VALUE-ADDED PRODUCTS FROM FGD SULFITE-RICH SCRUBBER MATERIALS

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WET FGD SCRUBBER MATERIALS

(data from ACAA CCP 2006 survey)

FGD Wet Scrubber Materials

Sulfate-Rich ($CaSO_4.2H_2O$)

12.100 million tons per year

Currently 9.561 million tons utilized
(mostly in wallboard production,
~ 8.178 million tons)

~ 2.5 million tons must landfilled

Sulfite-rich ($CaSO_3.nH_2O$)

16.300 million tons per year

Currently 0.904 million tons utilized
(mostly in mining, agriculture, roads etc.)

~ 15.4 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

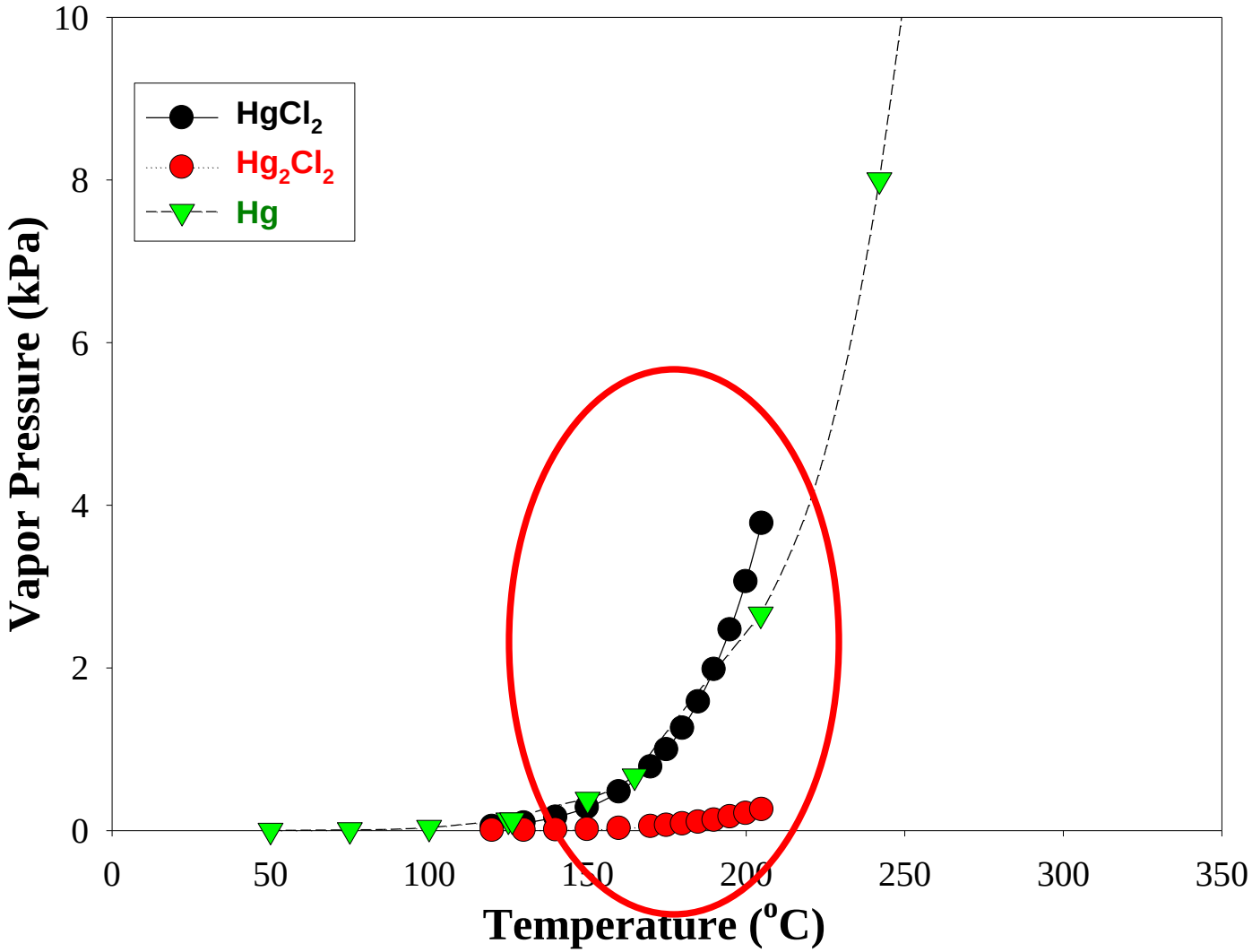
PRODUCTS:
Engineered Wood Product Substitutes
Advanced Polymer Nanocomposites:
Automobiles Parts

OVERALL GOALS OF OUR PROJECT

- 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
- Subject the products developed to rigorous performance evaluations
- Generate manufacturing parameters needed for upscaling to a pilot-scale product manufacturing

HURDLES WE FACE IN MEETING OUR GOALS AND STRATEGIES TO SURMOUNT THEM

To produce our products, we need high temperature and pressure ➔ what happens to Hg


HgCl2
Hg2Cl2
Hg
Vapor Pressure (kPa)
Temperature (°C)
0
2
4
6
8
10
0
50
100
150
200
250
300
350

HURDLES WE FACE IN MEETING OUR GOALS AND STRATEGIES TO SURMOUNT THEM

High density of sulfite-rich scrubber material:
~ 2500 kg/m^3

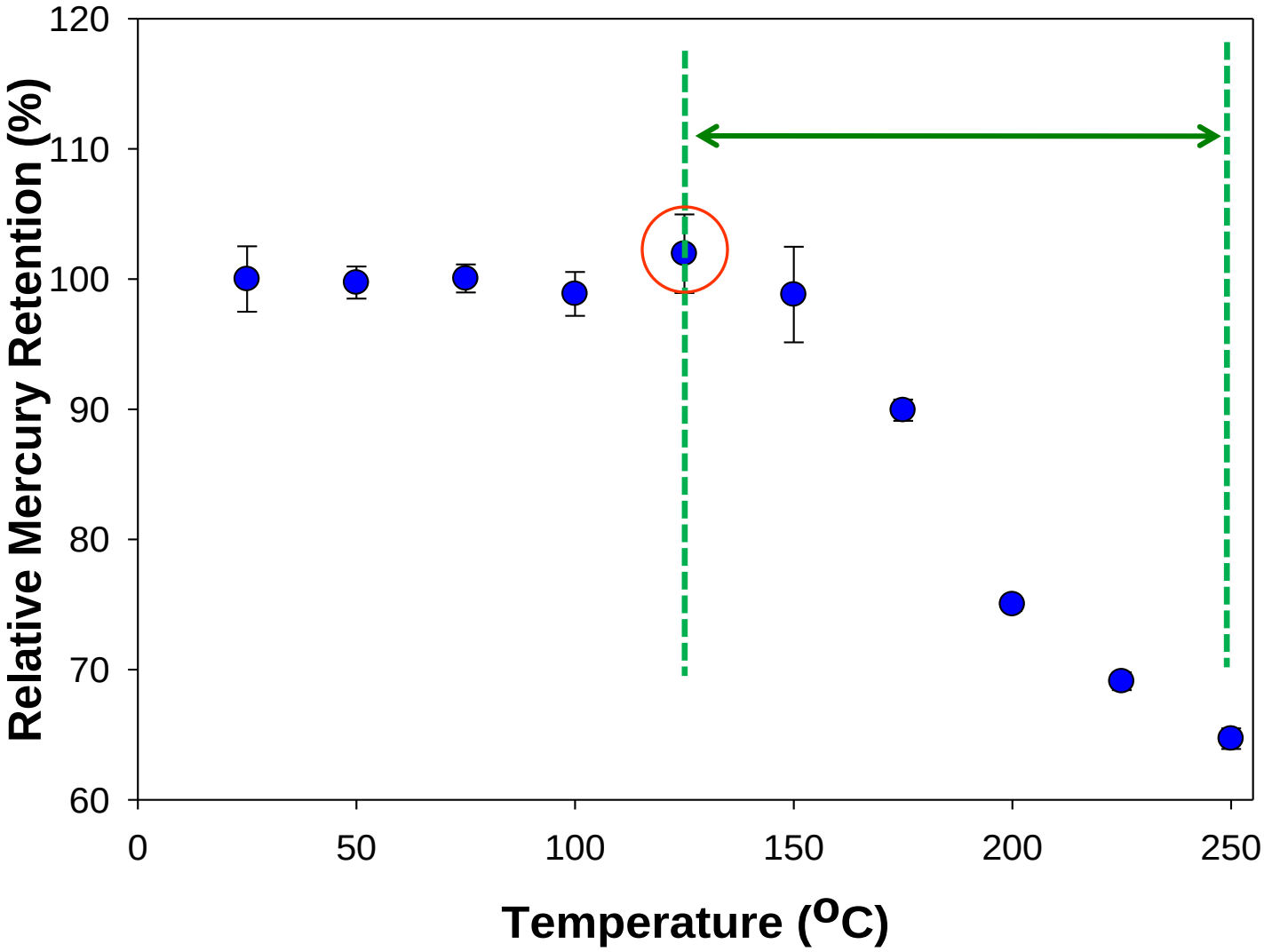
↓

The products derived from scrubber material must be able to compete against engineered wood and wood plastic products

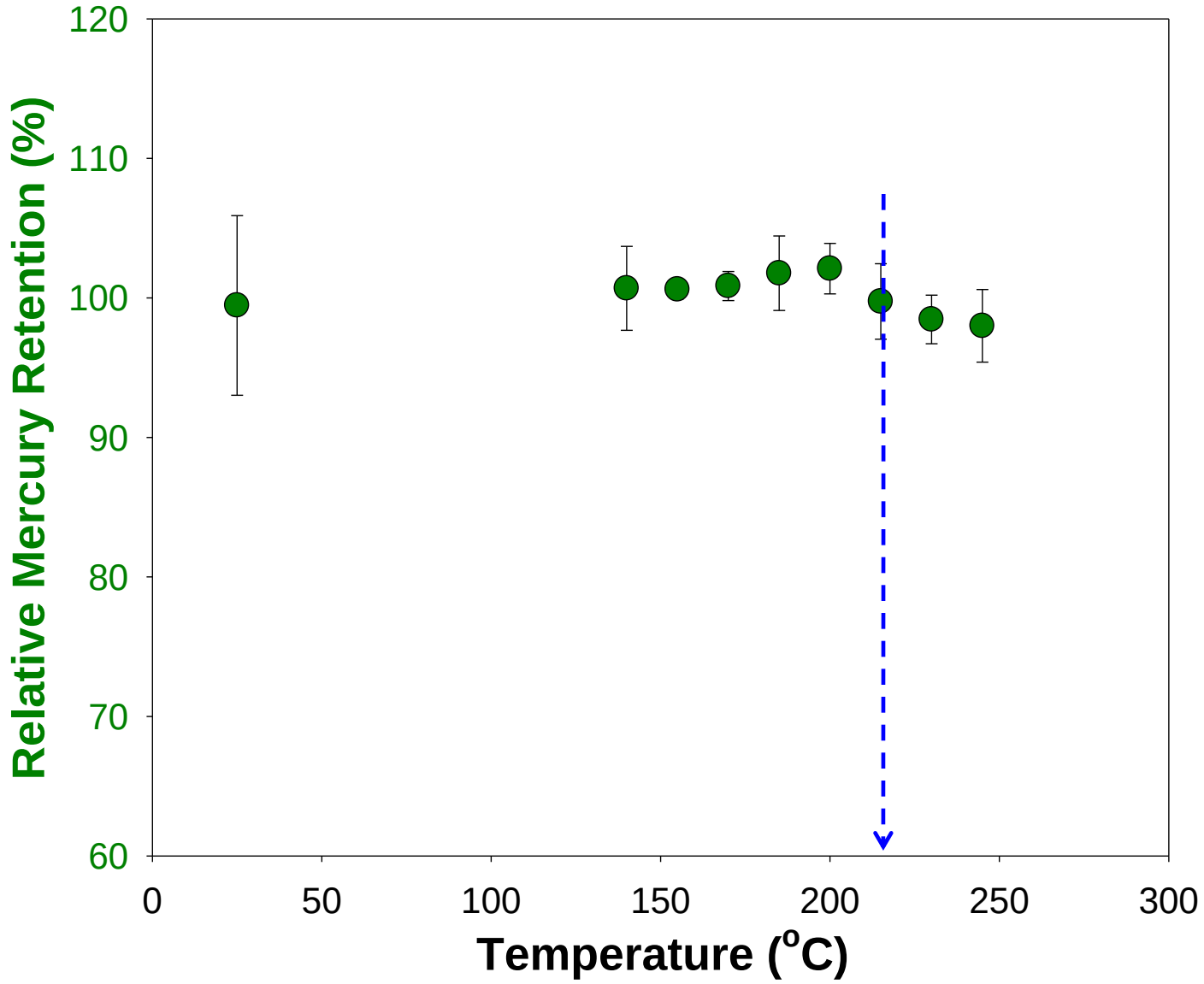
➔

must have better specific strength {= (strength/density)} than the products on the market

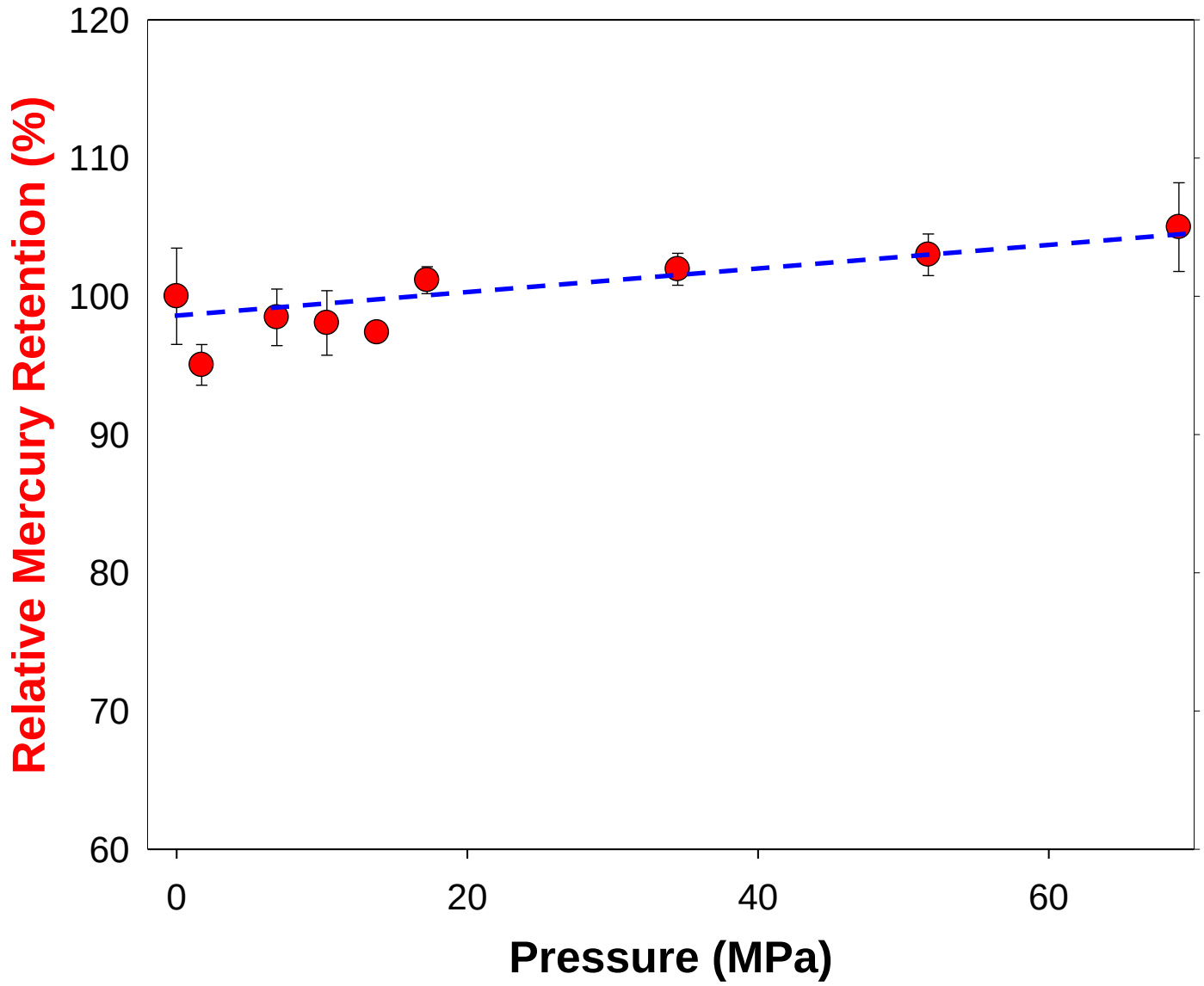
Effect of thermal shock at ambient pressure on the mercury concentration: FGD sulfite-rich scrubber material



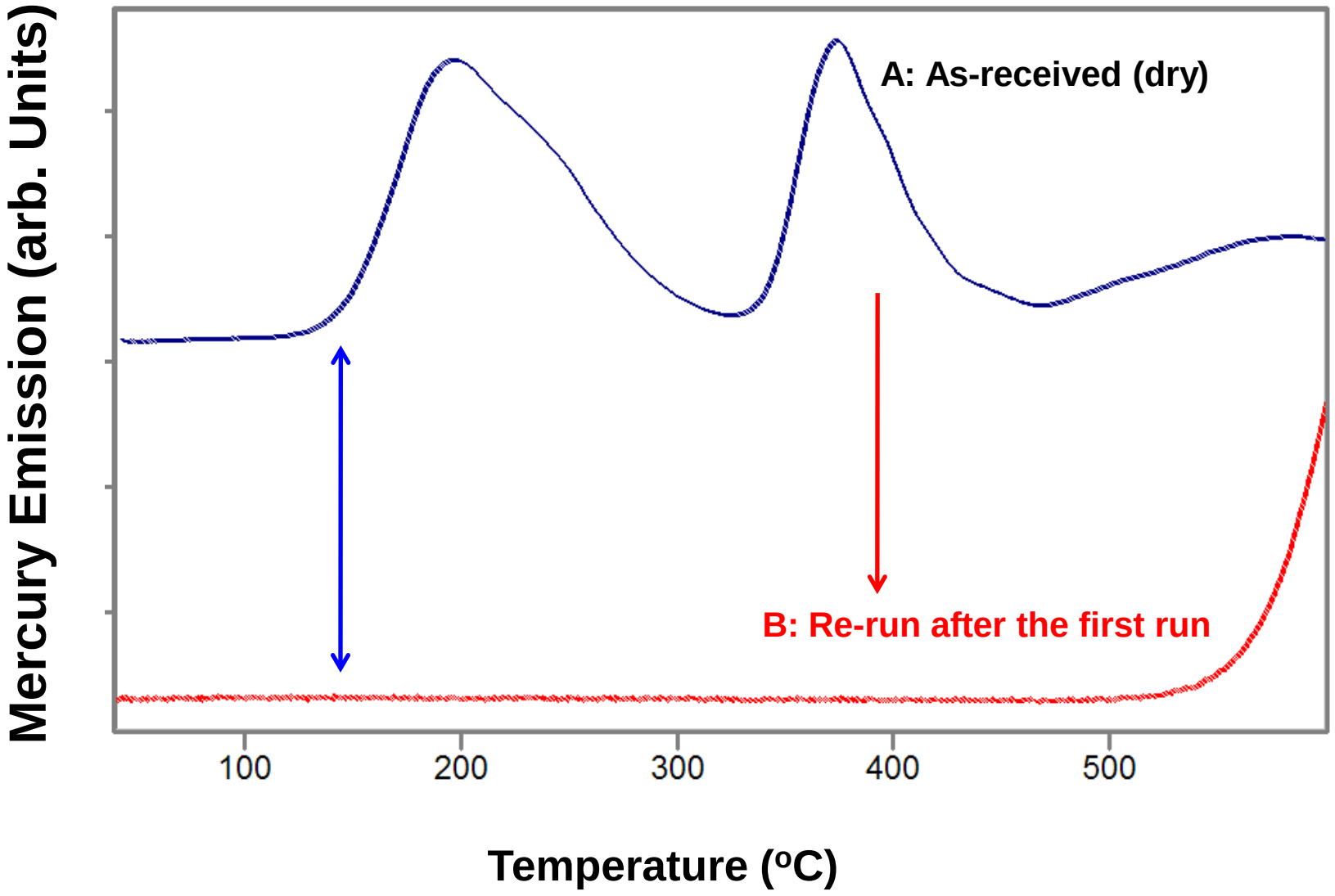
Effect of thermal shock at 3.5 MPa (~ 508 psi) pressure on the mercury concentration: FGD sulfite-rich scrubber material



Effect of pressure on the mercury concentration at 210°C : FGD sulfite-rich scrubber material



Scrubber material's temperature ramped at 10°C/min under argon and emitted Hg detected by AF Spectrometer (PS Analytical system)



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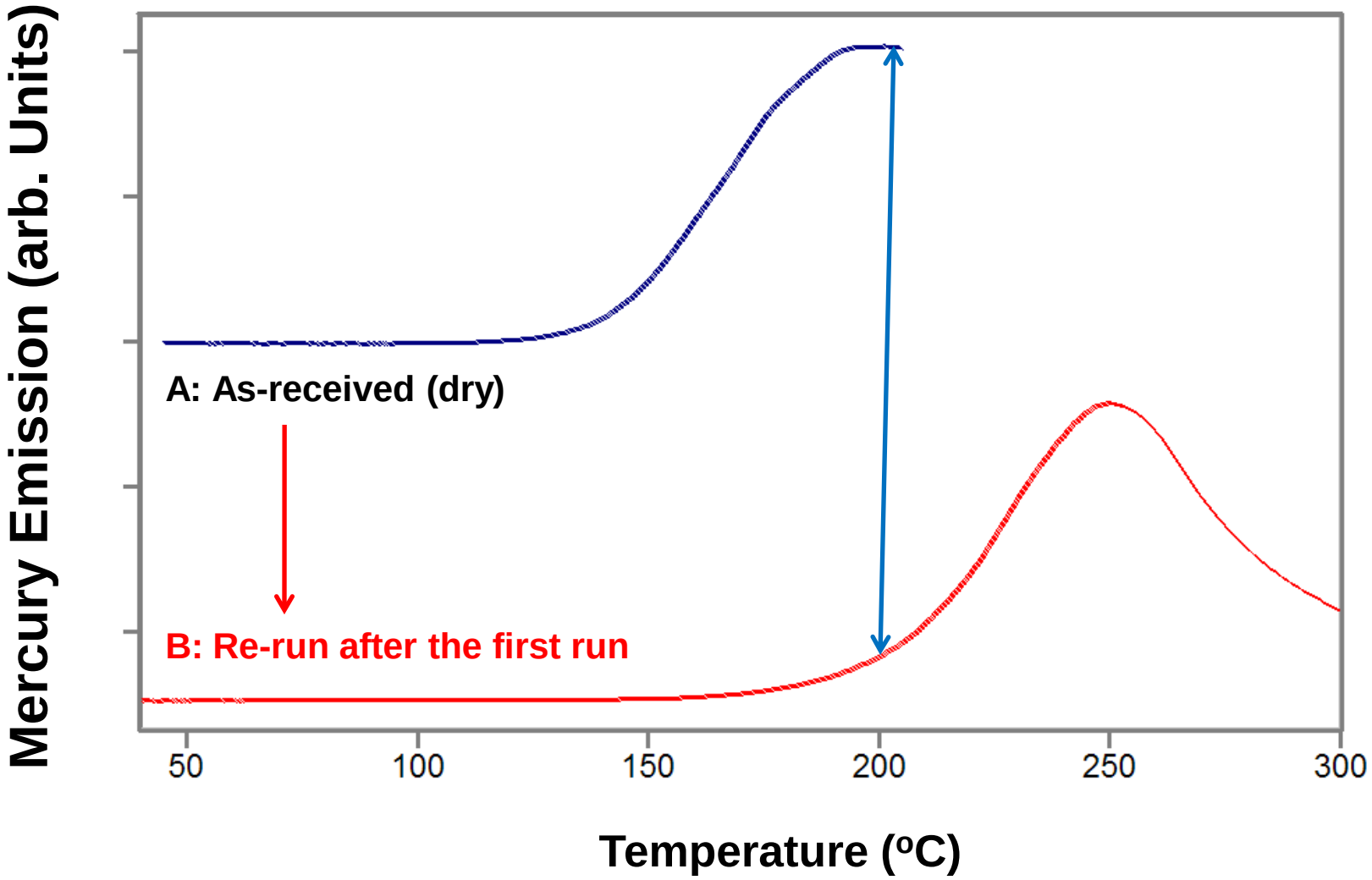

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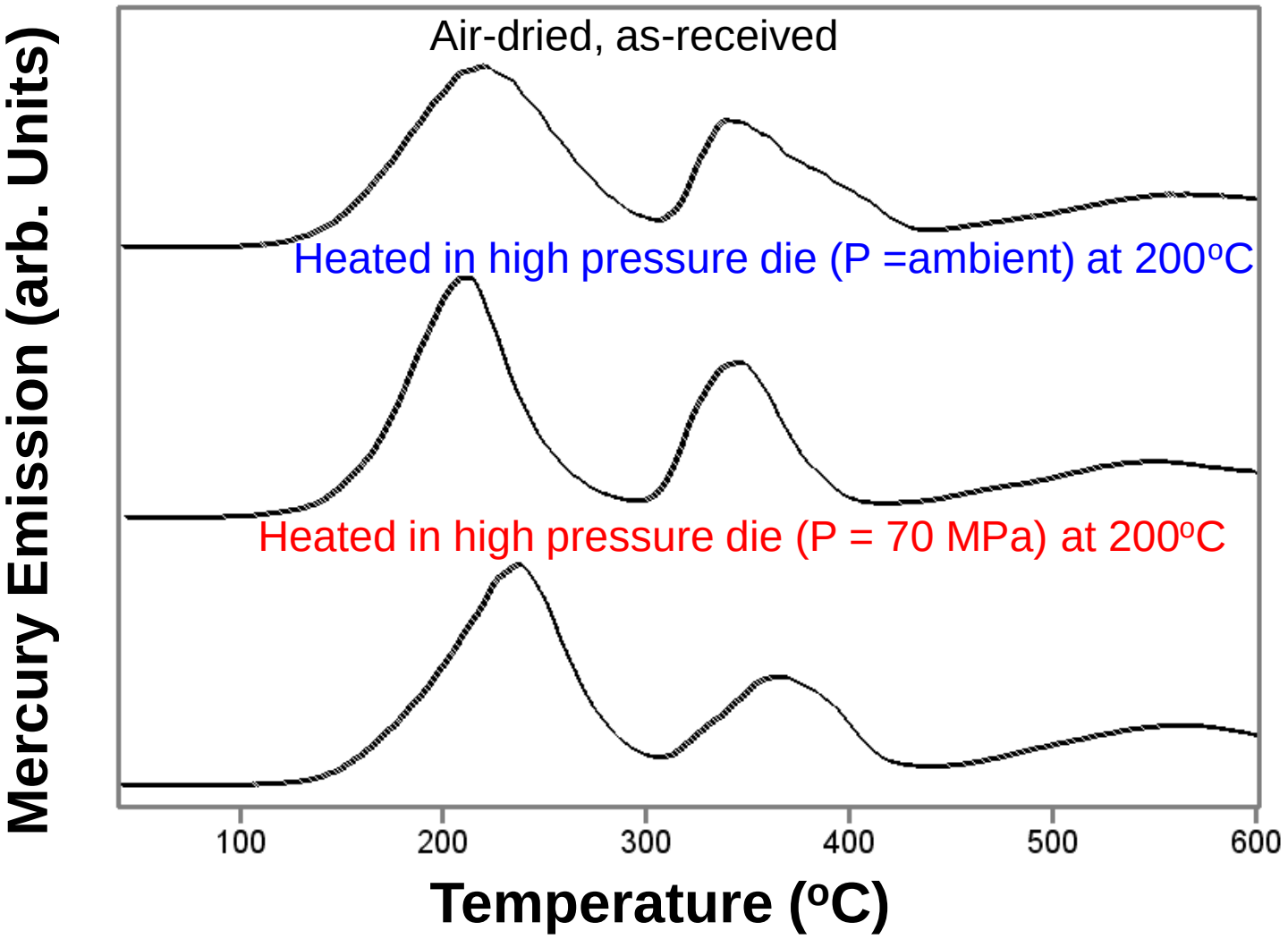



Genesis

CALCIUM SULFITE WOOD-SUBSTITUTE COMPOSITES (CSW Composites): Fabrication and Mechanical Properties

DECKING MATERIAL STRENGTH REQUIREMENT#:

Material should not fail under reasonable load ➔ flexural strength

International Code Council (ICC) Requirement = 100 lbs/ft^2 ➔
Safety Factor = 2.5 X 100 = 250 lbs/ft^2 = 1.725 psi = 0.012 MPa

$$Break\ Load = \frac{8\ I\ FS}{LH}$$

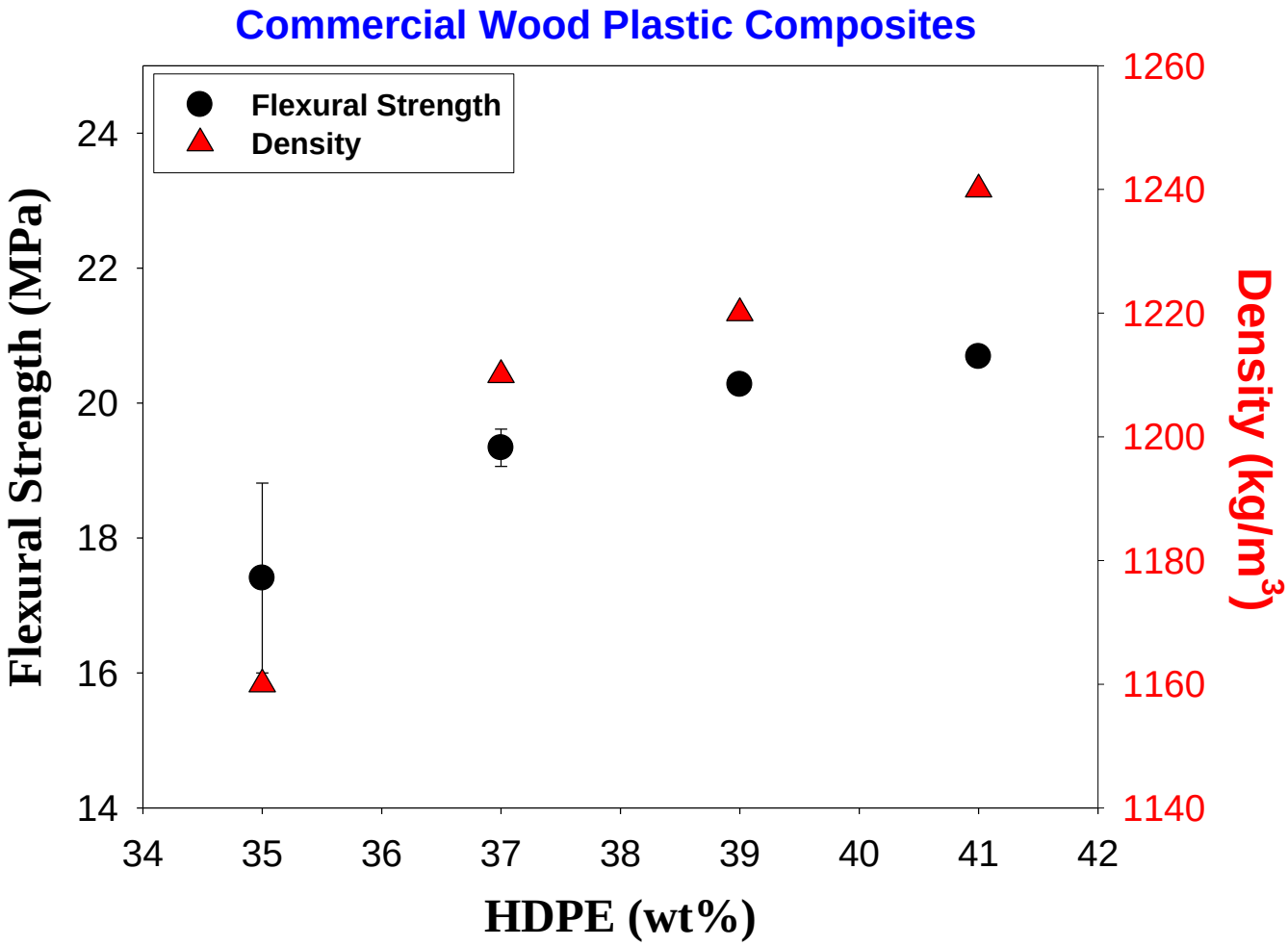
FS → flexural strength
L → span (16”)
H → board thickness
I → moment of inertia { = (width)(thickness)^3/12}

Most wood-plastic materials are made from polymer (~ 40 to 80 wt%) like polyethylene (HDPE or LDPE), polypropylene (PP), or polyvinyl chloride (PVC) and wood byproducts

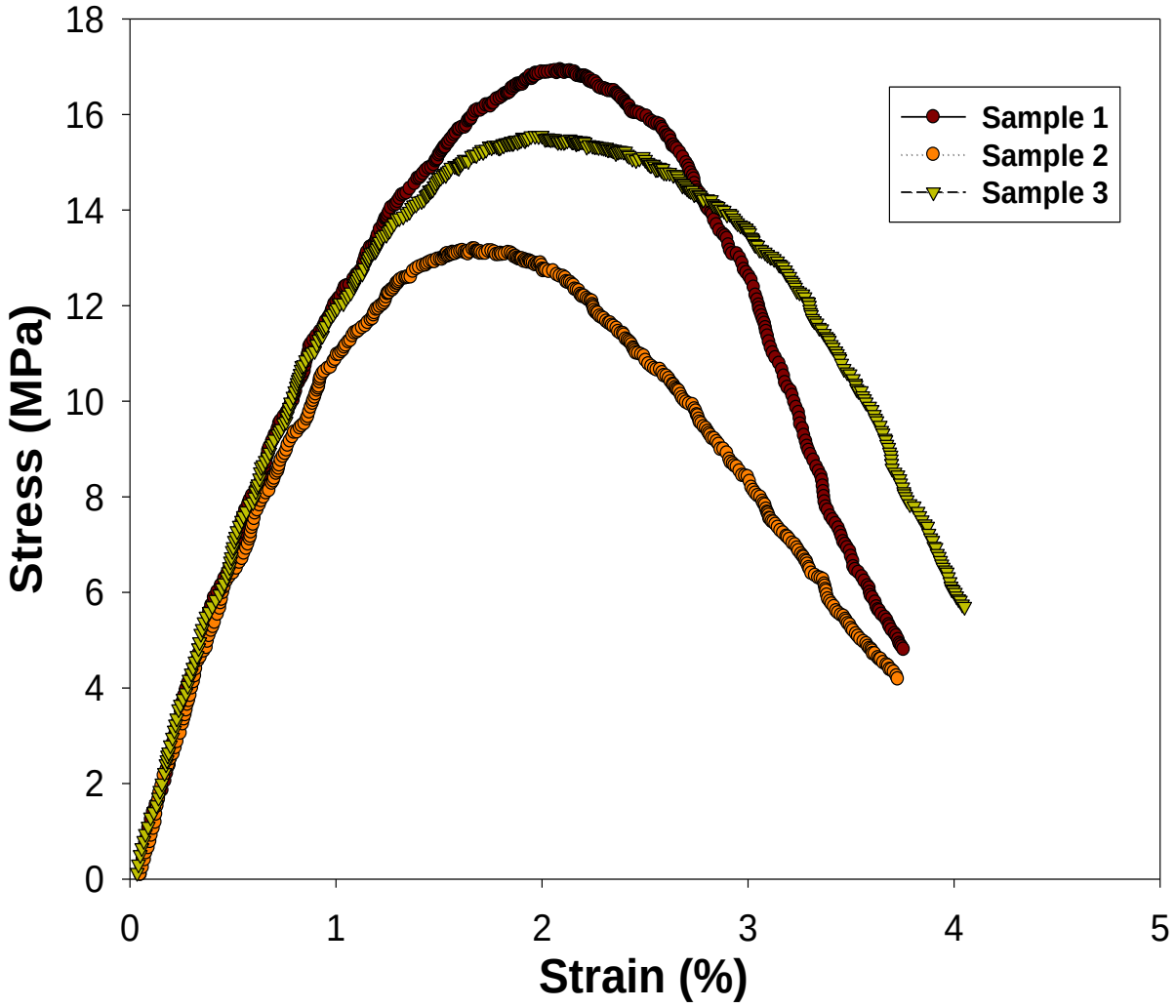
Typical flexural strength of commercial products (GeoDeck, Eon, etc.) = ~ 1500 to 4000 psi (~ 10.3 to 27.6 MPa)

#A. A. Klyosov, WPC, Wiley, 2007.

Mechanical Properties Of Commercial Wood Plastic Composites

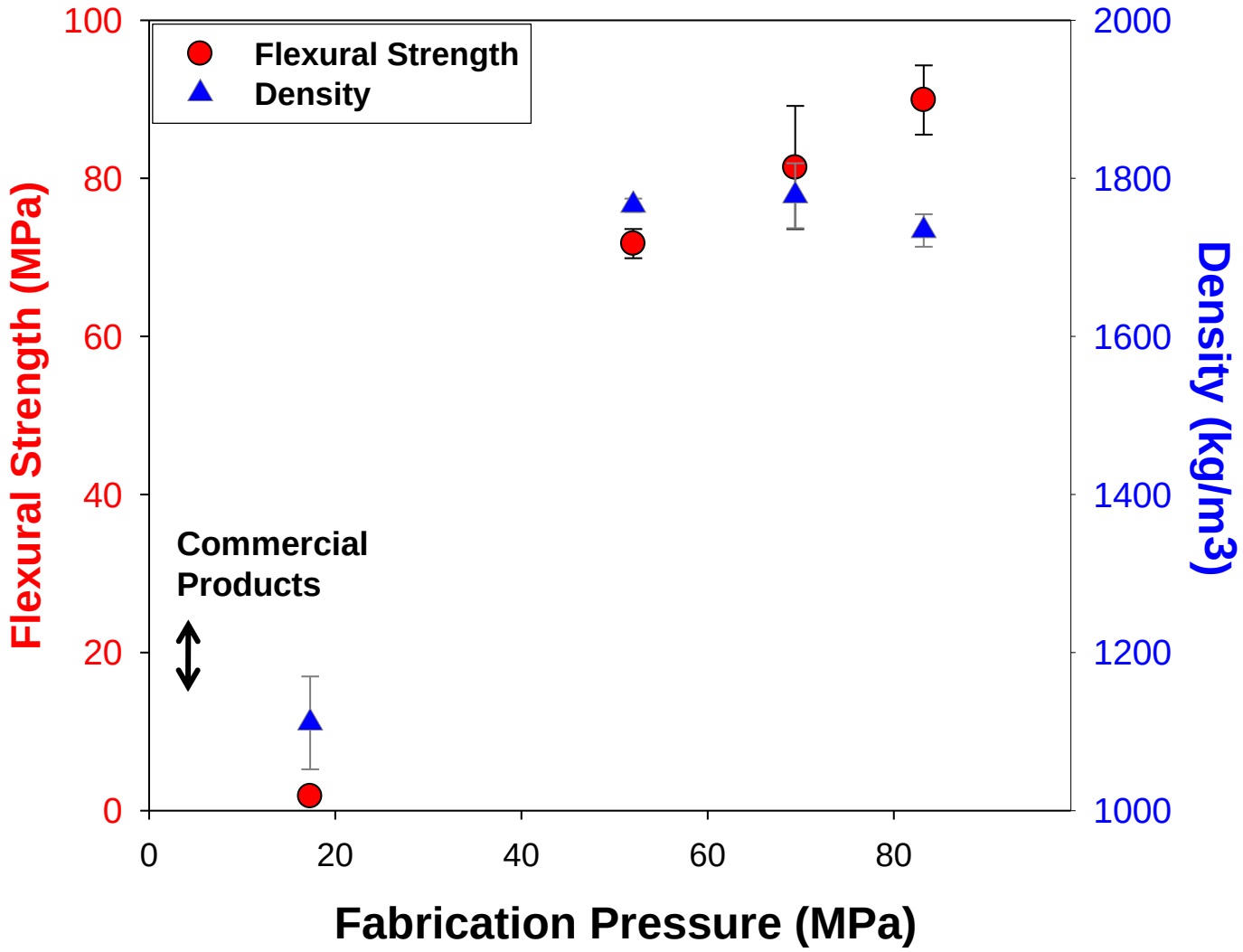


Mechanical Properties Of Commercial Wood Plastic Composites



Our products derived from FGD sulfite-rich material

Composites fabricated from FGD sulfite-rich scrubber material, plant byproducts, and natural polymeric material



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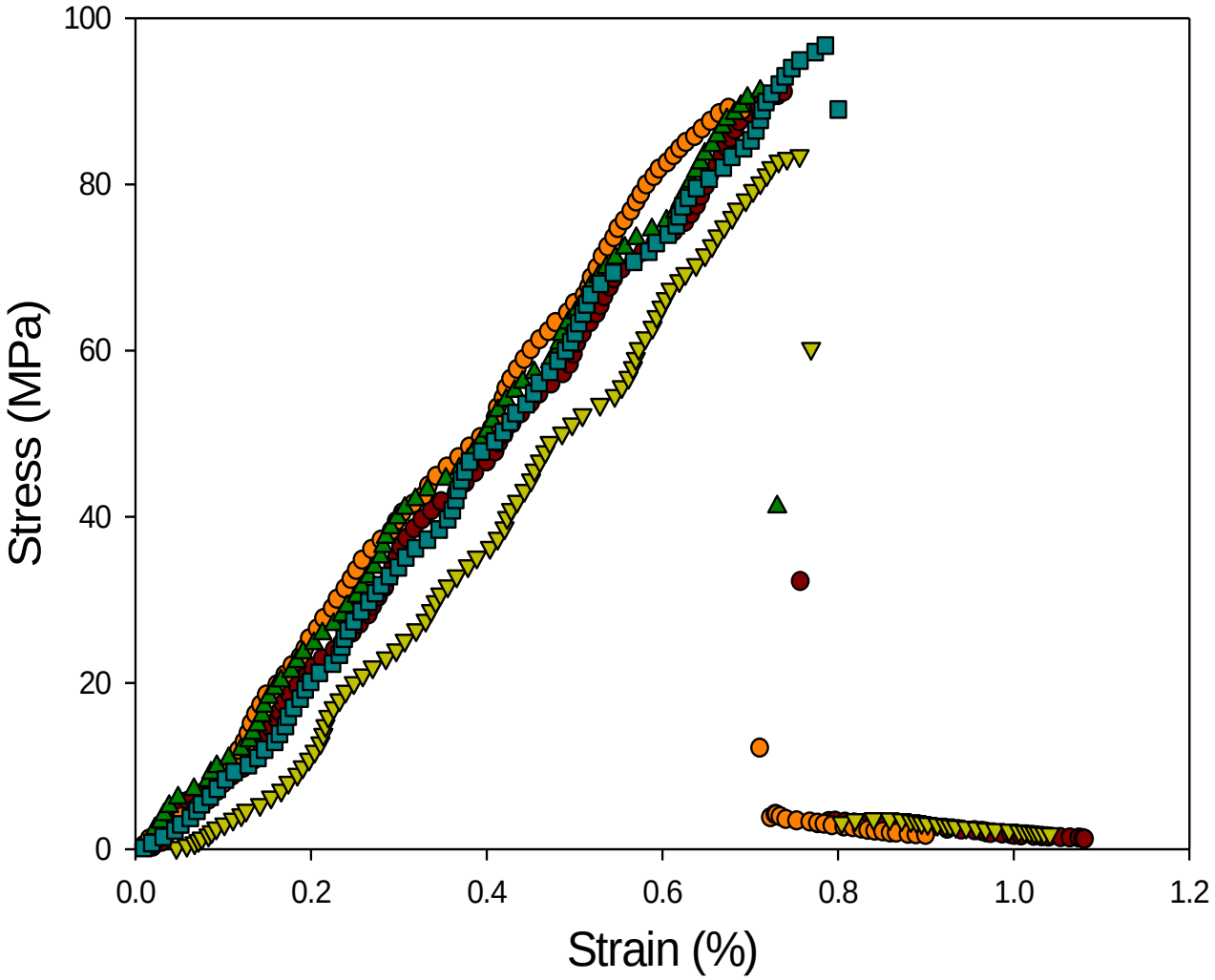

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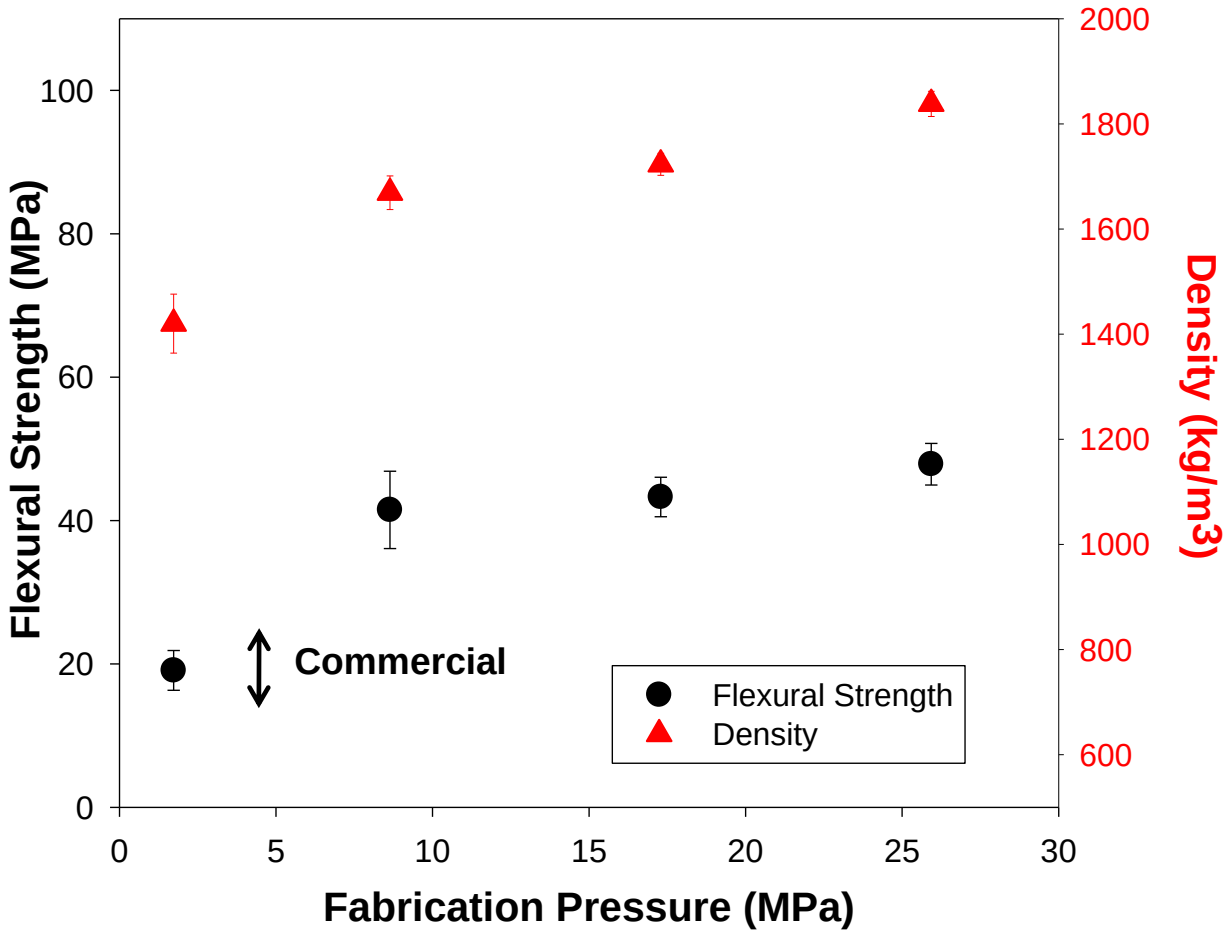
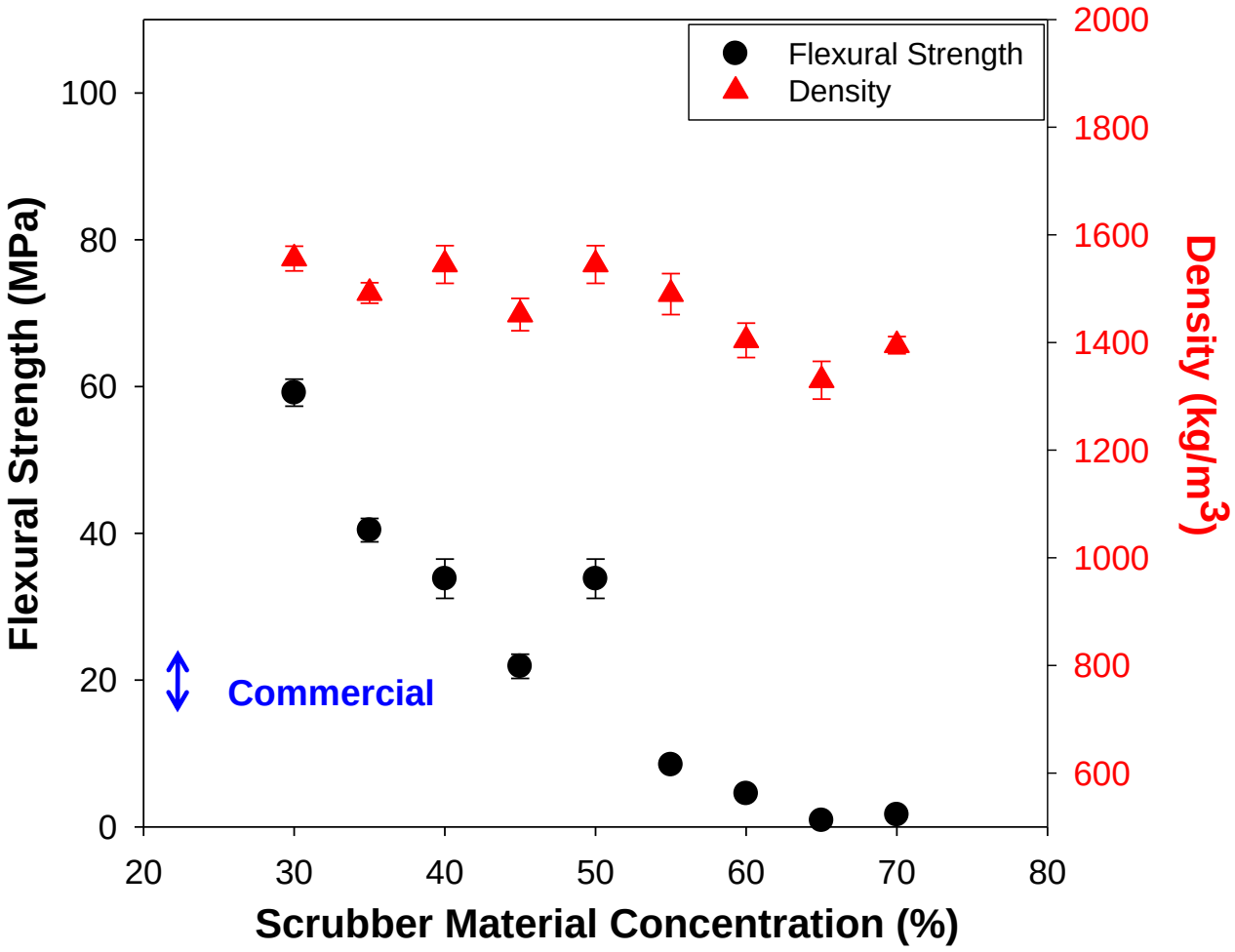


Composites Fabricated from 60 wt% (dry basis) sulfite-rich scrubber

Our products derived from FGD sulfite-rich material

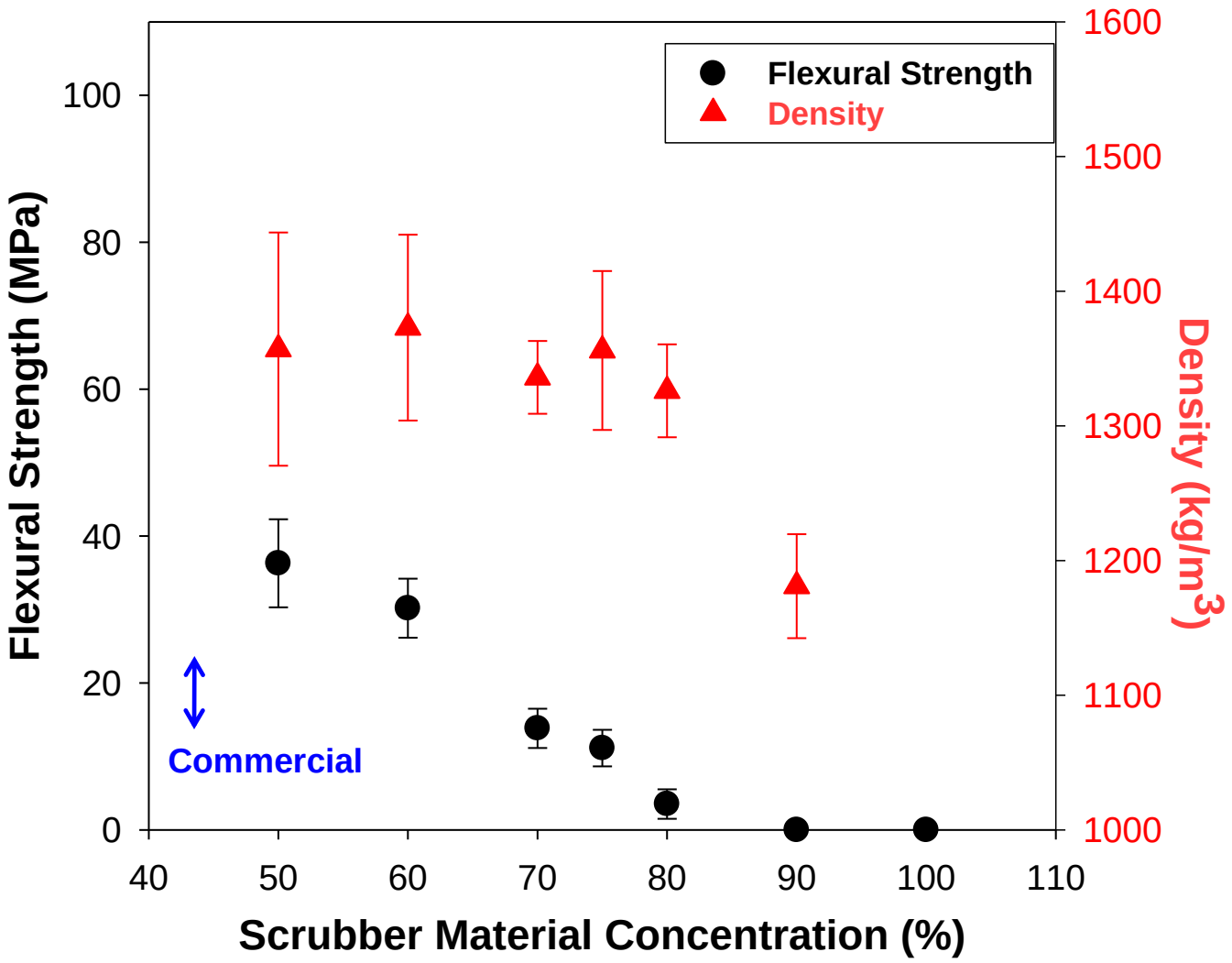
How much scrubber material could safely be used



Polymer:Plant Material Ratio: 4:1

Our products derived from FGD sulfite-rich material

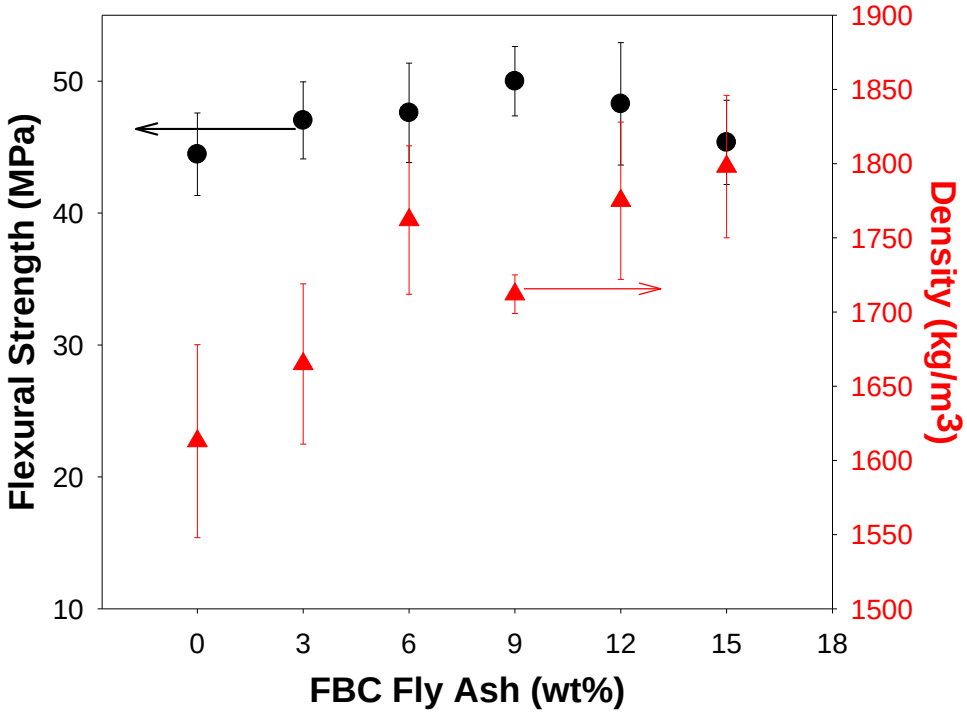
How much scrubber material could safely be used

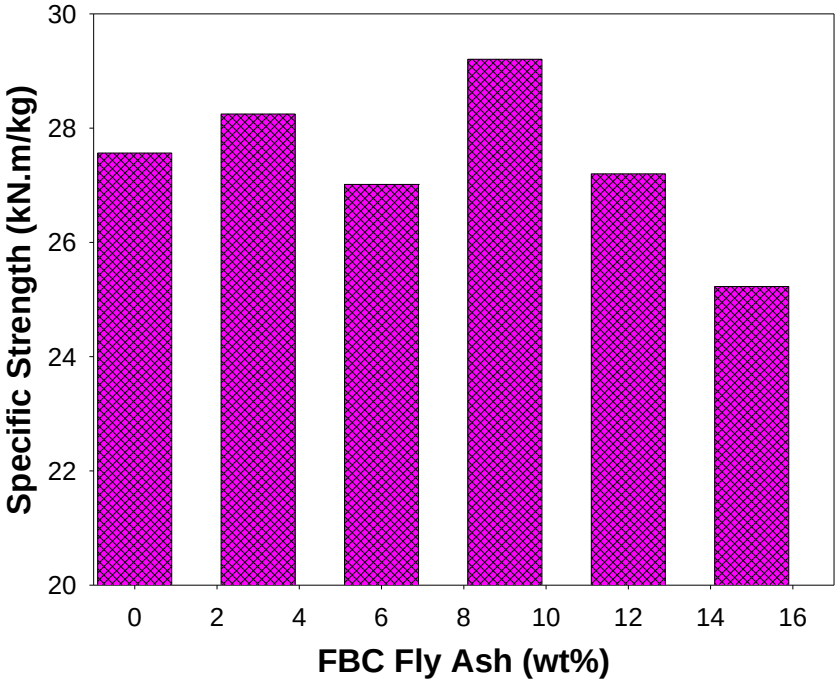


Polymer:Plant Ratio: 1:1

Our products derived from FGD sulfite-rich material

Density Reduction Attempts: FBC fly ash

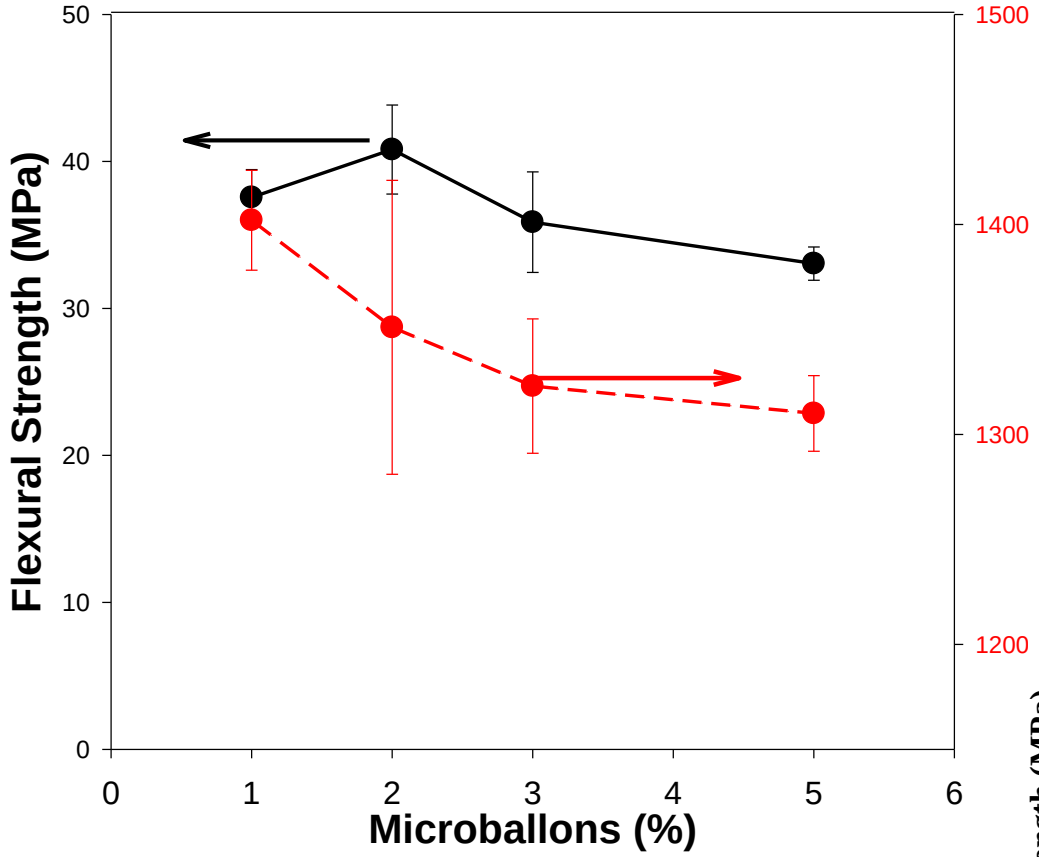


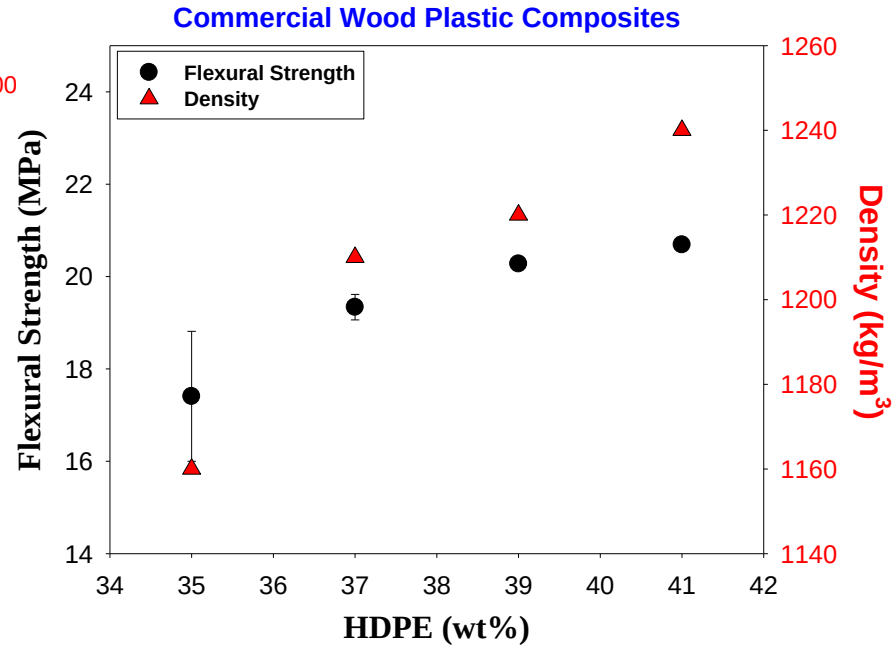


Composites Fabricated from
50 wt% sulfite scrubber material and
with various concentrations of FBC fly ash

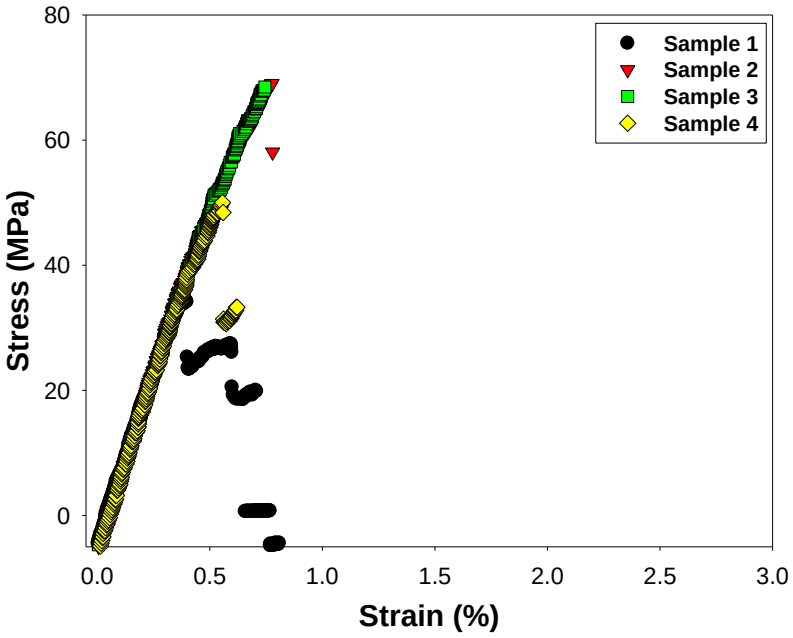
Our products derived from FGD sulfite-rich material

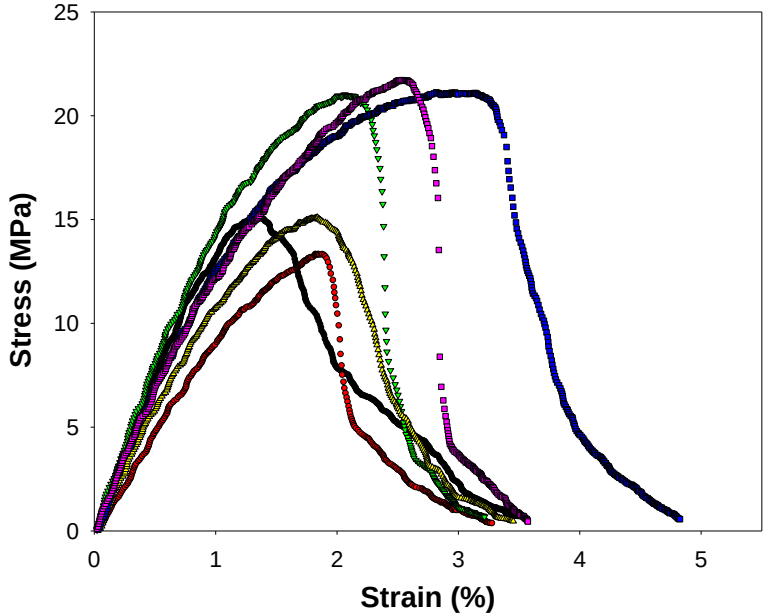
Density Reduction Attempts: Microballons



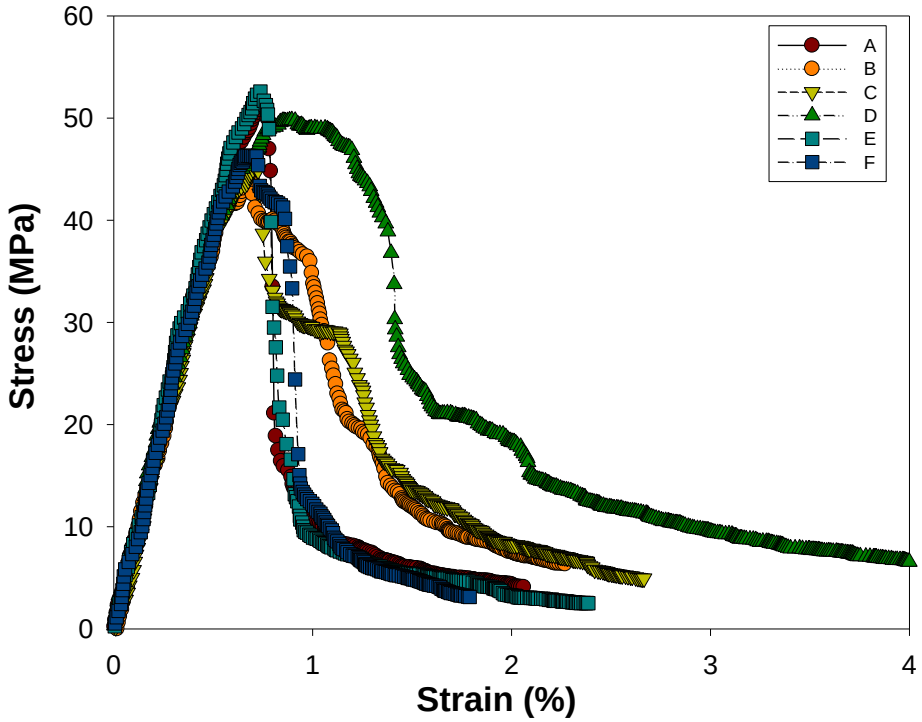


Our products derived from FGD sulfite-rich material





Strategy to Tackle Brittleness



Composites fabricated from 50 wt% FGD sulfite scrubber material and jute fibers

SUMMARY & CONCLUSIONS

- Last year we reported that applied pressure inhibits mercury's emission from FGD sulfite-rich scrubber materials. Experiments were repeated and we believe though mercury emission is a distinct possibility (~ 35%) at ambient pressure, mercury is unlikely to be emitted at our high pressure fabrication conditions at T < 250°C.
- The composites developed from sulfite-rich scrubber material, plant, and natural polymer had strength as high as 90 MPa (~ 13050 psi) and may be suitable products for shipping containers.
- It appears that we can use 60 wt% sulfite-rich scrubber material in our wood-substitute products and still have strength greater than commercial products on the market.
- The addition of FBC fly ash did not decrease the bulk density of the composites derived from sulfite-rich scrubber material, however, the addition of microballons did.
- Our initial wood substitute composites developed from sulfite-rich scrubber material show great promise ➔ further nurturing is required and is ongoing.