Twin Screw Extrusion Processing of a Nanoalumina Based Formulation

15th JOCG Continuous Mixer and Extruder User Group Meeting

Presented by Rajen Patel

Contributors

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Outline

- Nano-Energetics
- Twin Screw Extruder
- 7.5 mm Mini Twin Screw Extruder Details
- Experimental Results
- Conclusions
- Future Work

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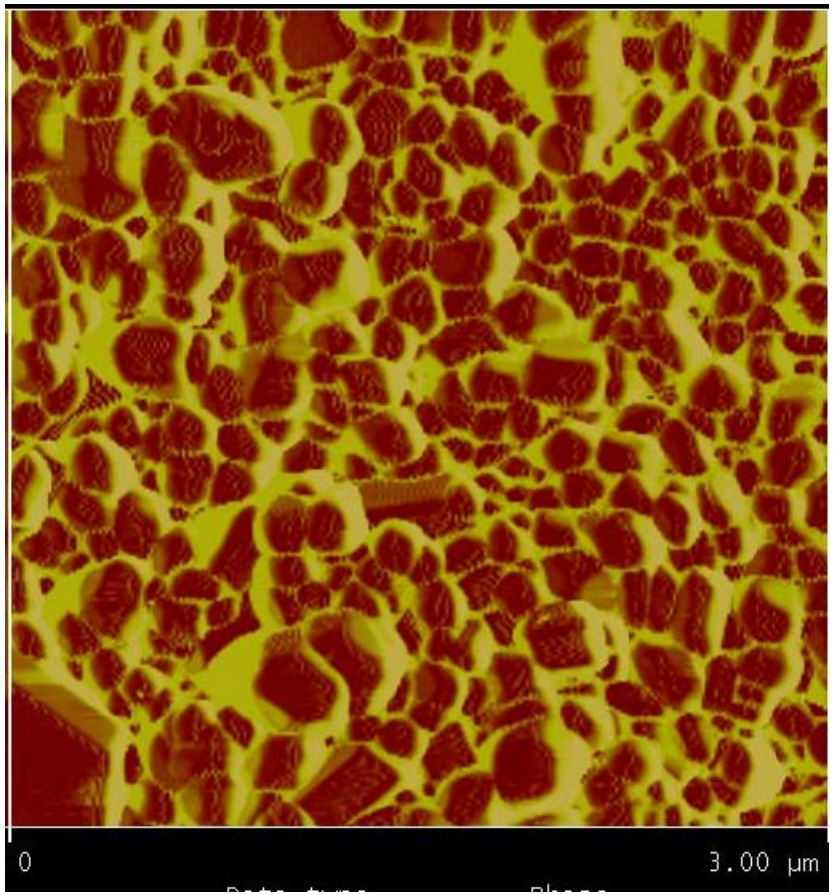
Nano-Energetics

Benefits

- Increased Lethality and Performance
- Decreased Sensitivity

Drawbacks

- Expensive
- Difficult to Process

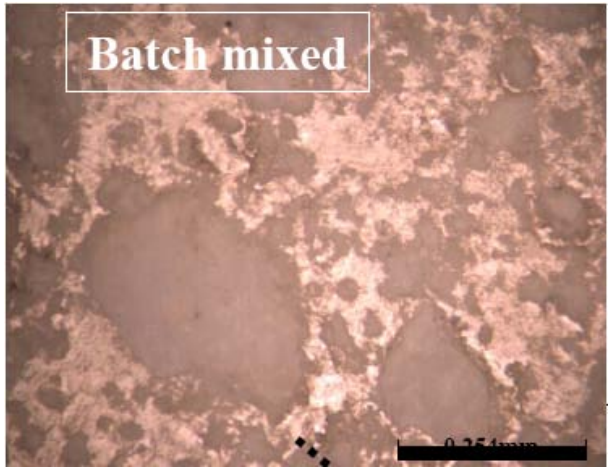


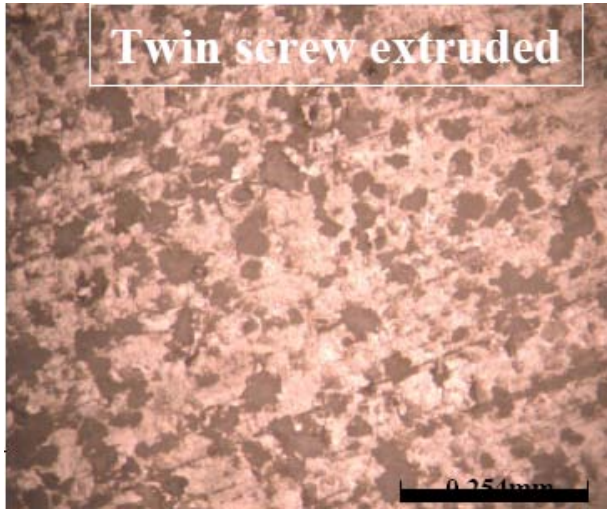
Twin Screw Extruder

- Continuous, high shear process
- Precise controls available throughout extrusion process

-Feed Rates Controllable

-Additional mixing sections can be used





Twin Screw Extruder and Nanoenergetics

- Twin Screw Extruder can solve problems inherent in nanomaterials
- A simulant formulation was used to test TSE's ability to process nanomaterials

-75% HMX, 5% nano-Aluminum, 8% CAB, and 12% ATEC

- Material was processed at ARDEC using a roll mill and at Stevens using Twin Screw Extruder
- After the project, Twin Screw Extruder was moved to ARDEC

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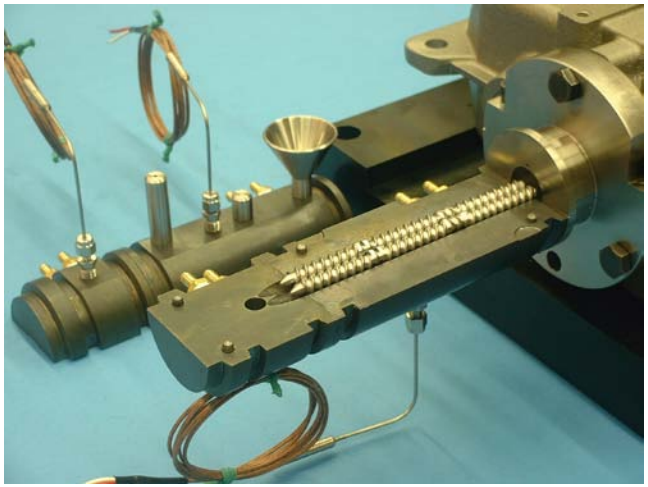
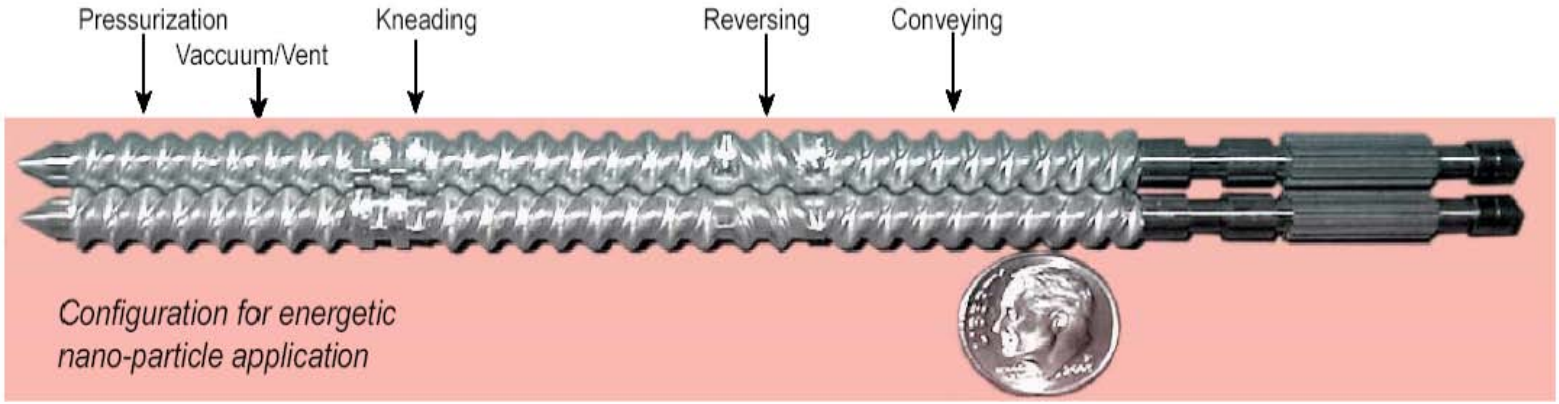
7.5 mm Twin Screw Extruder

- Fully Intermeshing, Co rotating, bore diameter of 7.5 mm, screw diameter of 7.38, and clearance is D/128 (+/- 60 microns)

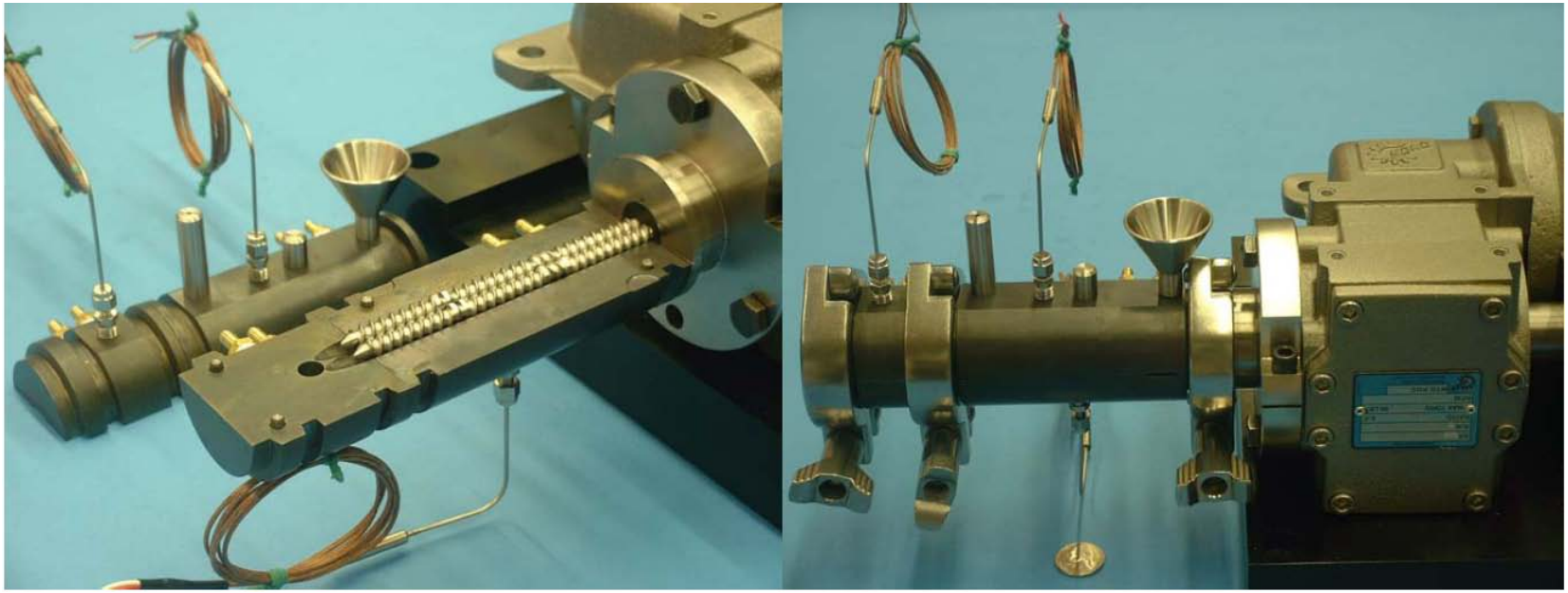
- Screws monolithic, made from cast iron, possessing kneading and reversing sections, 3 sealed mixing and vacuum zones





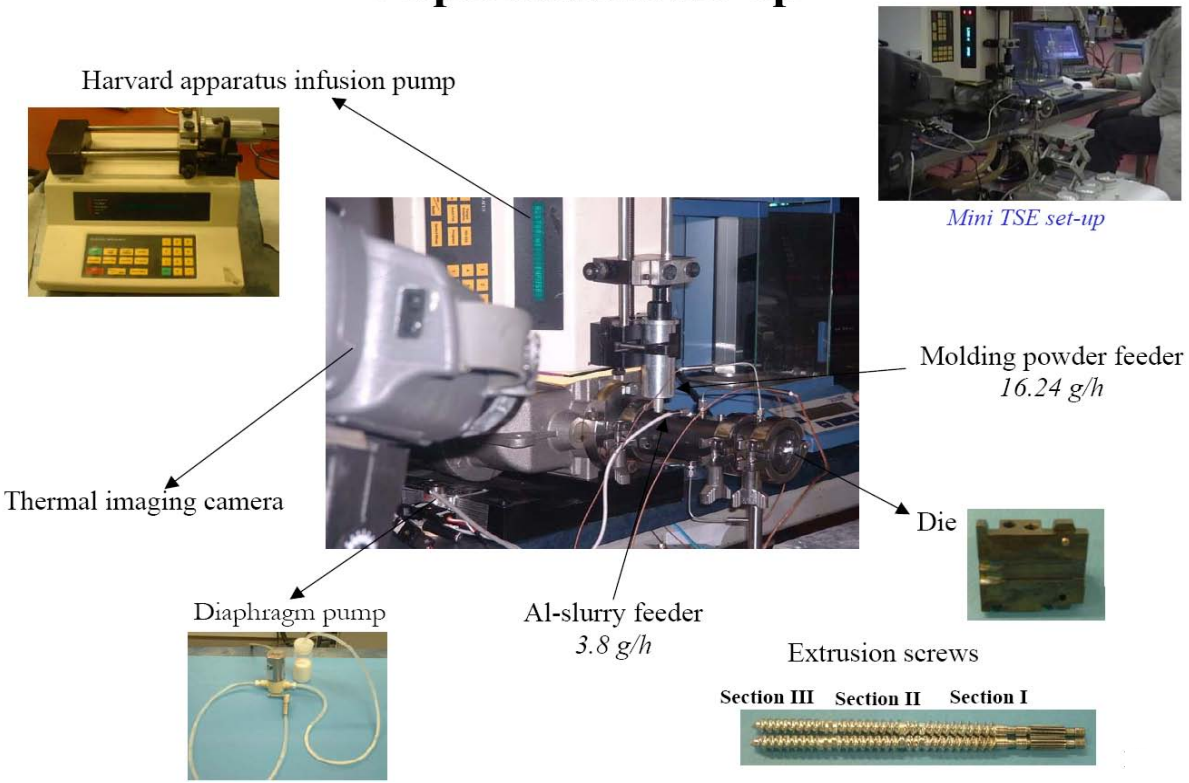
7.5 mm Twin Screw Extruder

- Assembly includes the following: Two Temperature Control Zones, 3 thermocouples for controlling metal temperature, screw speed controllable up to 200 rpms



Experimental Set Up

Experimental set-up



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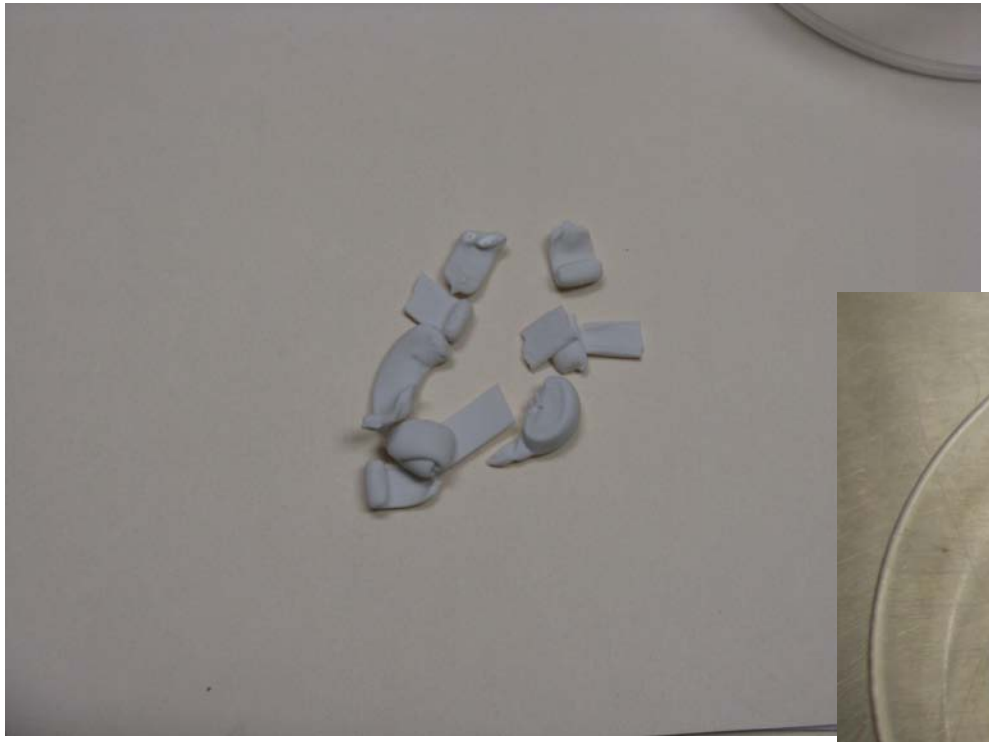
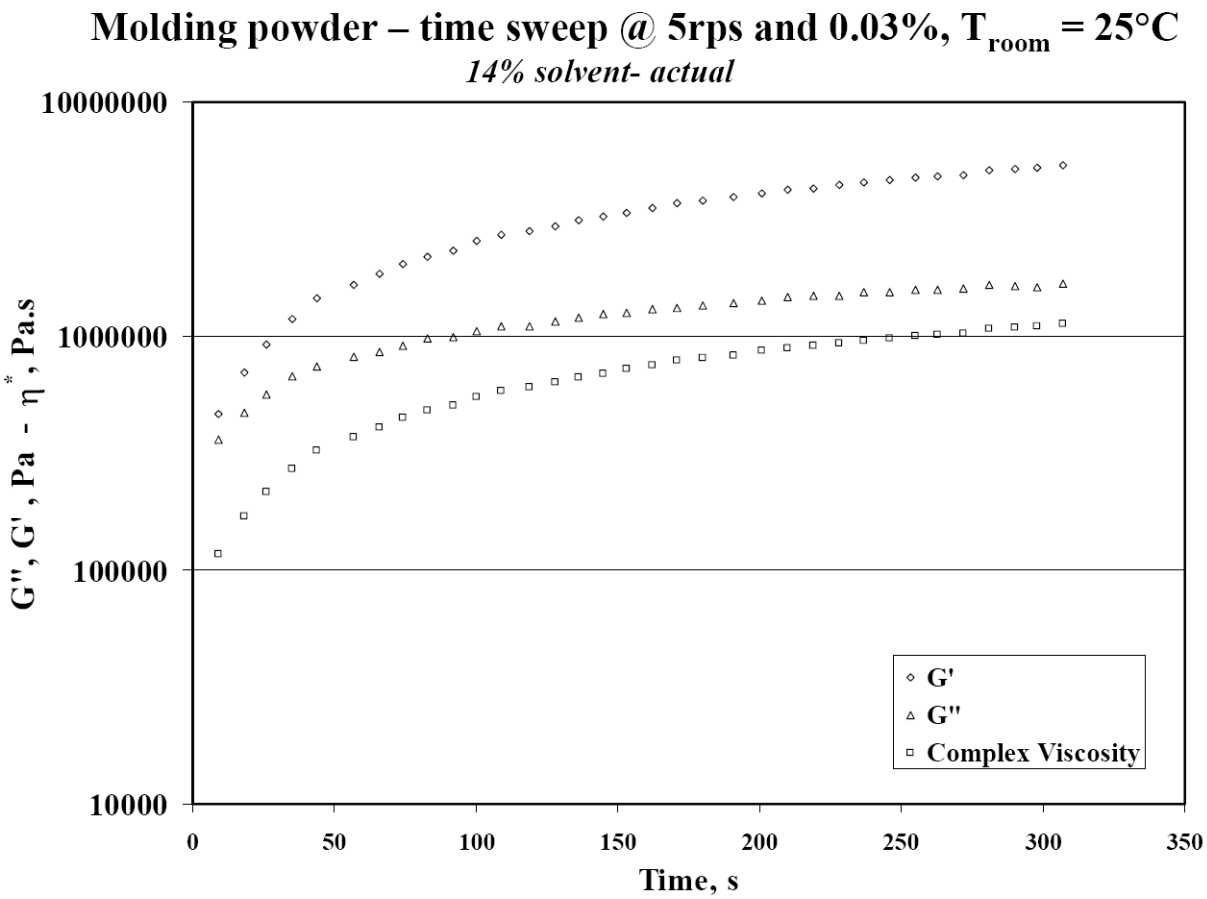
Roll vs. Twin Screw Extruder



Twin Screw Extruded material is visibly homogeneous, and further analysis was performed.

Roll Milled material is visibly not well mixed, and suffers from settling issues. Further work was not performed.

Dependency of Properties on Solvent loss



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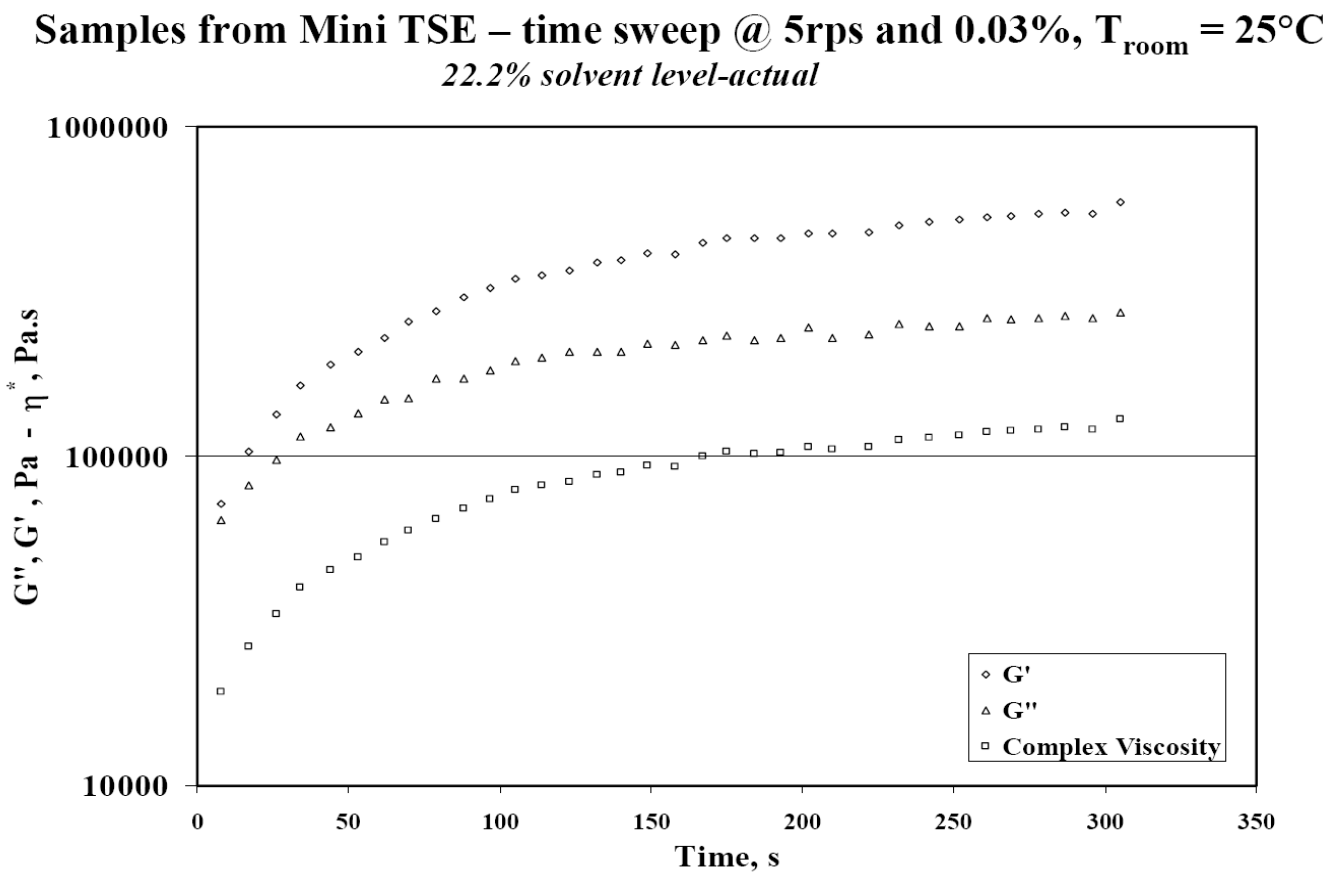
Dependency of Properties on Solvent loss



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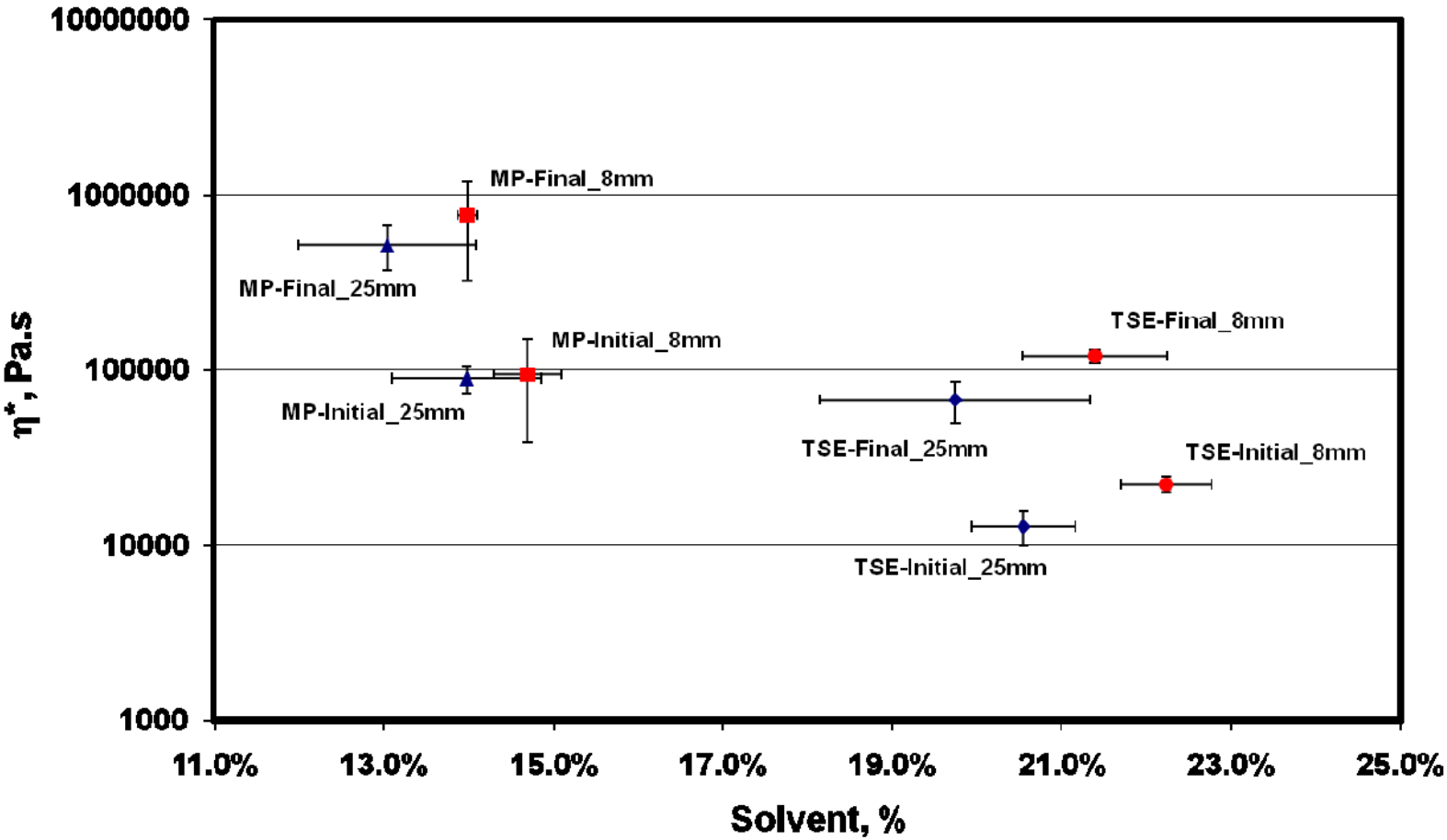
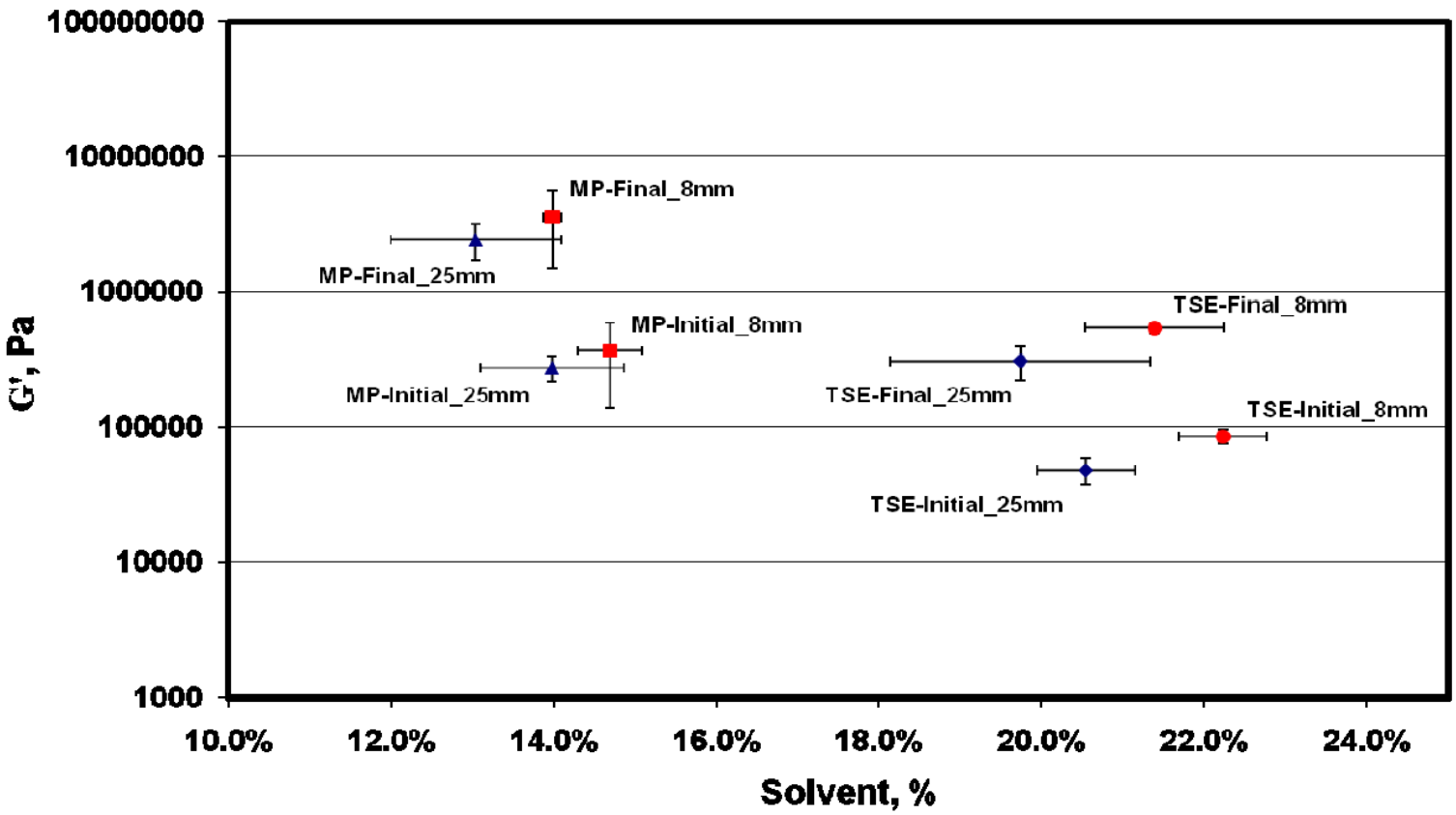
Magnitude of Complex Viscosity vs. Solvent



Shear Storage Modulus vs. Solvent Concentration



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Conclusions

- In order to evaluate results completely, degree of mix study is needed
- Rheological properties highly dependent on solvent mixture

-Using solvents one can utilize TSE to process nanomaterials

- Final formulation has lower dynamic properties than original molding powder
- Narrow confidence intervals indicate material is relatively homogenous
- Roll Mill was grossly inadequate in comparison to Twin Screw Extruder

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Future work with TSE

- Dispersion of nanomaterials into polymers

-Disperse nanotubes within polymer to enhance properties

- Creation of new nanoexplosives
- Formulation of traditional explosives/IM Explosives in more efficient, more controllable method
- 7.5 mm TSE will provide ideal device to experiment with continuous operations on novel and legacy explosive formulations