Formulating Ferromagnetic Inks to 3D Print Magnetically Controllable Microstructures

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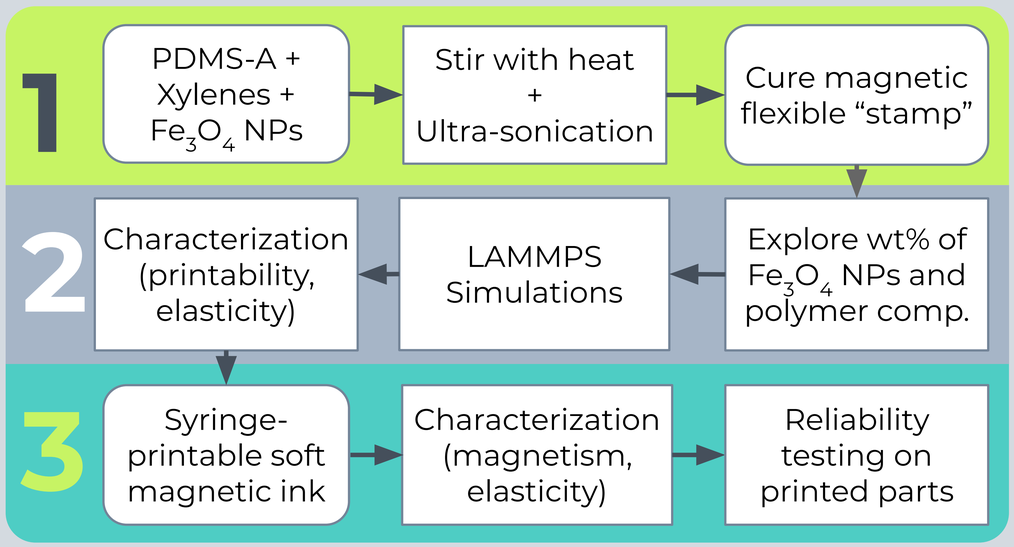
Abstract

This project is an investigation into the development of a polydimethylsiloxane (PDMS) polymer-based ink mixed with iron oxide particles for use in the 3D printing of complex nanostructures. We planned to work in the lab to synthesize this material, but due to the COVID-19 pandemic we shifted our focus to modeling the ink virtually and writing a review article. Through the use of LAMMPS simulation software, the printing ink is being simulated at various compositions of PDMS polymer and iron oxide nanoparticles, to find the optimal conditions of increasing magnetizability and flexibility of a printed film.



Simulations

Using the molecular dynamics software LAMMPS to model a potential ink and examine:

- How the ink equilibrates as the wt% of Fe_3O_4 increases
- How to tune the material to give it the viscosity curve necessary for 3D printing
- How the application of a magnetic field impacts a structure made of this material

Research Question

Can ferromagnetic micro/nano-particles be combined with a soft polymer base to 3D print soft, flexible, and magnetically-controllable microstructures?

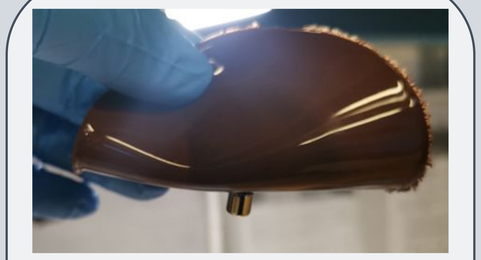


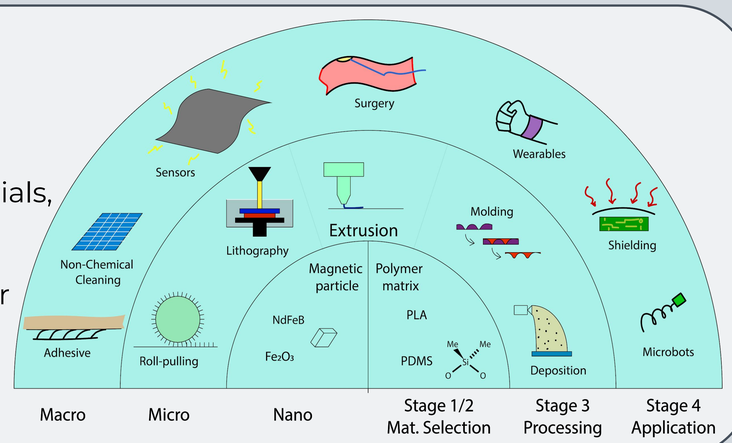
Figure 1: Photograph of a film fabricated using a preliminary ink of PDMS and Fe_3O_4 NPs

Review Article

Synthesizing the research we gathered from our literature review, we drafted a paper that we plan to publish discussing the following aspects of soft, magnetic films:

- Materials: polymer nanocomposite (e.g. PDMS + Fe_3O_4)
- Fabrication: 3D printing, lithography, and molding
- Characterization: desirable magnetization, elastic modulus
- Applications: microscale object locomotion, triggering fluid flows, microbots

Figure 2: Overview of possible materials, fabrication processes, and applications for magnetizable films



Future Directions

- Additional properties
  - ☐ Electric responsiveness
- Reduce minimum dimensions of printed structures
- Controllable adhesion
  - ☐ Magnetically actuated microgrippers

Equity Impact

- Lower production cost
- Increased material attainability
- Review article consolidates information into an accessible platform

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