

Concrete: Why Early Strength?



Application: Home and building foundations, concrete molds

Problem: Current Concrete **does not last** and **produces 8.6%** of CO₂ emissions.¹



Long Term Goals:

- Greener city and community infrastructure
- Self-Healing, Carbon-Negative Concrete²

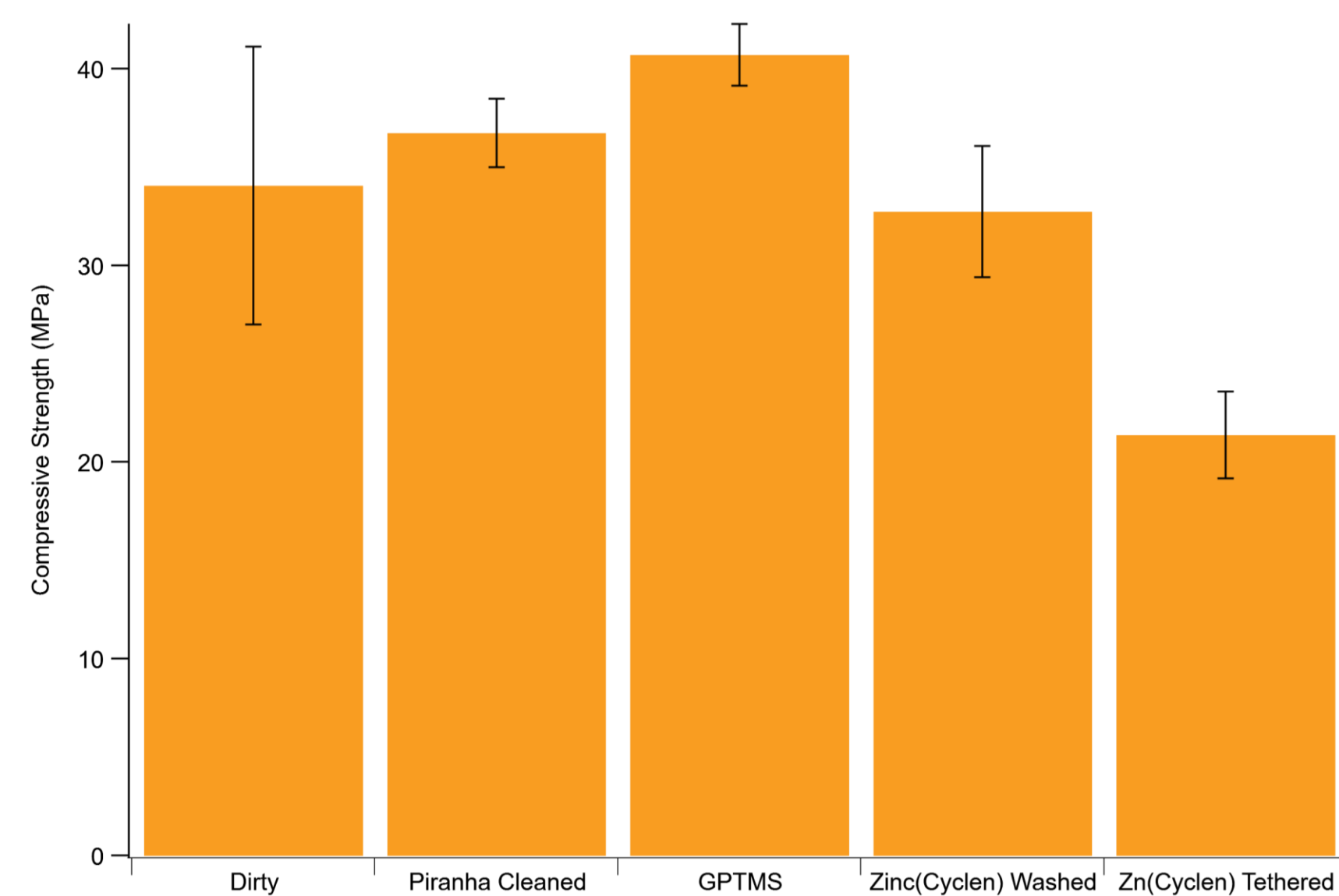
Summer Research Goals:

- Understanding Concrete Surface Chemistry
- Exploring Silane and Zn(Cyclen) functionalized concrete



The Motive: Concrete Strength Tests

Compressive Strength of 14 Day Cure of Treated Sand Samples



Concrete Strength Questions

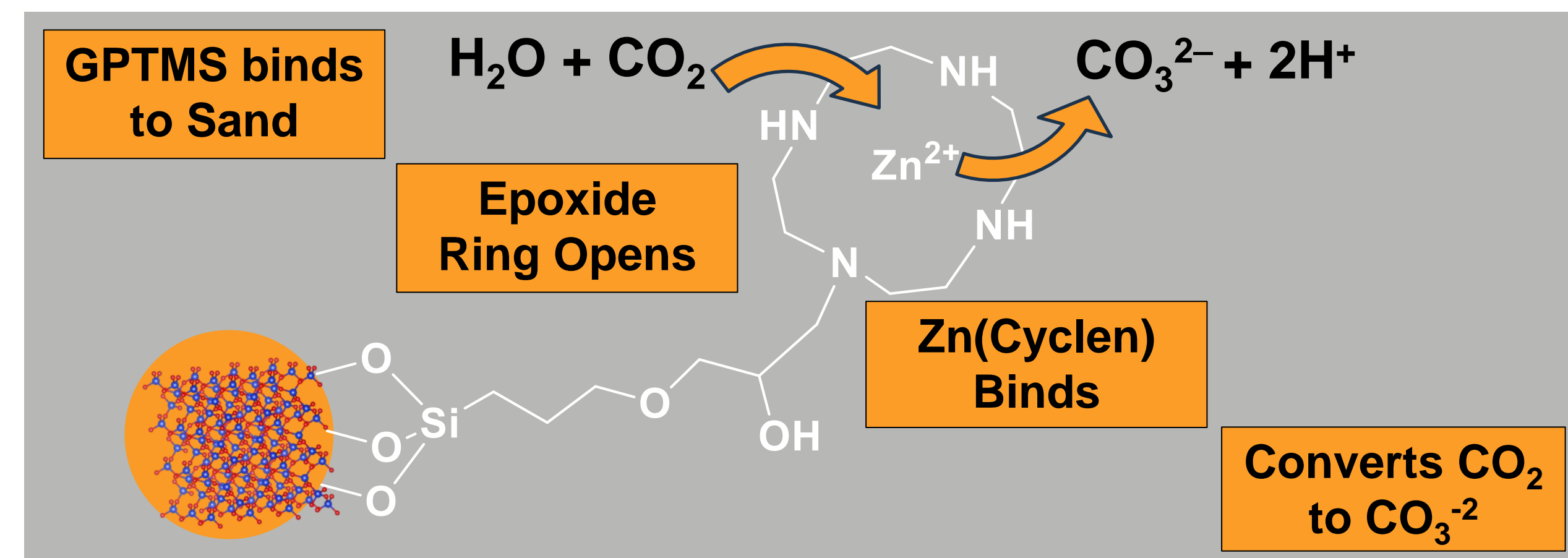
What structurally is causing **increased strength** in epoxy terminated silane **GPTMS**?

Does **Zn(Cyclen) GPTMS** tethered have **greater early strength** than other samples?

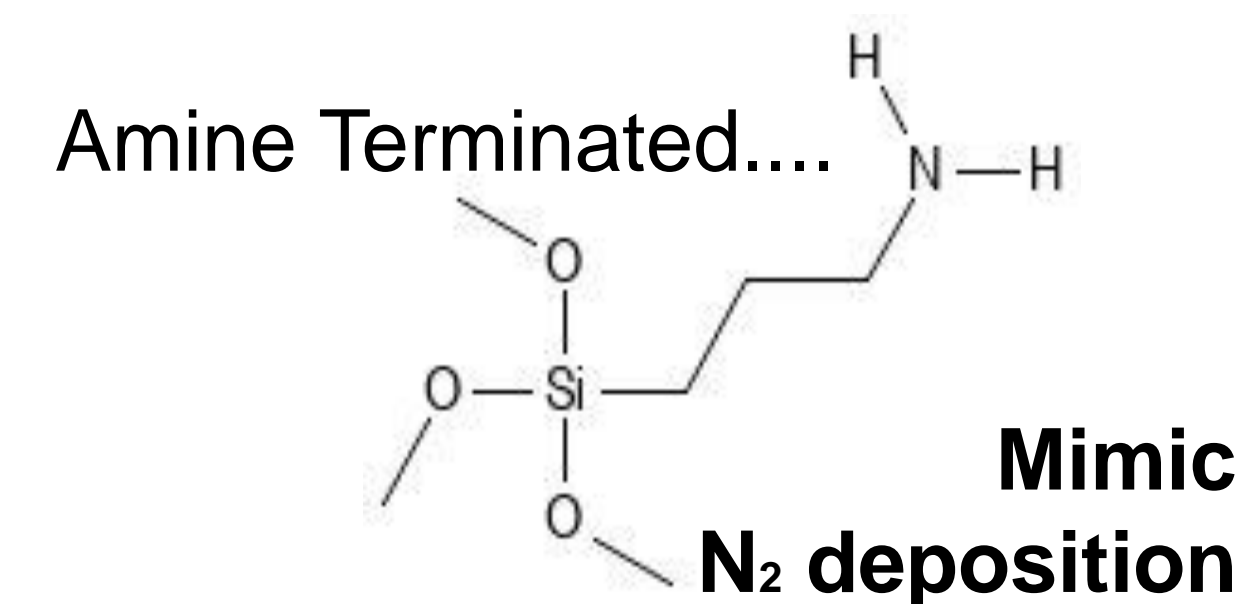
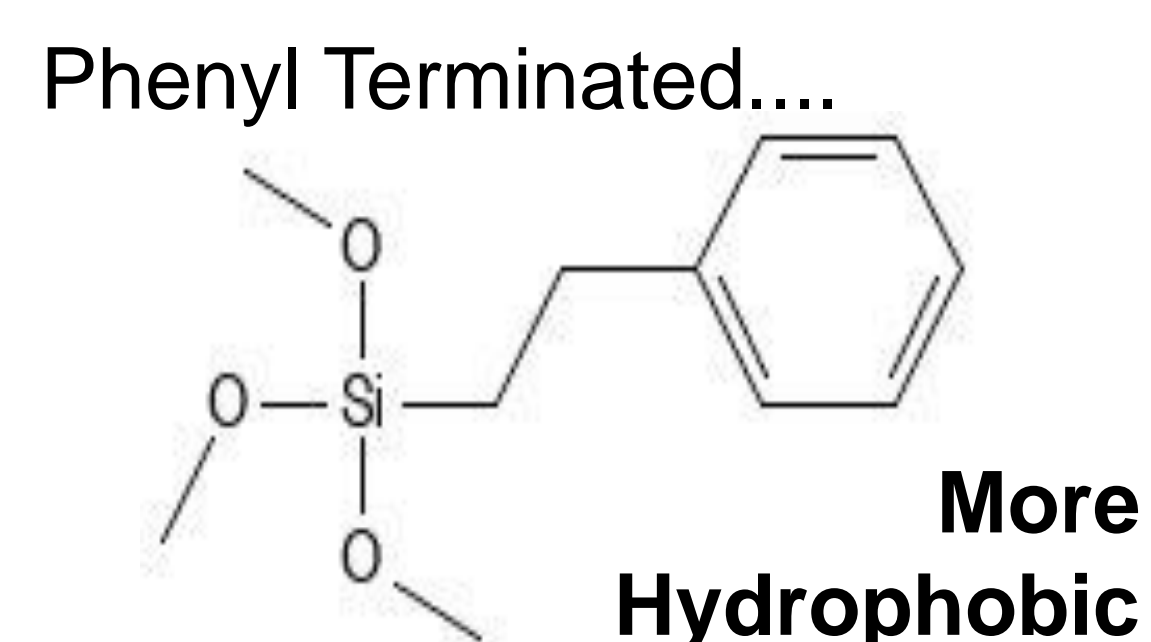
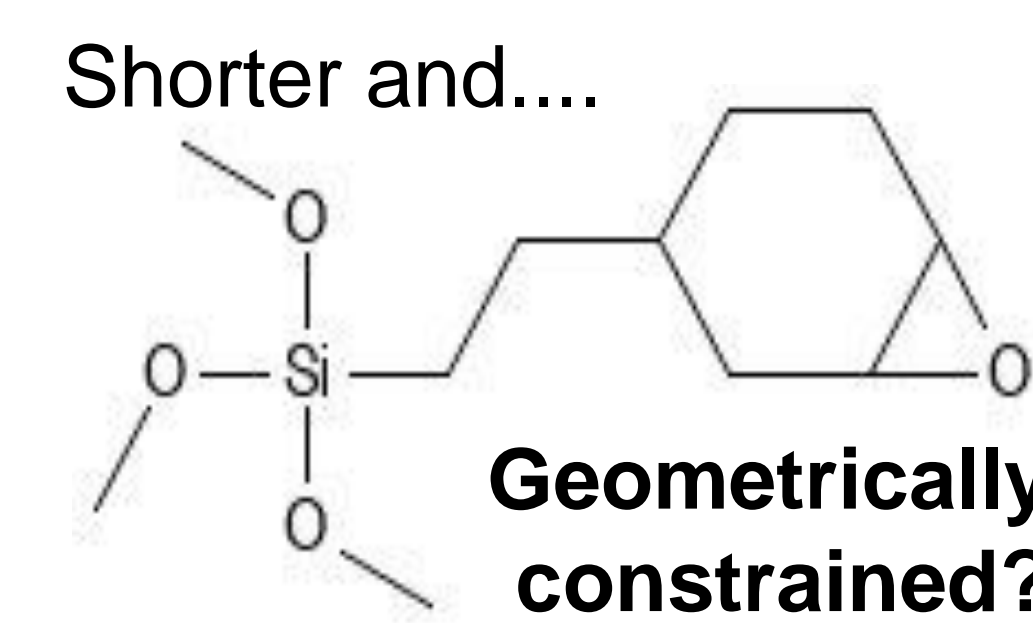
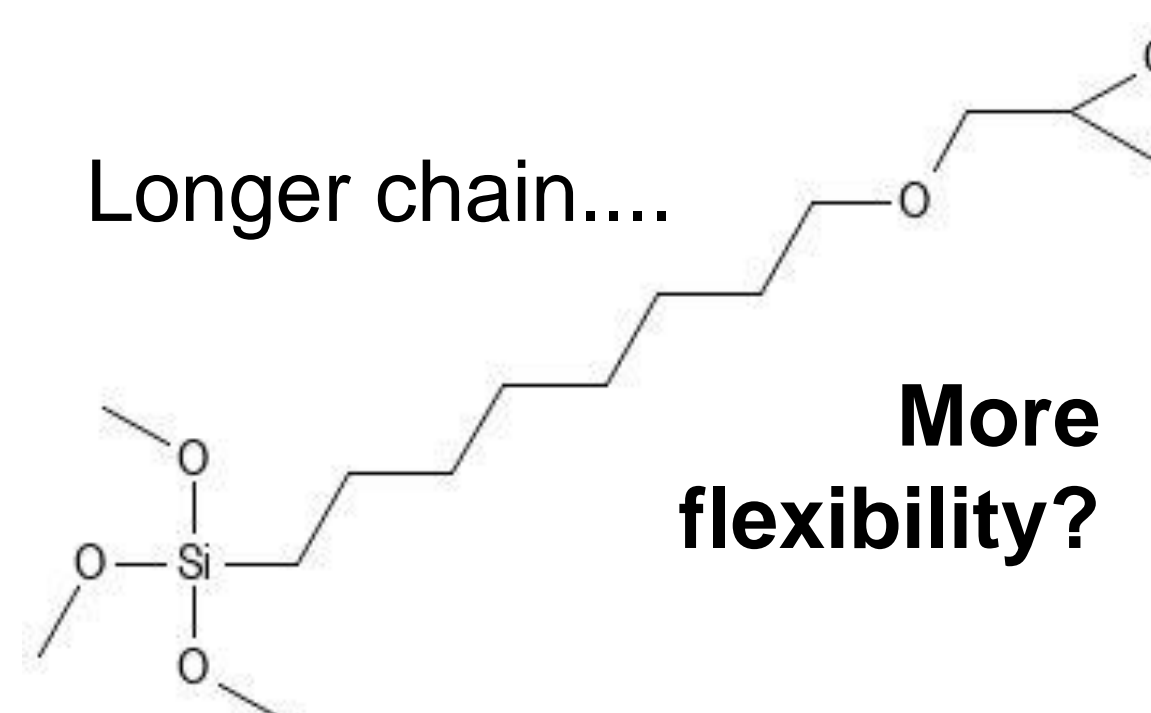
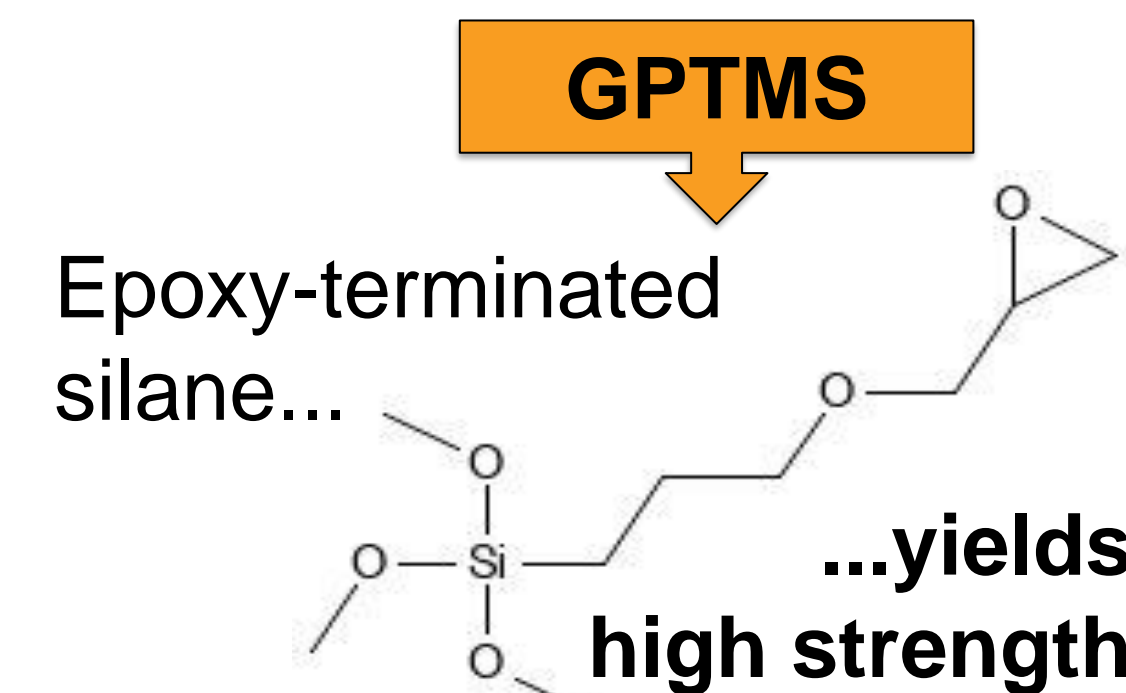
Concrete for Strength Tests



Big Picture: Zn(Cyclen) Tethered GPTMS Sand

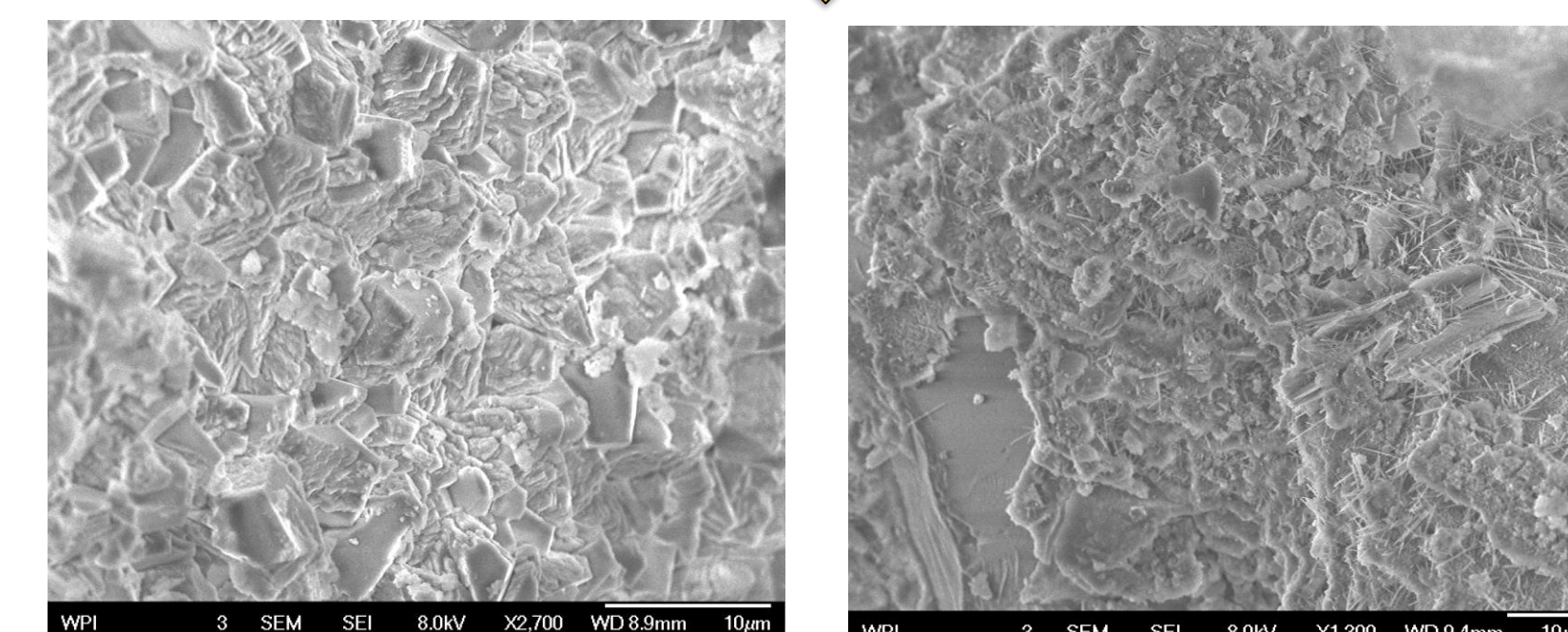


The Cast: Silanes Attached to Sand

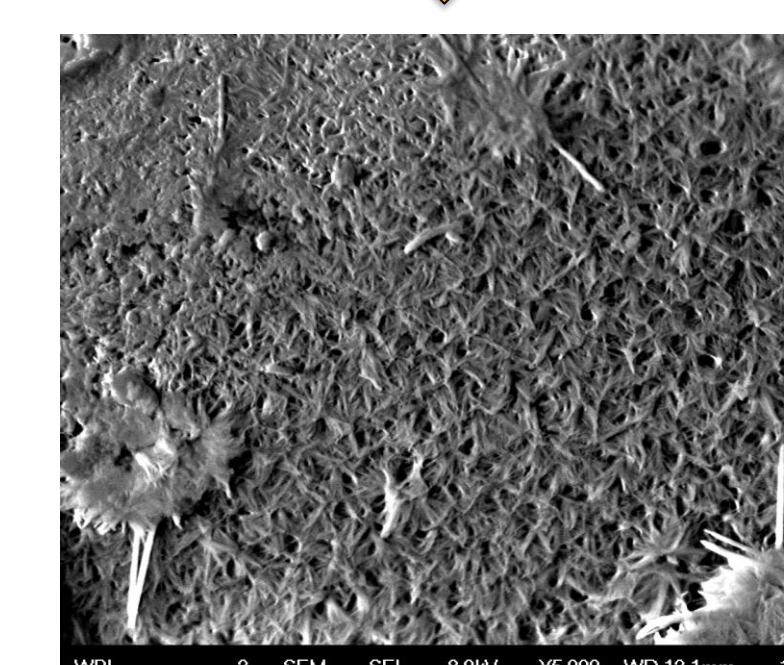


Exploring Early Concrete Strength of Zn(Cyclen) Tethered GPTMS Sand

SEM of Concrete using GPTMS bound Zn(Cyclen) to Sand Surface



SEM of Concrete using Unwashed "Dirty" Sand



Aragonite
 - Calcium Carbonate Crystal Structure
 - Same as produced by Carbonic Anhydrase and Zn(Cyclen)

Etringite
 - Calcium Aluminum Sulfate
 - Found in Portland Cement
 - Leads to cracking in concrete

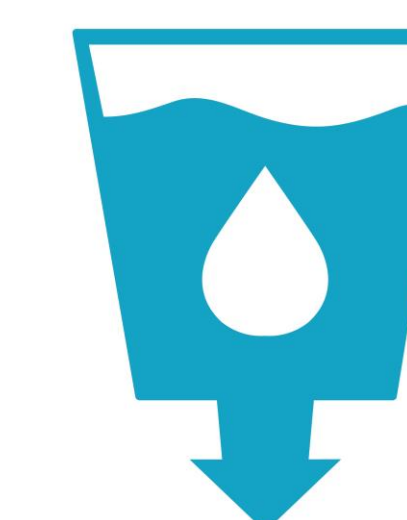
C3S
 - Gives concrete its strength in early phase of cure
CSH
 - Calcium silicate hydrates
 - Gives concrete its strength²

UN Goals: Classroom Connections

Purifying Water:
 A Separation of Mixtures Lab



- Can students design a water purifying techniques from an impure water sample?
- Culmination of Gen Chem lab techniques
- Using Physical & Chemical Properties
- Explore water purity issues world-wide



Methods

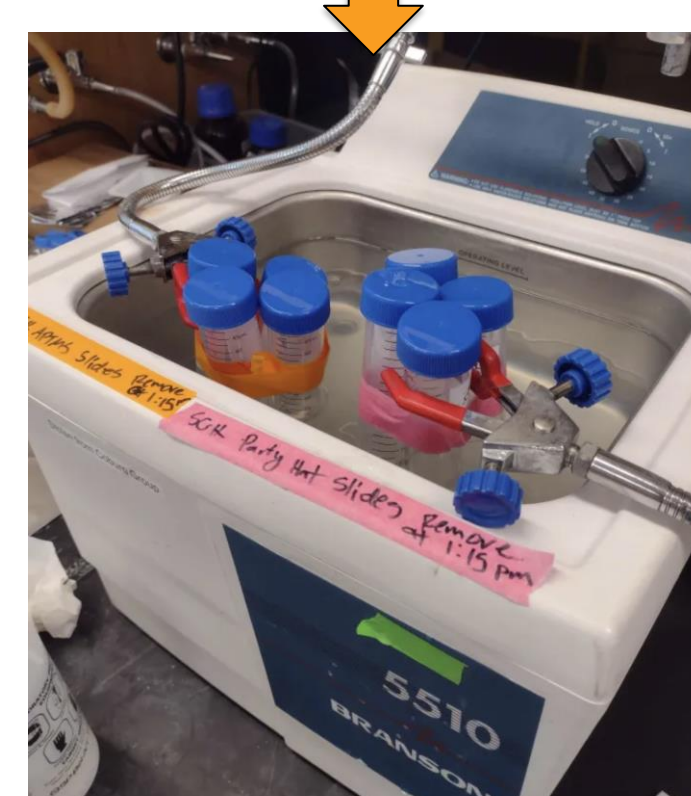
1st Piranha Cleaning Sand & Glass

- 3:1 18M H₂SO₄ & 30% H₂O₂
- Cleans off Organics!

2nd Silane Treating Sand & Glass

- 4 hr sonication in silane solution
- Binds Silane to sand surface!

Silanize in Sonicator



Acknowledgments & References

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References:

1. Miller, S. A.; Horvath, A.; Monteiro, P. J. Readily Implementable Techniques Can Cut Annual CO₂ Emissions from the Production of Concrete by over 20%. *Environmental Research Letters* **2016**, *11* (7), 074029. DOI:10.1088/1748-9326/11/7/074029.
2. Rosewitz, J. A.; Wang, S.; Scarlata, S. F.; Rahbar, N. An Enzymatic Self-Healing Cementitious Material. *Applied Materials Today* **2021**, *23*, 101035. DOI:10.1016/j.apmt.2021.101035.