Effect of Dispersion Homogeneity and Formulation on Electrical Properties of Liquid Metal Polymer Composites

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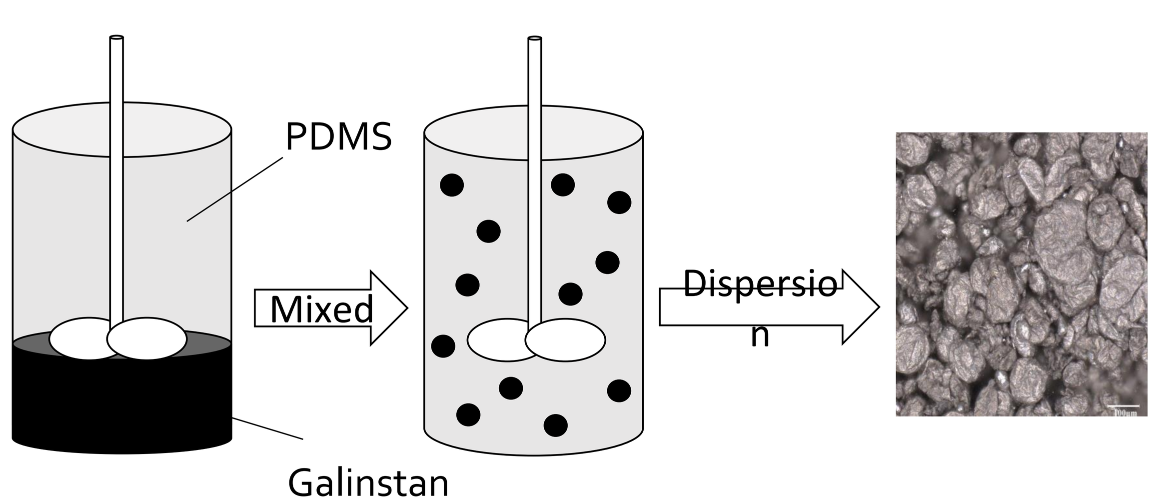
Introduction

- Composites of eutectic room temperature liquid metals (LMs), such as gallium-indium-tin (galinstan), have demonstrated effectiveness for creating soft materials with adjustable mechanical and electrical properties.
- Liquid metal polymer composites (LMPCs), Galinstan in PDMS, have high relative permittivity and low modulus, making them ideal for use as deformable dielectric materials. However, settling of the dense liquid metal particles prior to complete elastomer curing may affect morphology, mechanical performance, and dielectric behavior. This project will investigate that effects.

Methods



PDMS blends are made from additive-free pre-polymer, and it differs form each LM droplet size:

	Vinyl-terminated PDMS	Trimethyl-terminated PDMS
1µm	DMS-V41, 1 × 10^4 cSt	
10µm	DMS-V41, 1 × 10^4 cSt	DMS-T11, 10 cSt
100µm	DMS-V21, 1 × 10^2 cSt	DMS-T11, 10 cSt

Figure 1: Synthesis of of LMPCS.

Methods

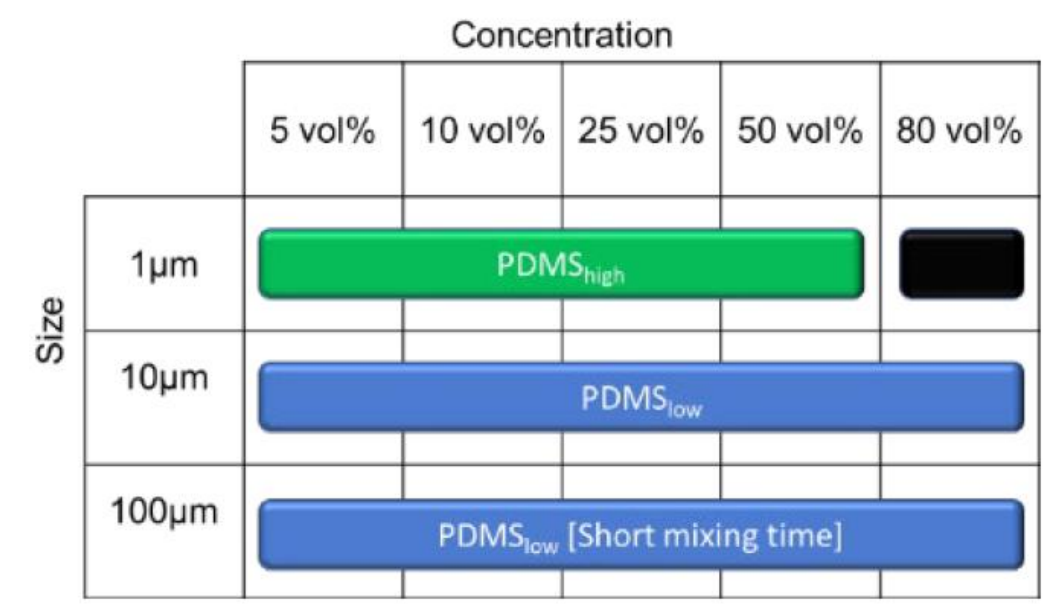
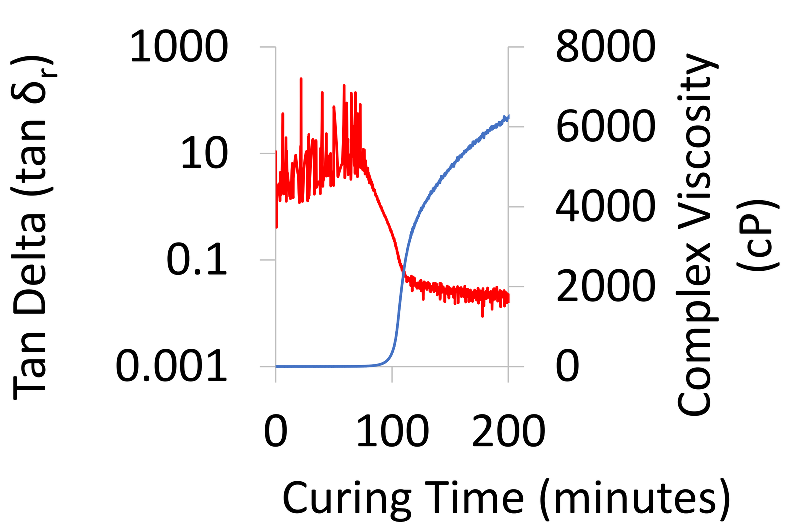
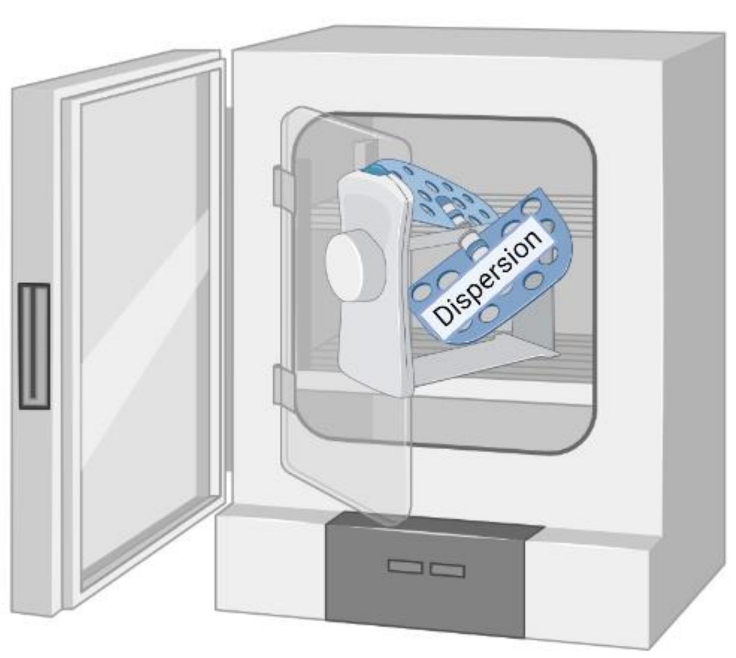


Figure 2: LMPC dispersion formulation matrix.

Complex viscosity and tan δ_r (ratio of loss to storage modulus, G''/G') of PDMS curing at 25°C.





Samples are secured onto a rotator and rotated until the time at which δ_r=1, then completely cured in an 82°C oven.

Figure 3: Synthesis of homogeneous LMPCs.

Figure 4: Electrical properties of PDMS were measured with an impedance analyzer and dielectric test fixture.

Results

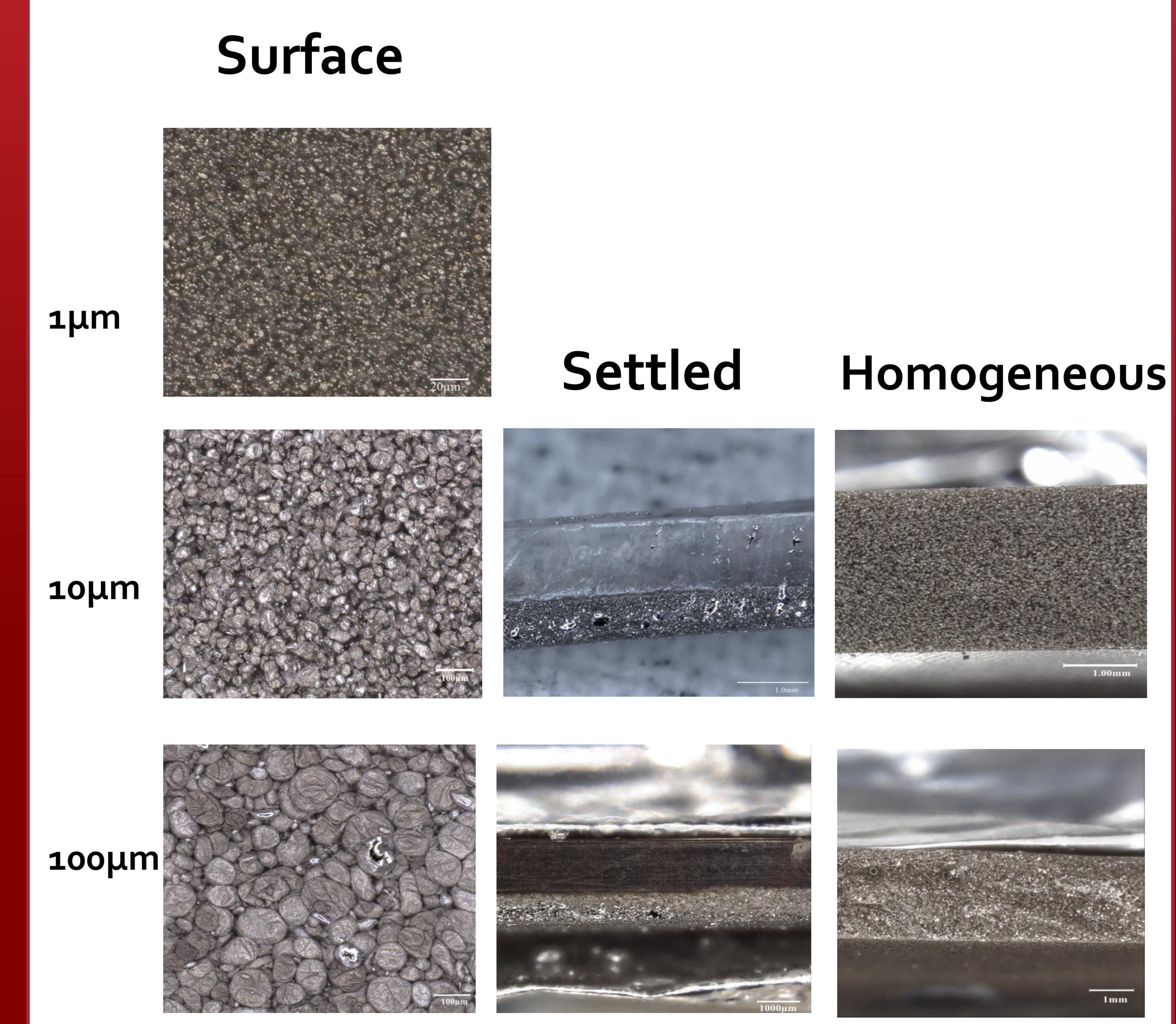


Figure 6: Digital microscopy images of LMPCs and their cross-section view for each droplet size. Showing the homogeneity of the samples.

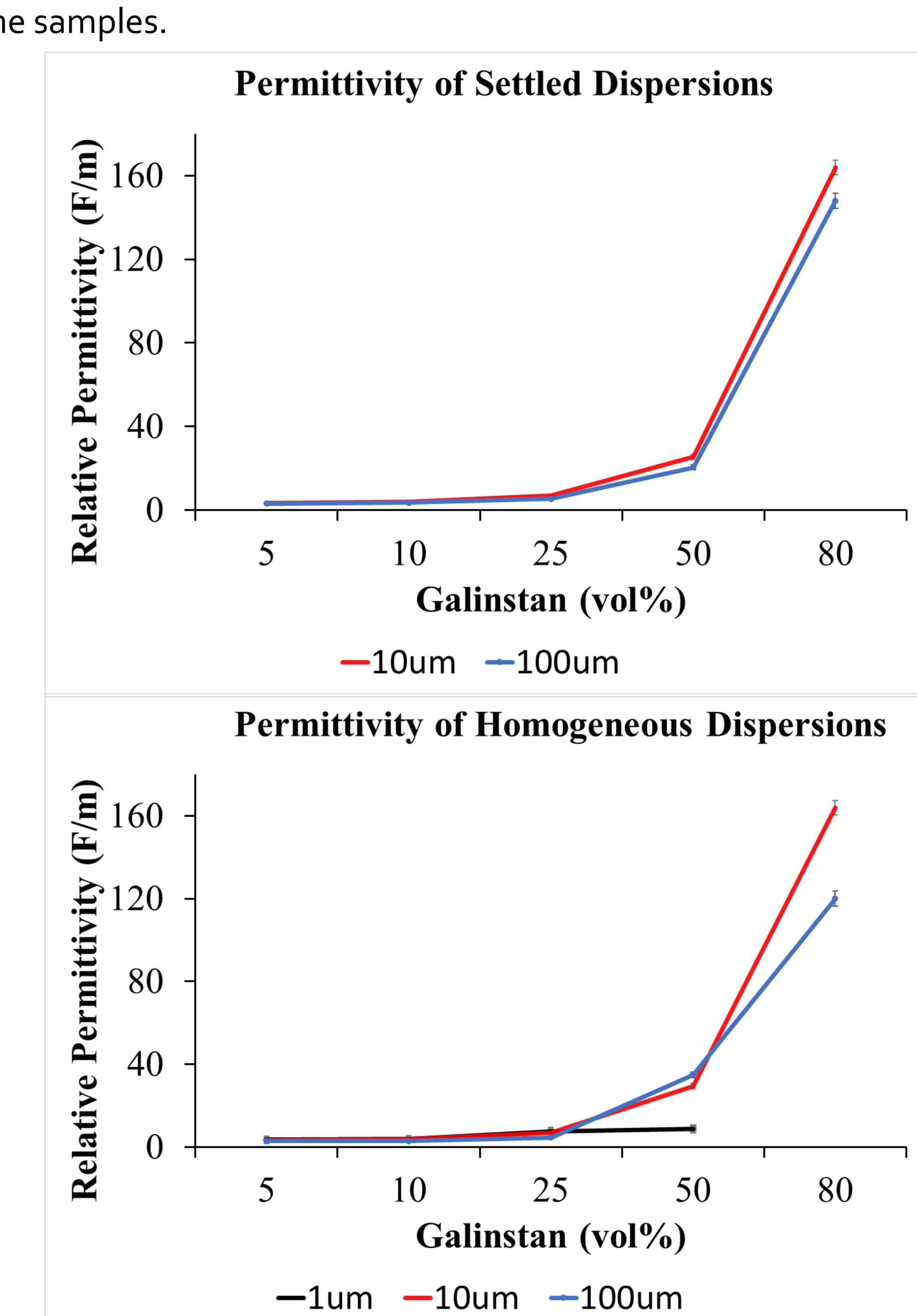


Figure 7: Permittivity of cured LMPCs at 5kHz. The 1µm dispersions has the lowest permittivity; 10 and 100 µm dispersions show little change in permittivity of settled versus homogeneous.

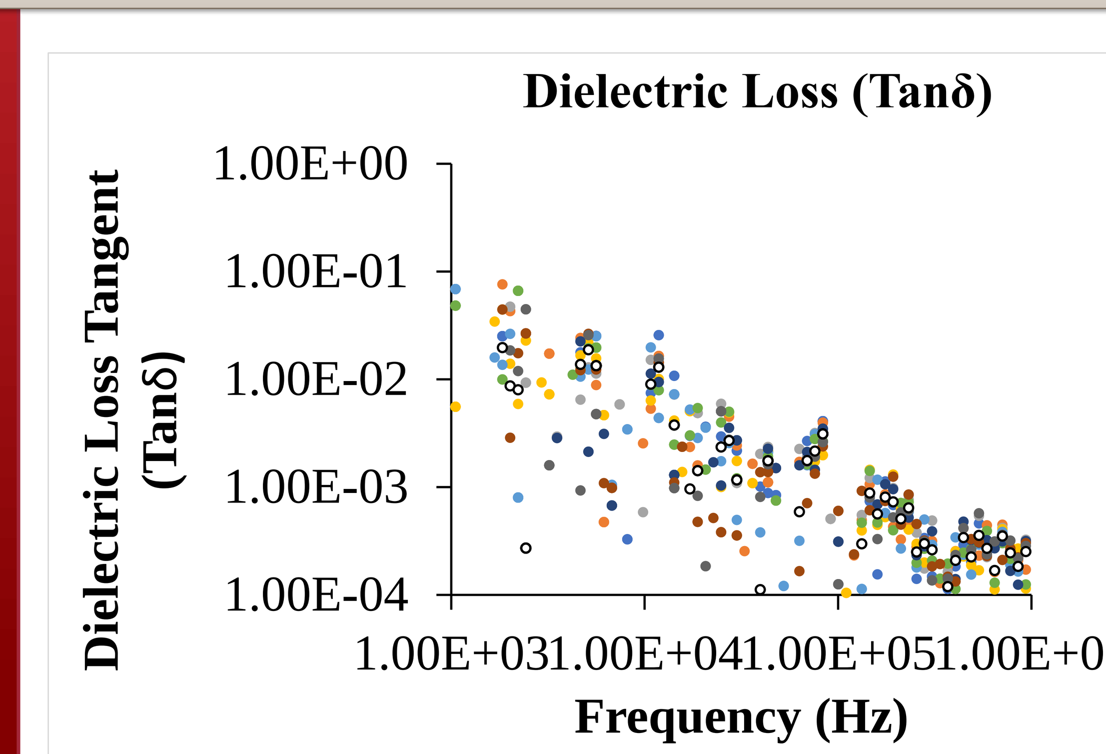


Figure 8: Dielectric loss tangent as a function of frequency. The dielectric loss tangent decreases with increase in frequency for each sample. Low dielectric loss values indicate LMPC as an effective dielectric material.

Conclusion

- Based on the findings of our experimental investigation, it can be concluded that the homogeneity of dispersion within liquid metal polymer composites had minimal effects to their electrical properties.
- Out of the three tested, the 10 microns droplet size had the highest permittivity and thus the most stable.
- Moving forward, we intend to expand our investigation by testing the mechanical properties of these materials to gain a more comprehensive understanding of their overall performance.

Acknowledgements

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