Compression Molding Fabrication of C/C Composite Produced via Highly Processable BODA-Derived Precursor Resin System

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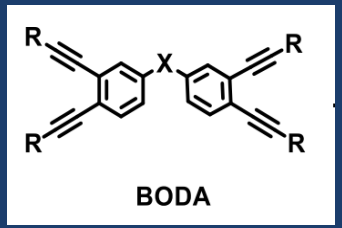

Introductions

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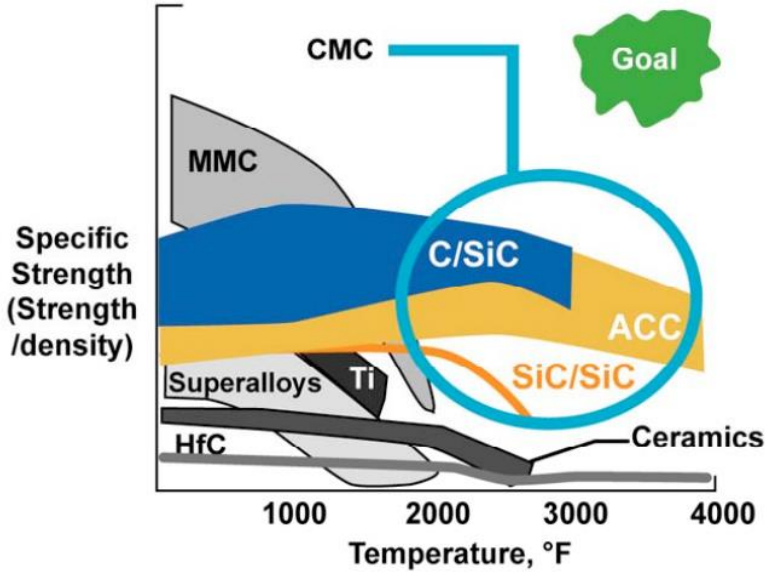
Problem Statement 1/2

- Carbon/Carbon (C/C) manufacturing
  - Long Manufacturing Time
  - Decades Old Precursor Technology
- Manufacturing Methods
  - CVD
  - Mesophase Pitch
  - Synthetic Precursor Resin
- Precursor resins allow for greatest production rates -> industry standard is phenolic resins which require multiple step carbonization and reinfusions to avoid porosity

Why do we want Carbon/Carbon?

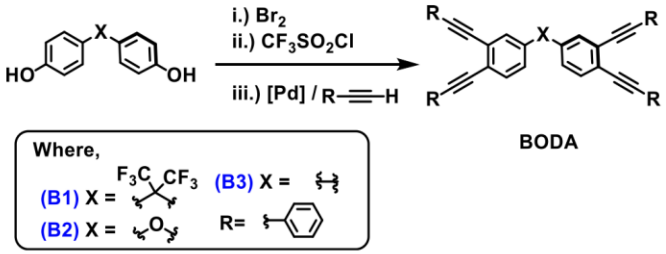
- Material Properties
  - High Specific Strength
  - High Thermal Stability
  - Low CTE
- Applications
  - Leading Edge of Space Shuttle
  - High Performance Brakes
  - Rocket Motor Nozzle Throats



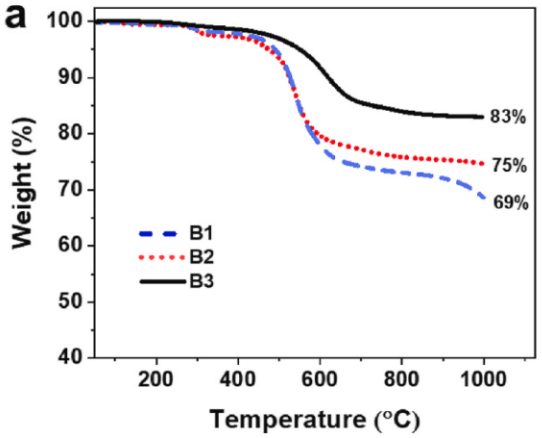
D. E. Glass, "Ceramic Matrix Composite (CMC) Thermal Protection Systems (TPS) and Hot Structures for Hypersonic Vehicles," 15th AIAA Space Planes and Hypersonic Systems and Technologies Conference, Dayton, OH, Apr. 28–May 1, 2008, AIAA-2008-2682.

Problem Statement 2/2

- BODA has high char yield and high oxidative stability as a polymer
- Properties allow for one-step infusion and carbonization greatly reducing processing time for a finished C/C part.



Borrego et. Al (citation not finished)



10 ° C/min under Ar flow

Composite manufacturing w/BODA

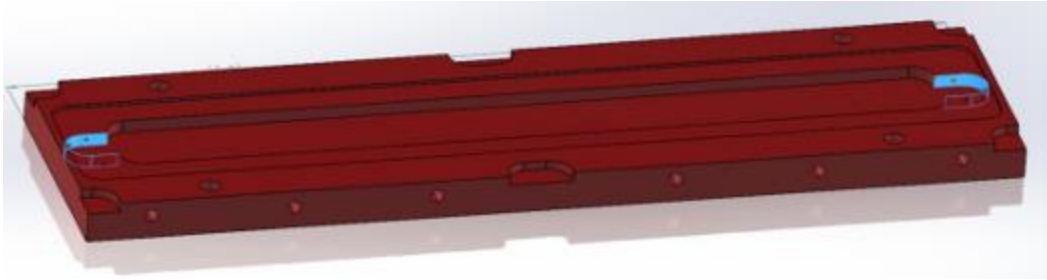
- BDR has limited composite manufacturing (TRL 4-5).
- Create a process for compression molding BDR C/C parts
- Get hands-on composite manufacturing experience

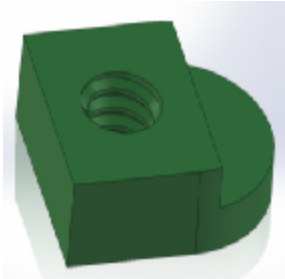
Overview

- "One-step powder-melt infusion and compression molding"
  - Mold (designed for ASTM D3039 coupons and fabricated)
  - Cure schedule (developed by chemists, iteratively improved by and for ASE students and instrument capability [more on this later])
  - Fiber and Resin Layup
  - Demolding
  - Processing
  - Carbonization

Mold

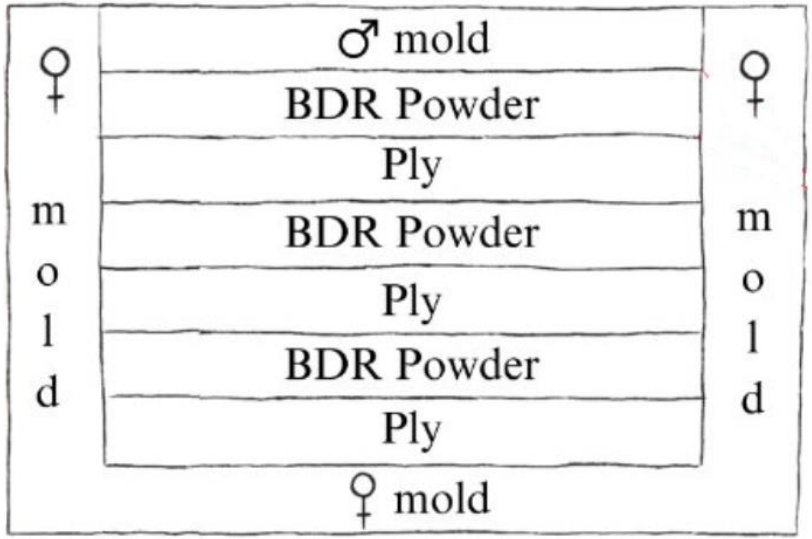
- Mold Design with features mentioned:
  - Draft angle
  - Male and female mold
  - Thermocouple port
  - Access pieces



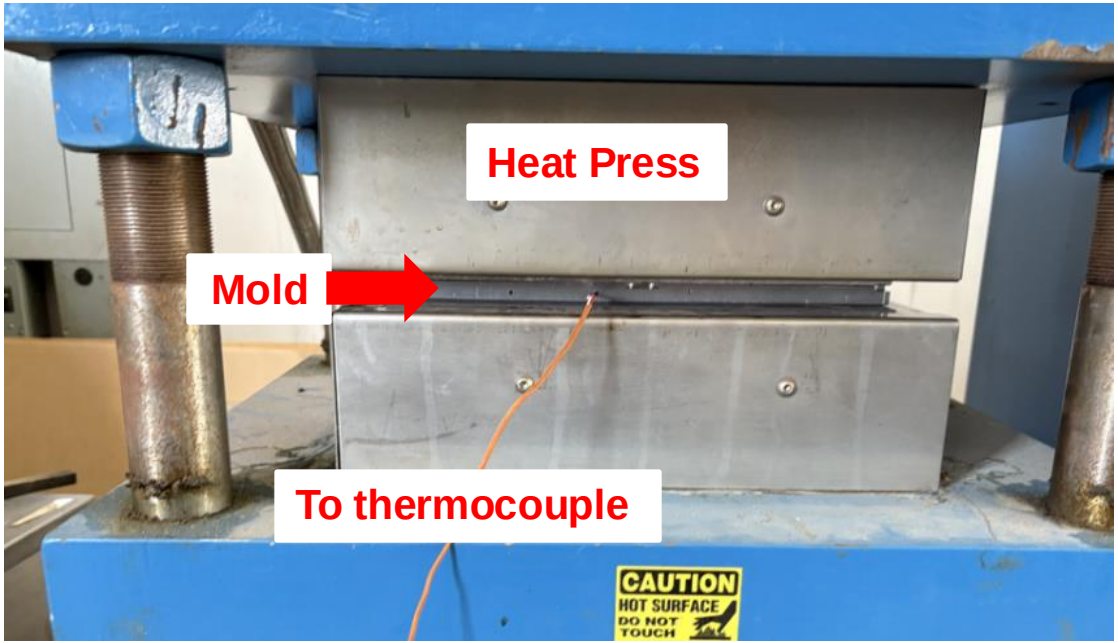


Mold Prep and Fiber/Resin Layup

- Mold prepped with 5 layers of Loctite Frekote 900-NC



Curing for Thermoset



Demolding and Carbonization

- Coupon pried from mold
- Cut to size
- Carbonized at 1000°C in a tube furnace

Results

Trial	Result
1	Resin starved, 1 ply saturated with resin
2	Resin starved; 2 plies saturated with resin
3	Resin starved, delaminated upon carbonization
4	Delaminated upon carbonization
5	Carbonized successfully
6	Carbonized successfully
7	Failure due to wrinkling while cooling
8	Failure due to wrinkling while cooling
9	Failure due to wrinkling while cooling
10	Failure due to wrinkling while cooling
11	Carbonized successfully
12	Carbonized successfully
13	Delaminated upon removal from mold

Failures

- Resin starvation
- Delamination
- Demolding CTE Mismatch Buckling

Conclusions

- Novel undergrad student-led C/C composite manufacture process
- Table of improvements
  - Hand Cut Fibers -> Gerber Machine-cut fibers
  - Unevenly Spread Resin -> Evenly Spread
  - Inaccurate heat press temperature -> Implementation of thermocouple
  - CTE Mismatch Buckling -> Demold before cooled to RT

Future Work

- SEM
- Porosity
- Tensile Testing

Acknowledgments

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- Matthew Roberson, Advanced Composites Institute

References

Questions?

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