Aluminum Organic Thickeners for Styrene-Free Resin SMC

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Outline

- ❑ Motivation for Styrene-Free SMC
- ❑ Aluminum Organic Thickeners
- ❑ Viscosity Studies
- ❑ Equipment
- ❑ SMC Compounding
- ❑ SMC Compression Molding
- ❑ Mechanical Characterization
- ❑ Conclusions & Future Work

Motivation for Styrene-Free SMC

- In recent years, more stringent regulations have been introduced to reduce volatile organic compound (VOC) emissions.
- The desire to reduce VOCs will have an impact on styrene which is a key component in most commercially available SMC resins.
- Manufacturers seek to develop styrene-free resins with properties comparable to traditional resin systems.
- Opening opportunities for compounding and molding studies with developmental styrene-free resins.

Aluminum Organic Thickeners

- Aluminum organic compounds are used as rheology modifiers and thickeners for resins and oils.
- Provide thickening by forming covalent and coordinate linkages with hydroxyl and carboxyl functionalities.
- Aluminum organic compounds have been demonstrated as thickeners for polyester resins
- ACCE 2018
- US Patents:
- Kowalczyk, 2020, No. 10,745,552
- Pratt, 1981, No. 4,265,975
- Bailey, 1977, No. 4,049,748

Aluminum Organic Thickeners
Advantages

- Inert to moisture effects observed with traditional MgO thickeners
- Provides a predictable viscosity build
- Maintains a stable target viscosity for molding
- Provides a potential thickening solution for systems where MgO and/or isocyanates are ineffective

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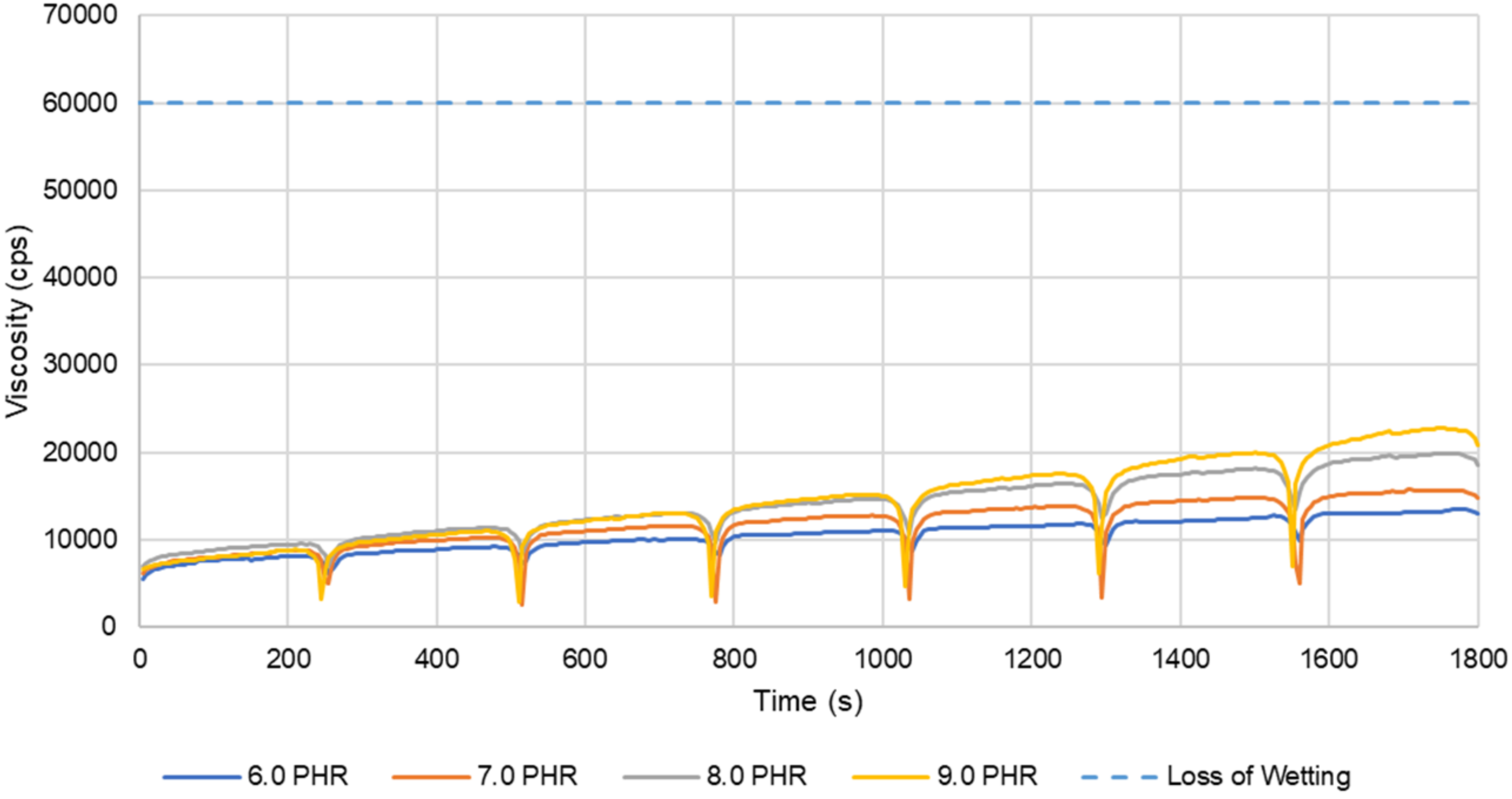
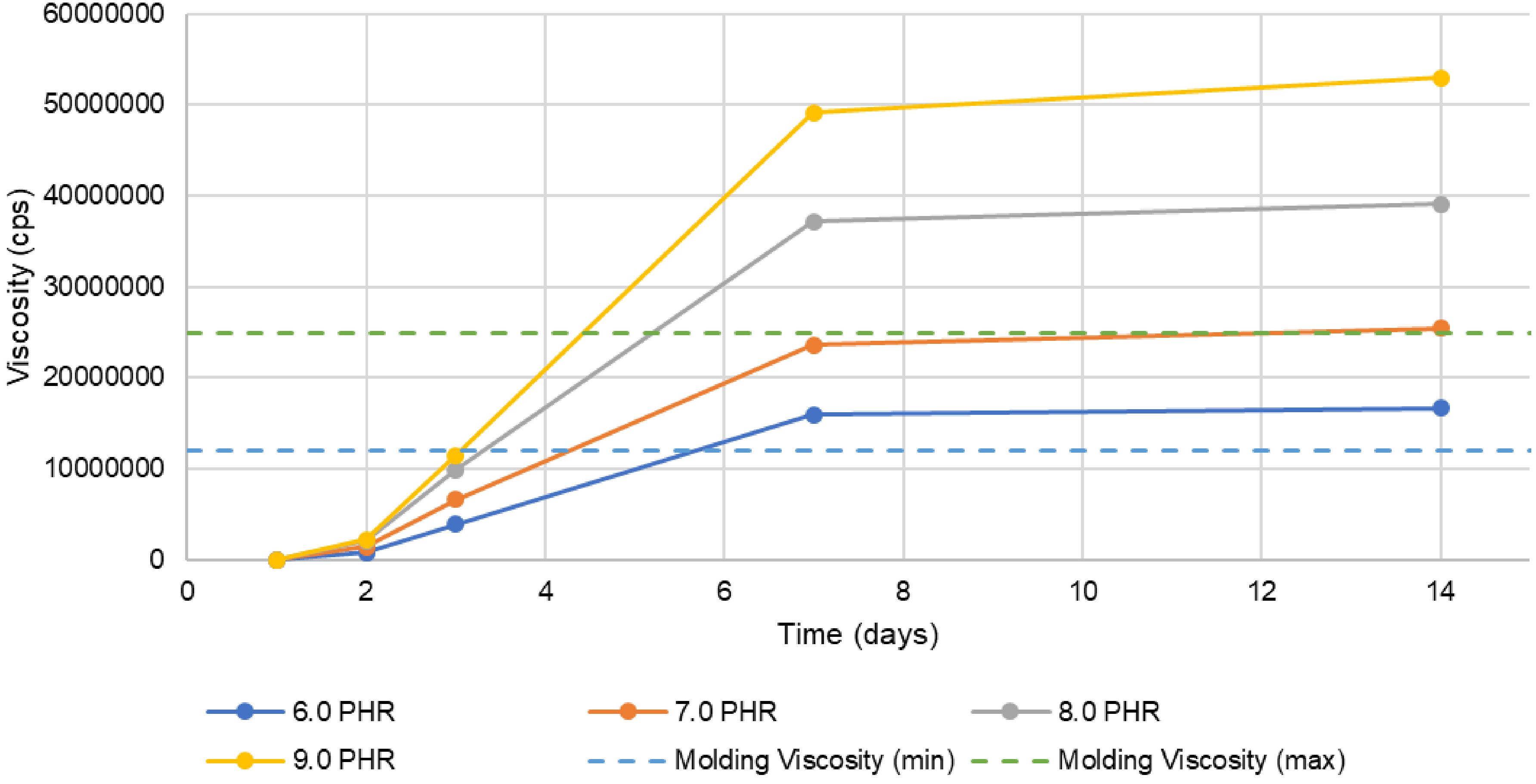
Viscosity Studies

- A novel styrene-free hybrid resin that cannot be thickened with standard MgO and/or isocyanates was chosen
- Viscosity screening studies were performed with this resin at FedChem using various Aluminum Organic Thickeners
- Suitable Aluminum Organic candidate was chosen based upon ability to meet desired viscosity targets
- Viscosity studies conducted at FIP were used to determine loading levels to meet viscosity targets for compounding and molding trials

Initial Viscosity Build



Target Molding Viscosity



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SMC Paste Formulations

Component	No LPA Paste (phr)	LPA Paste (phr)
Styrene-Free Hybrid Resin	38.00	38.00
Low Profile Additive	---	7.00
Dispersant	1.00	1.00
p-Benzoquinone (10%)	0.24	0.24
t-Butyl Peroxybenzoate	0.60	0.60
Calcium Carbonate	60.00	56.00
Zinc Stearate	2.00	2.00
FedChem XP519	2.66	2.66

Equipment

- SMC Line and 2500 tonne hydraulic press

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SMC Compounding

- Paste formulations were compounded with 30% or 40% glass fiber (GF) loadings
- Batch 1 – No LPA @ 30% Glass Fiber
- Batch 2 – No LPA @ 40% Glass Fiber
- Batch 3 – With LPA @ 30% Glass Fiber
- Batch 4 – With LPA @ 40% Glass Fiber

SMC Compounding

- Four batches of material successfully compounded. Fiber impregnation looks good on all batches.

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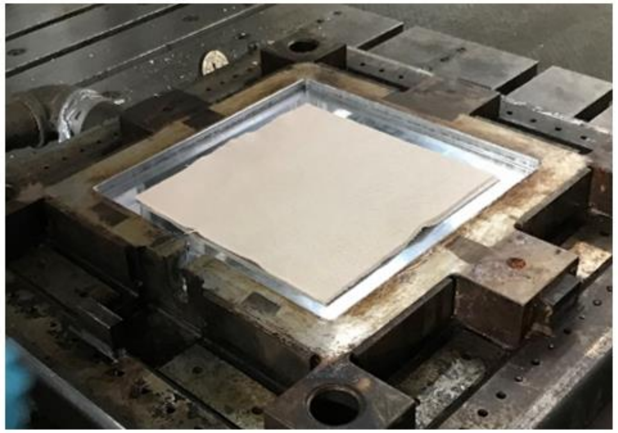
SMC Compression Molding



Tool Surface Temp.	Press Force	Closing Speed
150 ˚C	2,100 kN (100 bar)	Ramp: 100 – 1 mm/s over 10mm

- ❑ Roughly 3mm thick SMC parts were molded using a square plaque compression molding tool (18” by 18”).
- ❑ Charge pattern was two layers of 36 cm by 36cm squares (62% mold coverage).

SMC Compression Molding

- No noticeable differences in molding when compared to commercially available SMC
- No qualitative difference in appearance between parts created with or without LPA (30 wt% GF)
- Unfortunately, we observed some dry fiber with the Batch 2 parts (40 wt% GF, without LPA) so these parts were not included in further testing

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Mechanical Characterization

- Four plaques were selected from each of the three successful batches for mechanical testing
  - Batch 1 – no LPA @ 30% GF
  - Batch 3 – w/ LPA @ 30% GF
  - Batch 4 – w/ LPA @ 40% GF
- Tensile Testing (ASTM 638) – 2 per plaque
- Flexural Testing (ASTM 790) – 2 per plaque

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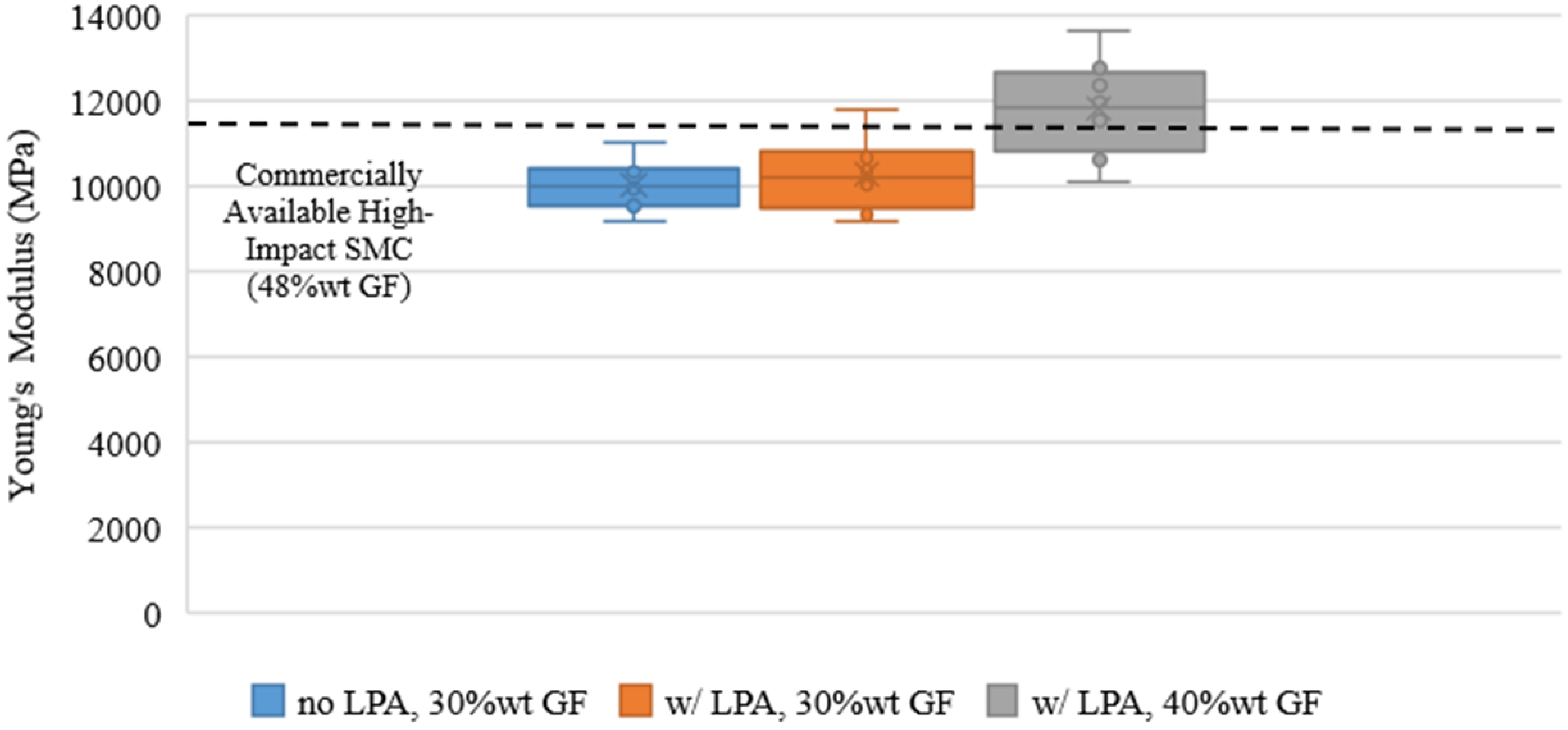
Tensile Properties – Young's Modulus by Batch



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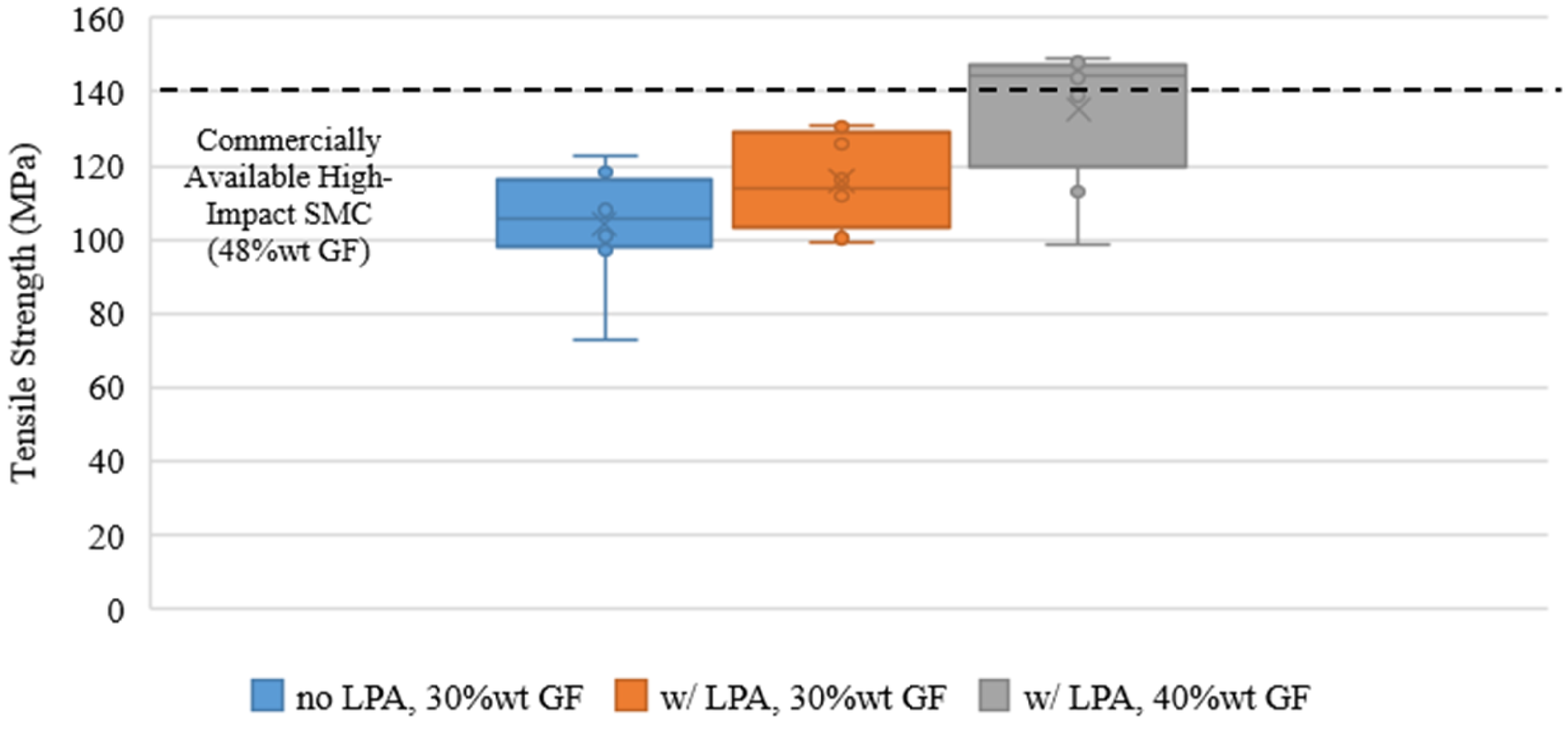
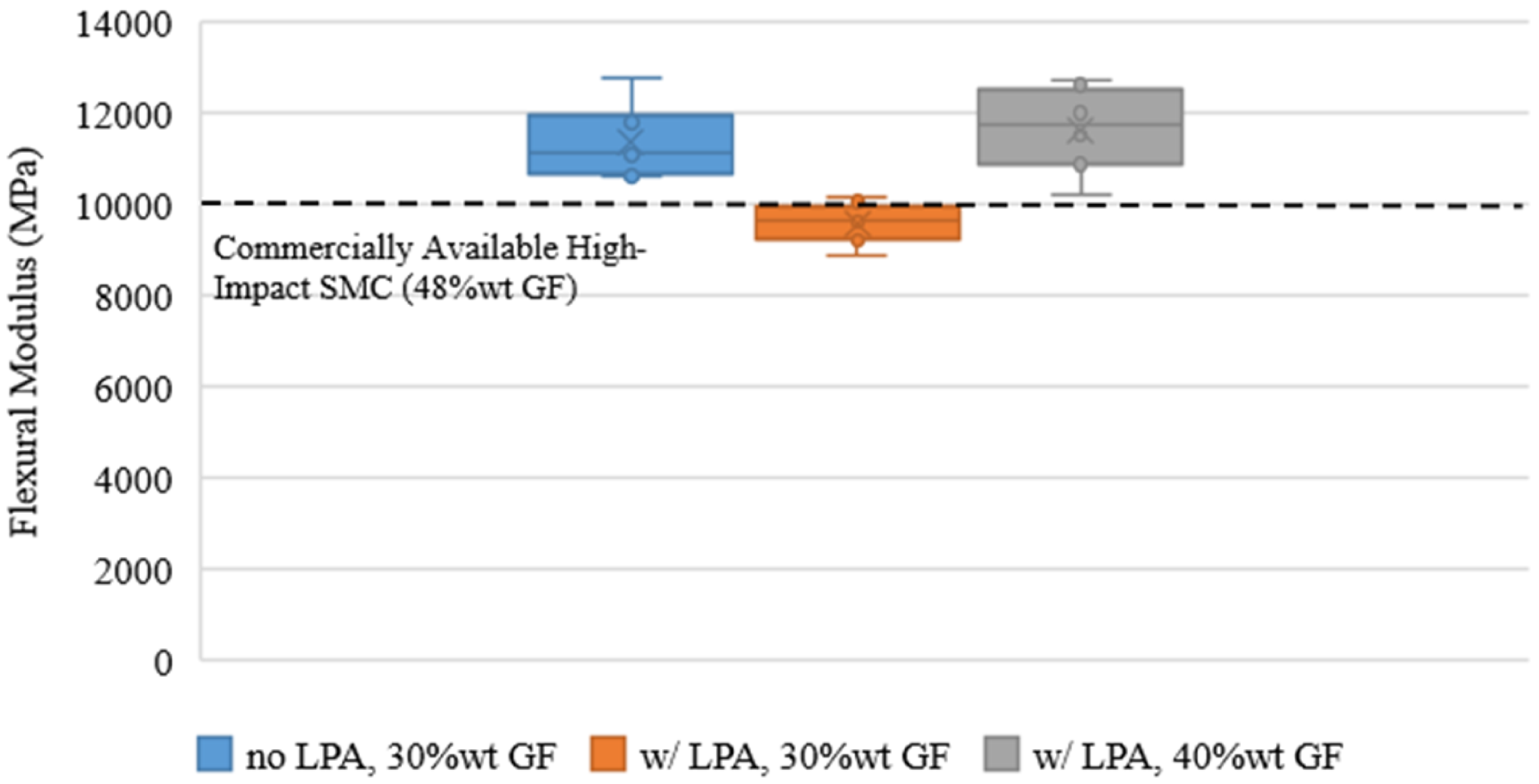
Tensile Properties – Tensile Strength by Batch



Flexural Properties – Flexural Modulus by Batch



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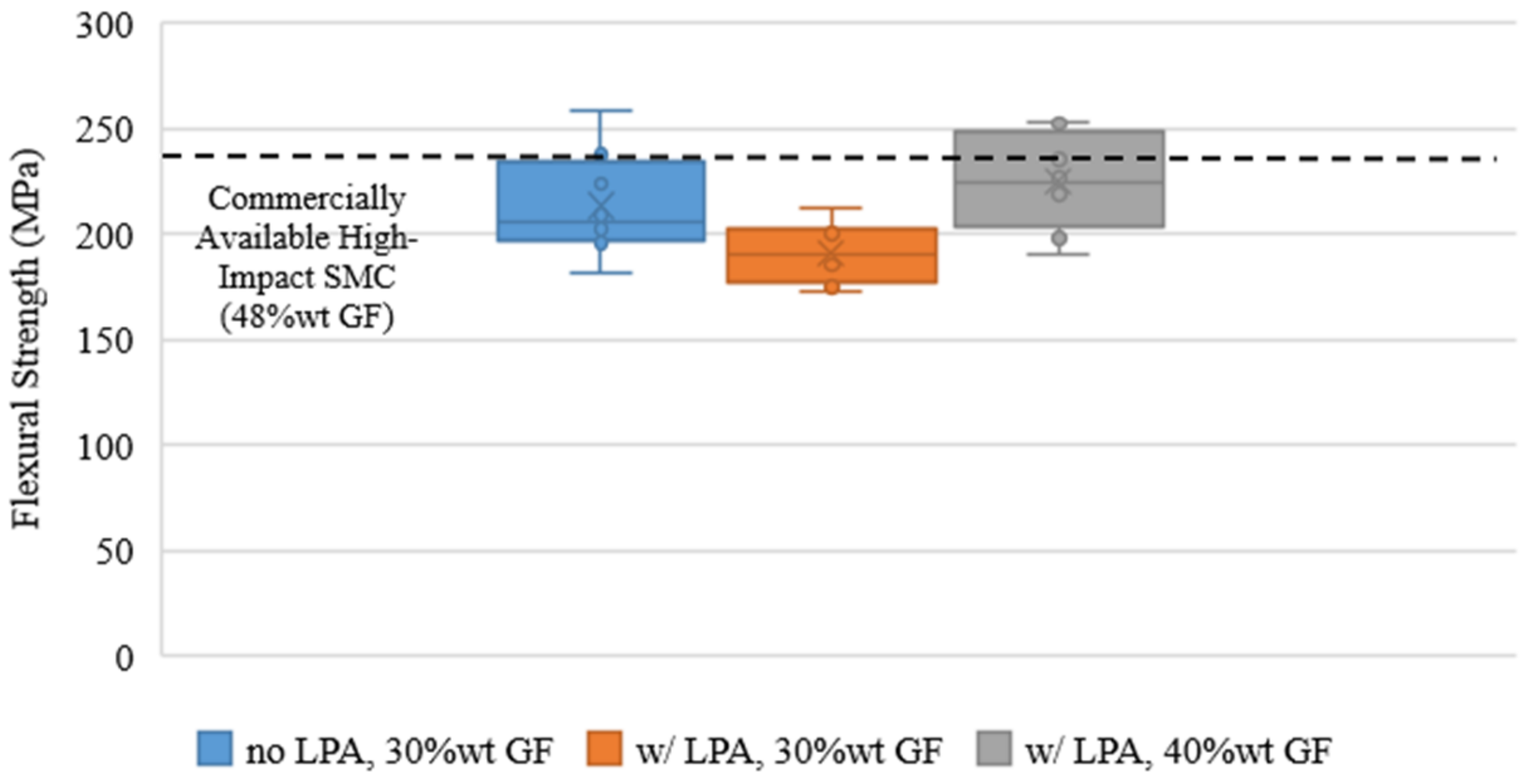
Flexural Properties – Flexural Strength by Batch



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Comparison of Mechanical Properties

- ❑ Mechanical testing results were promising and suggest good interfacial bonds between resin and fiber despite lack of styrene (Batch 1).
- ❑ The styrene-free resin could not be thickened with MgO or isocyanates. No true control.
- ❑ Comparing Batch 4 (w/ LPA, 40%wt GF) to a commercially available SMC (48%wt GF)
  - ❑ Young's modulus, tensile strength, and flexural strength within 10% of control
  - ❑ Flexural modulus outperforms commercially available SMC by ~15%.

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Conclusions and Future Work

- ❑ Aluminum Organic Thickeners provide an alternative method for compounding and molding novel resins systems not amenable to standard thickening agents
- ❑ Mechanical testing shows that these thickeners can produce parts with properties comparable to commercial available SMC
- ❑ Explore truly styrene-free systems with Aluminum Organic Thickeners
- ❑ Continue to optimize this chemistry for SMC applications

Acknowledgments

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