The Environmental Hazard Assessment of Nanoscale Exfoliated Graphene and Graphene Oxide: Impacts of Particle Preparation

Hans Brown, OSU
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Overview:

1. Intro to nanotoxicology and graphene

2. Research question

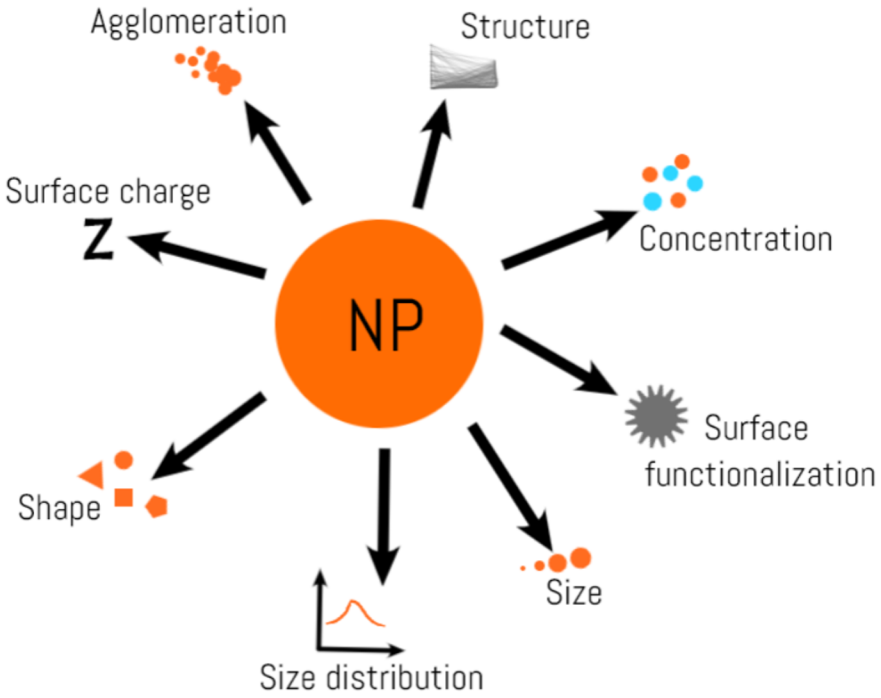
3. Experimental methods

4. Results

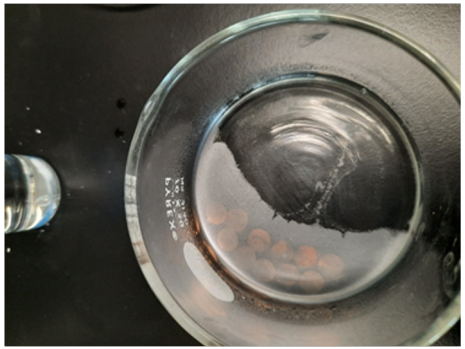
5. Discussion

6. Recommendations for the future

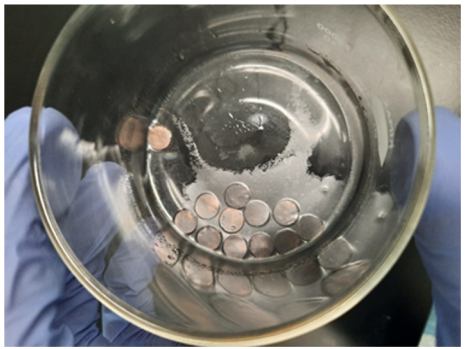
Nanotoxicology



- Materials <100 nm
  - High surface-area to volume ratio
  - Unique physical and chemical properties
- Many are capable of entering cells and crossing the blood-brain barrier
- Growth in research and production of nanomaterials (NM) increases potential for humans and the environment to be exposed.



Jiao lab images of a film



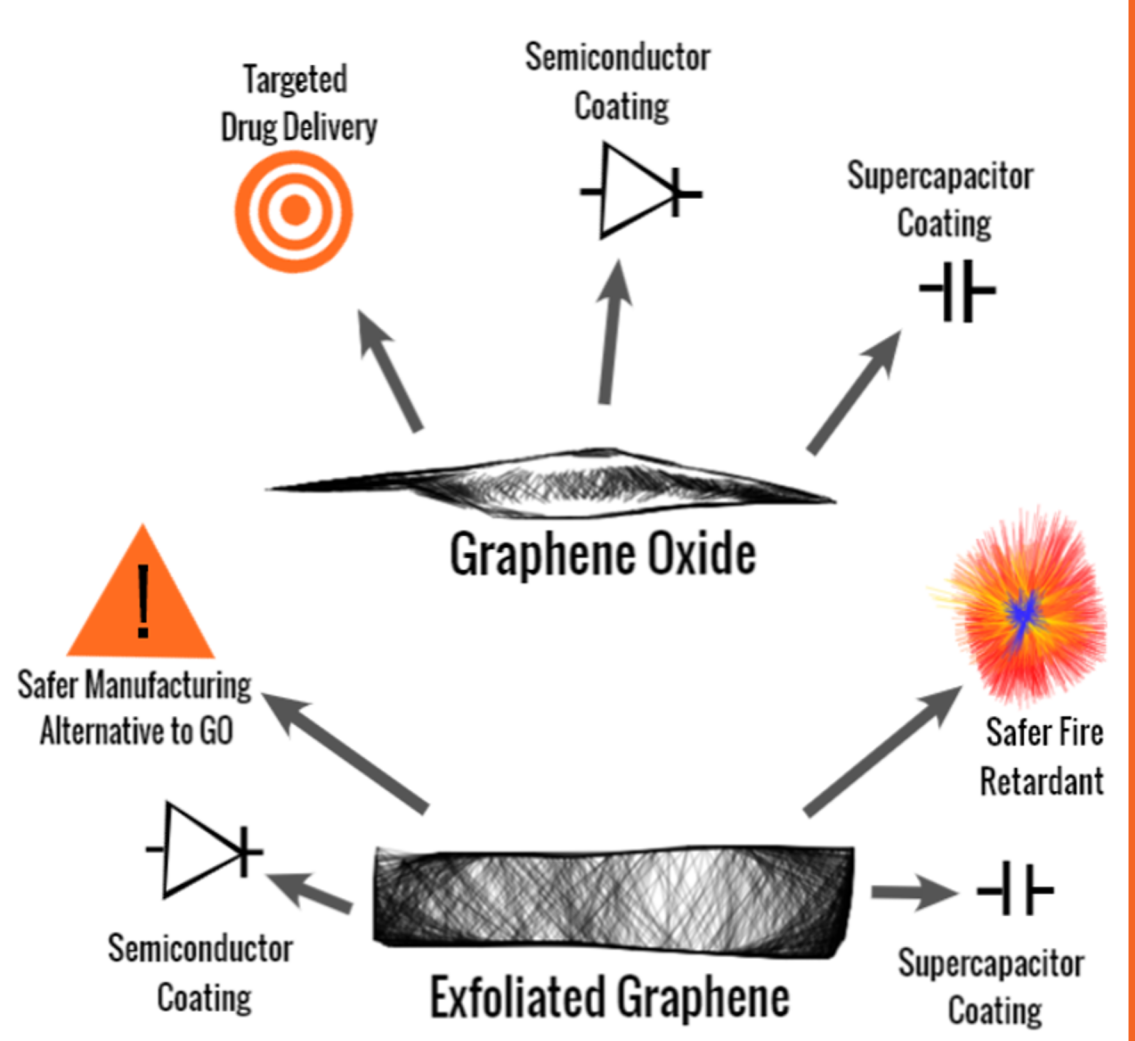
Exfoliated Graphene (EG) and Graphene Oxide (GO)

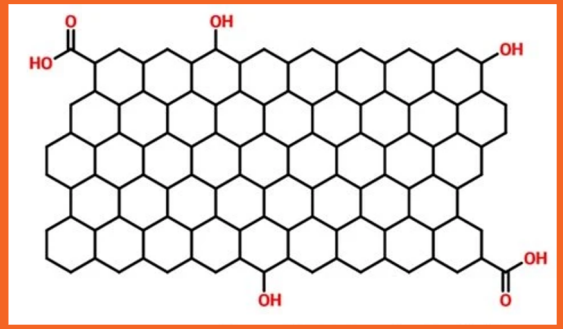
Graphene Oxide

- Forms a 2-3 nm monolayer (2D) film ✓
- Higher dispersibility ✓
- Requires harsh reducing step during synthesis ✗

Exfoliated Graphene

- Forms a 4-8 µm film ✗
- Lower dispersibility ✗
- Does not require a reducing step ✓





Applications

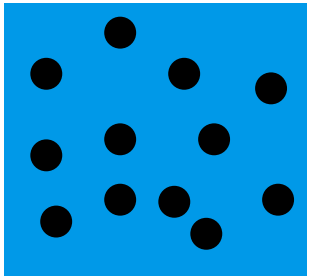
These carbon-based NM are resistant to ion exchange at the molecular and atomic level!

Solvents

N-methyl-pyrrolidinone (NMP)

Extends the duration of suspension and reduces agglomeration

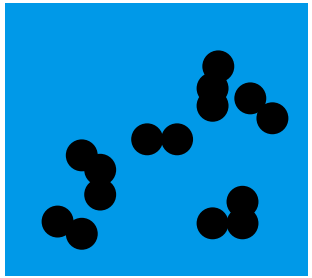
~3 months



Ethanol

Less effective at extending suspension and reducing agglomeration

~1-2 weeks



DI-water

Causes rapid agglomeration and settling due to material hydrophobicity

<24 hours

What are the toxicological effects of nanoscale EG and GO prepared in different common solvents?

D. magna

EPA approved organism commonly used for freshwater ecotoxicity testing

Materials and Methods

All materials were dehydrated and rehydrated in DI-water before transfer to the Harper Laboratory.

Samples : 500 mg/L

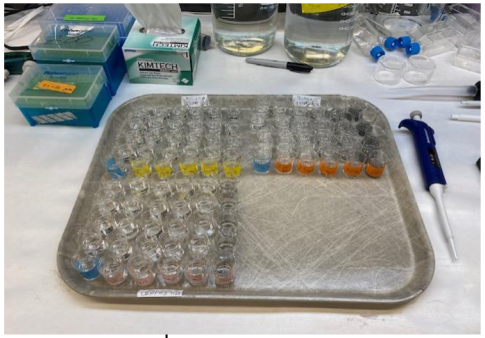
- EG in NMP
- EG in NMP and Ethanol
- EG in Ethanol
- EG DI-water
- GO in Ethanol
- GO in DI-water

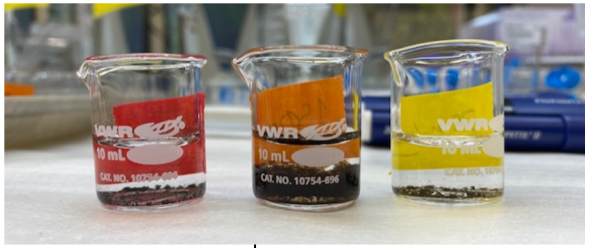
Range-Finding

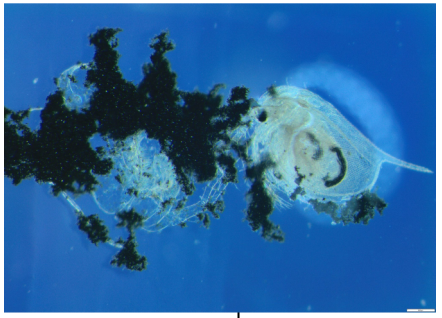
- 0-75 mg/L
- Data used to inform concentration-response

This was a single blind study.

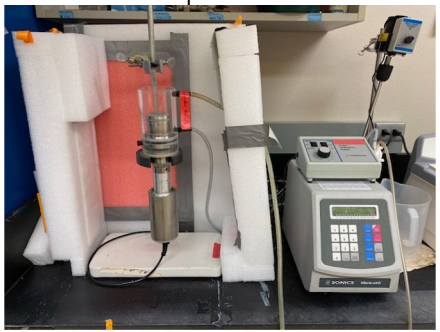
Developing a Concentration-Response

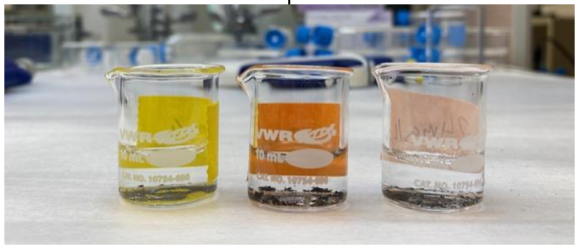






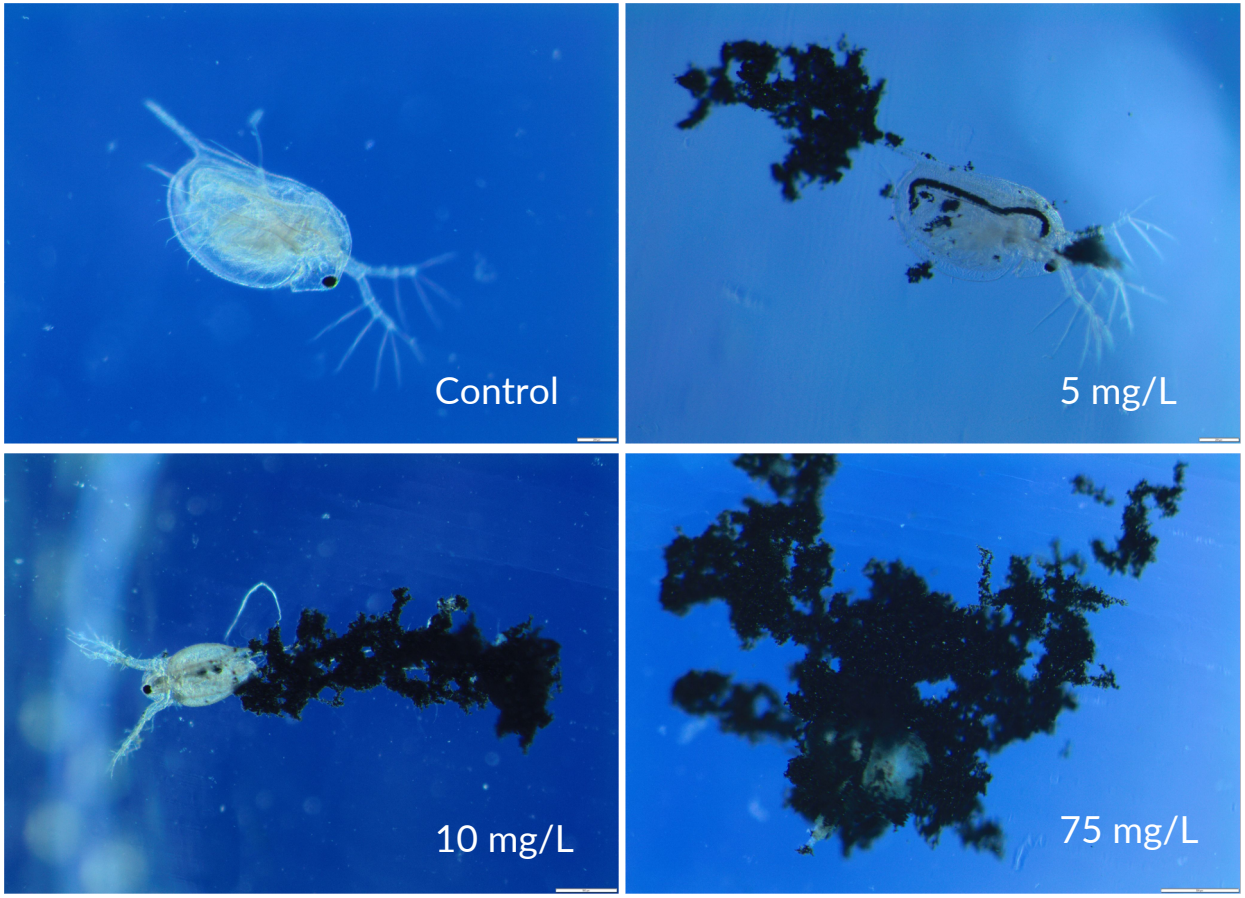
Set-Up → Suspension Maintenance → 24-hrs → 48-hrs → Imaging & Analysis

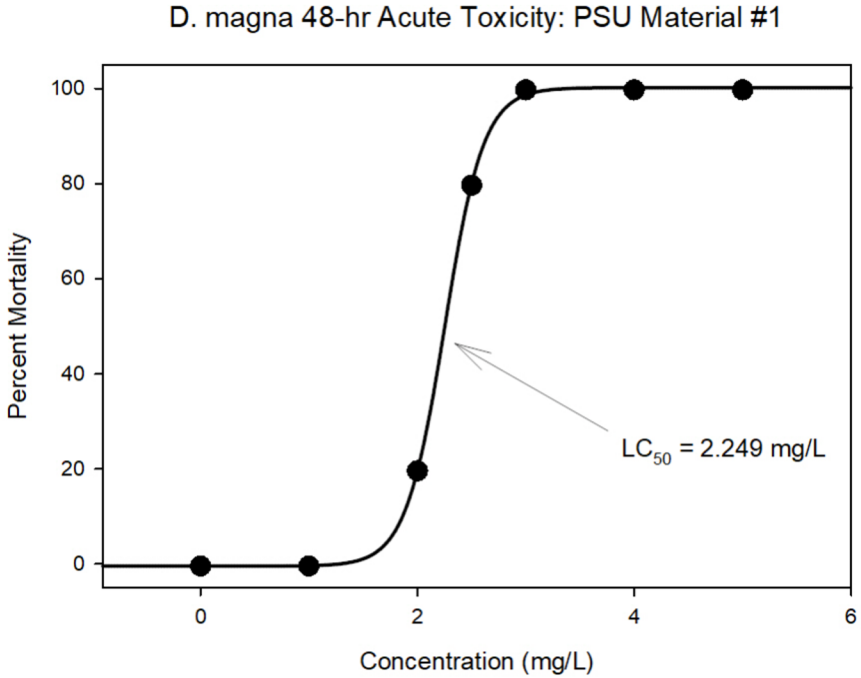




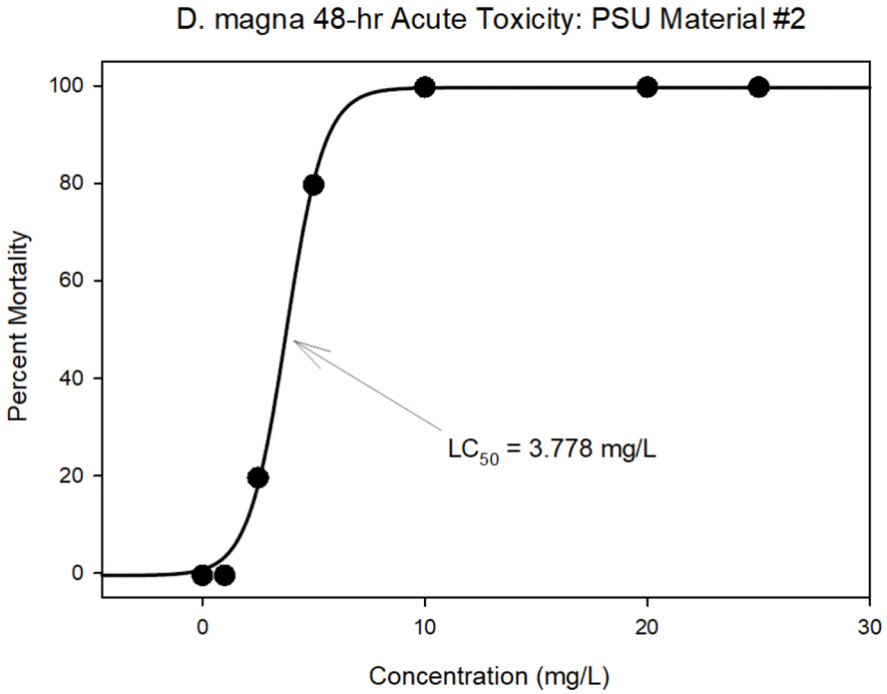
Results

Daphnia in EG prepared in DI-water

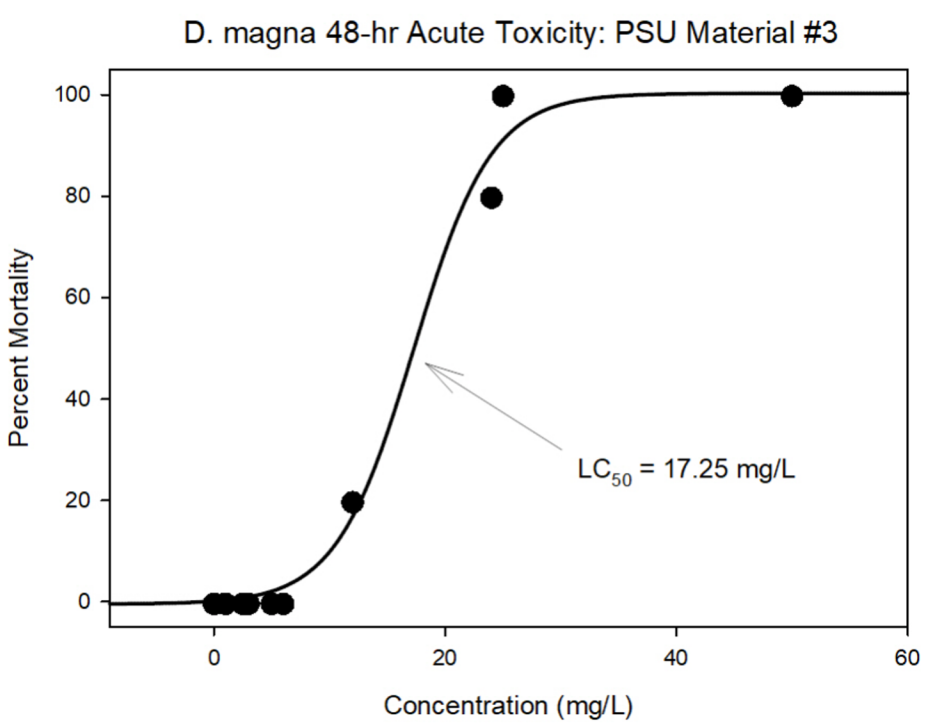




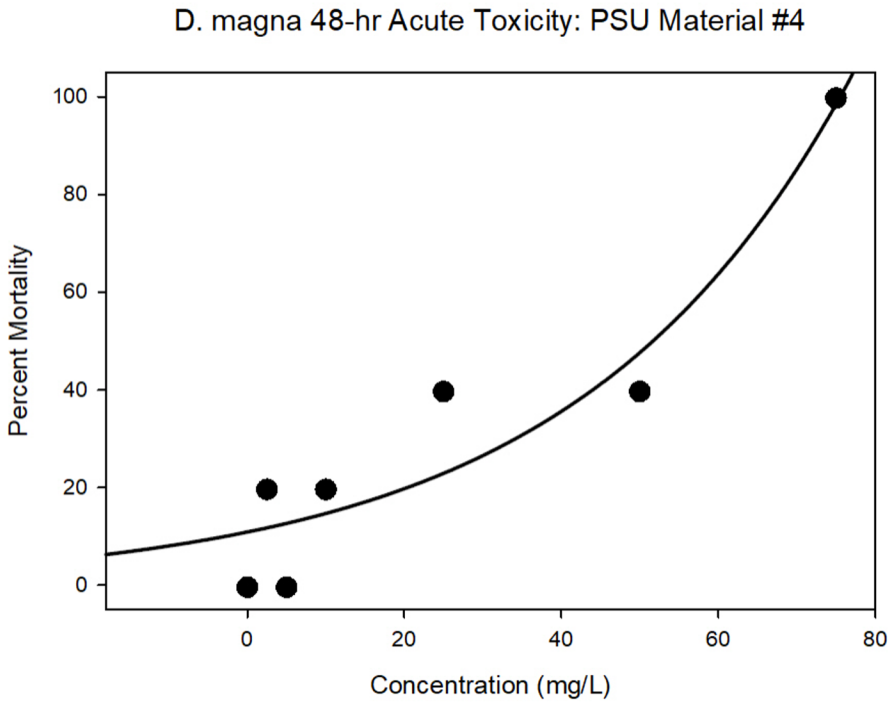
EG prepared in NMP



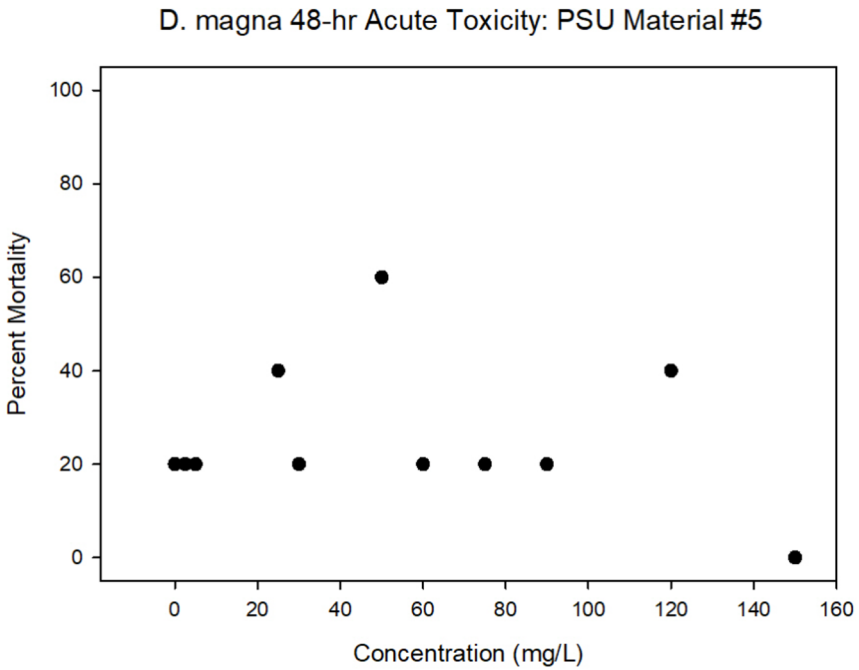
EG prepared in 1:1 NMP and EtOH



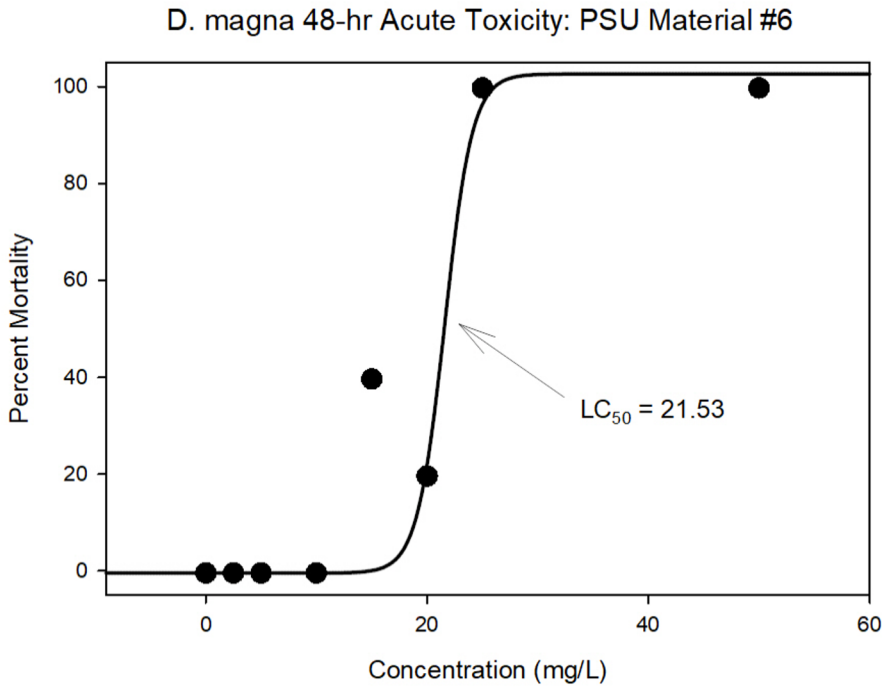
EG prepared in EtOH



EG prepared in DI-water



GO prepared in DI-water



GO prepared in EtOH

Discussion and Future Work

Producing nanomaterials that are **safer by design**!

Limitations

Mode of toxicity

Chronic and sublethal effects

Human effects

- Zebrafish Assay
- Replication
- Characterization

Conclusion

Most Toxic → **Least Toxic**

EG in NMP	EG in 1:1 NMP/ EtOH	EG in EtOH ≈ GO in EtOH	EG in DI-water	GO in DI-water
Residual NMP is hazardous		Safest alternative	Requires more testing	

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