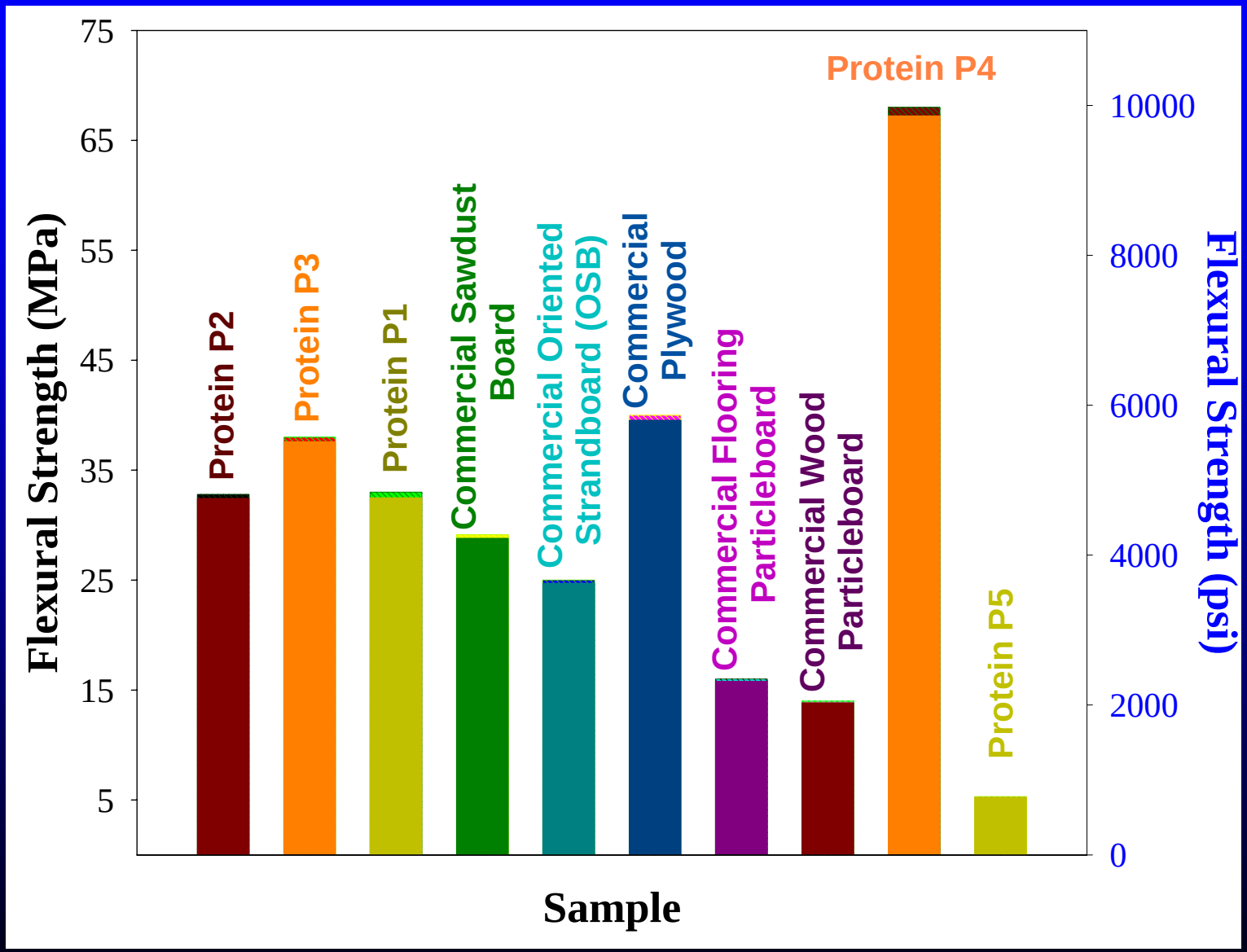


TYPE II: to replace plywood

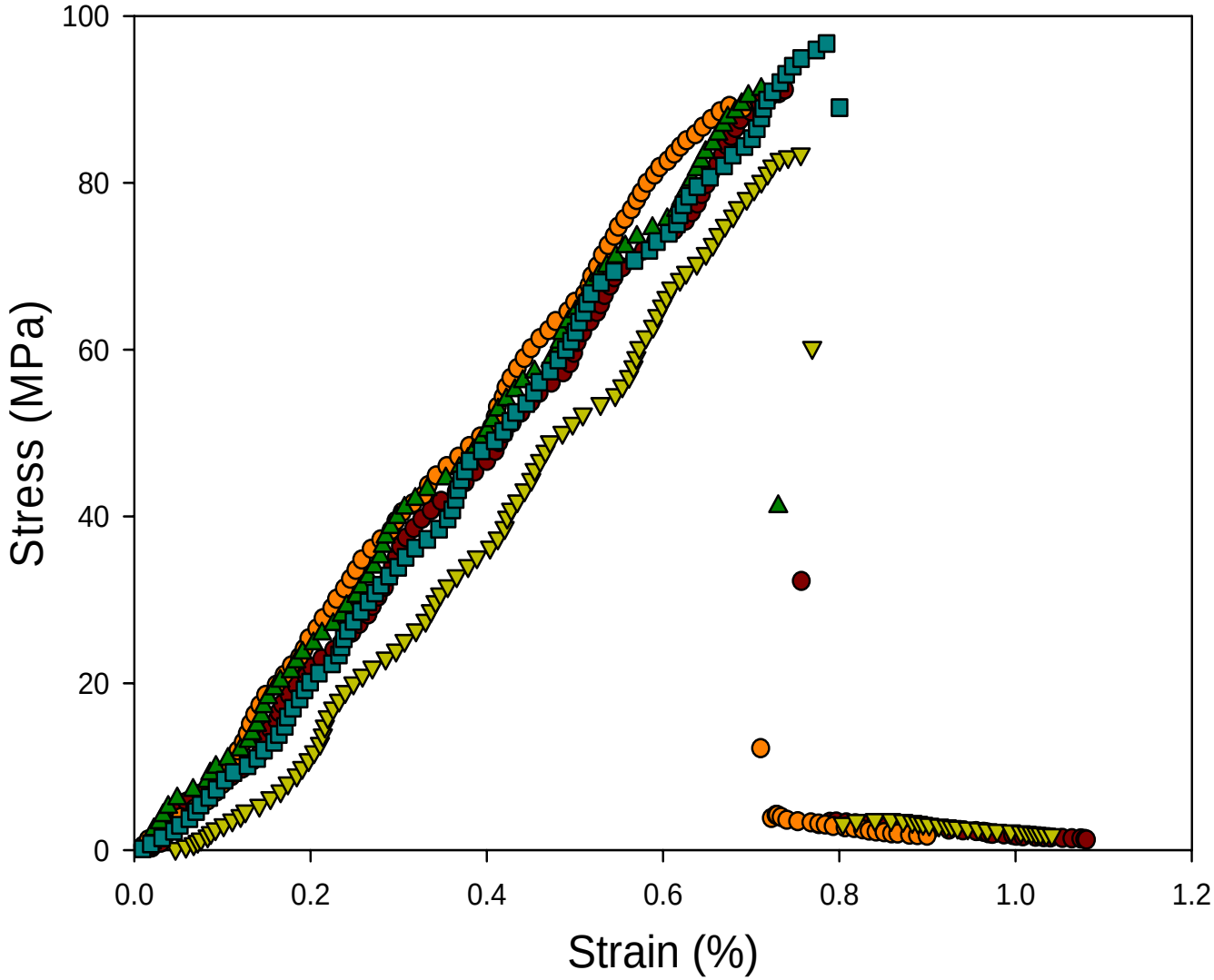
NO POLYMERS USED

Artificial Wood Products: FGD Sulfite-rich Scrubber Material

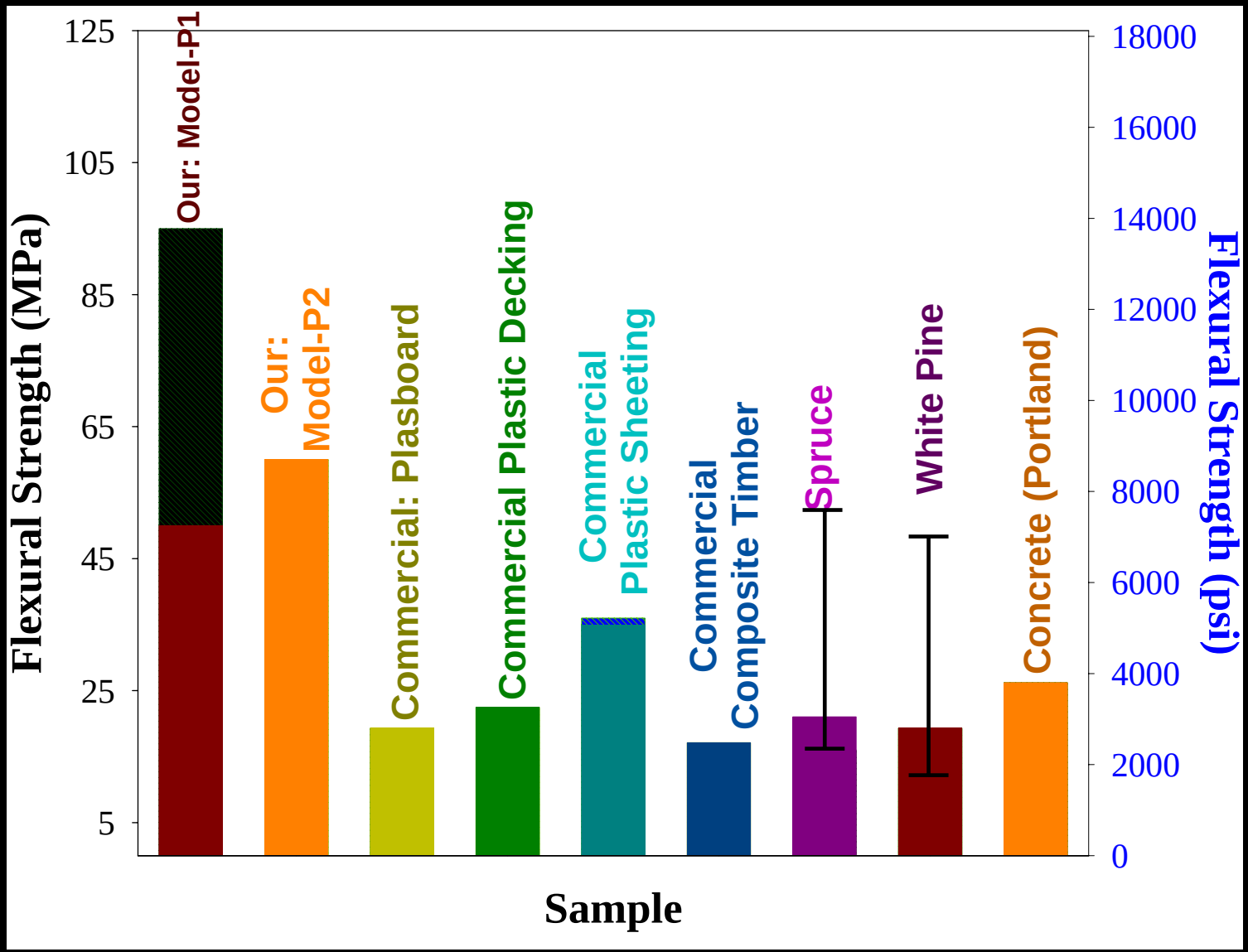
NO COMMERCIAL POLYMERS USED for our products



Flexural Strength Properties of Wood Substitute Lumber and Wood Siding: Sulfite-Rich Scrubber



Lumber Type Products: FGD Sulfite-rich Scrubber Material US against THEM



SUMMARY & CONCLUSIONS

- The mercury associated with scrubber material from one of the power plants showed considerable variation ➔ raising the potential of heterogeneous mercury distribution in the scrubber material
- Fabrication of our products at high pressure dramatically retards the mercury emission from scrubber material even at temperatures as high as 235^{o}C.
- Decomposition of crystalline water at 390^{o}C < T < 440^{o}C is expected to inhabit fire in our sulfite-rich scrubber material derived products
- The wood substitute composite fabrication steps do not alter the scrubber material's structural properties
- Our initial wood substitute composites developed from sulfite-rich scrubber material show great promise ➔ further nurturing is required and is on going