# Characterization of Mechanical and Adsorption Properties of Silica Based Gels of Varying Hydrophobicity for Bacterial Encapsulation

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## Objective

Create a hydrophobic gel for bacterial encapsulation that maintains its mechanical integrity

## Background

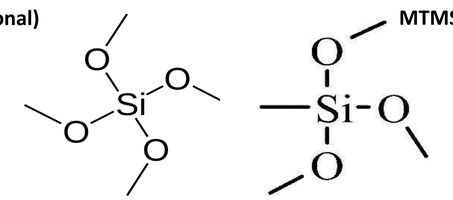
Current methods for removing organic contaminants from hydraulic fracturing (fracking) wastewater are expensive and inefficient, and the use of naturally occurring bacteria for the bioremediation of such waters is an area of exploration[1]. Encapsulation in a silica gel matrix has been shown to protect and promote metabolic activity in bacteria[2] for use in the potentially dangerous environment of fracking wastewater. A novel method of producing hydrophobic gels that aid in the removal of hydrophobic organic compounds in the wastewater water is the focus of this research.


Figure 1: Fracking wastewater in an above ground holding pit. Photo courtesy of ohiocitizen.org

## Methods

Varying mechanical and mass transport properties were obtained by adjusting the ratios of two different gel precursors, TMOS (tetramethylorthosilcate) and MTMS (methyltrimethoxysilane). To evaluate the mechanical integrity of gels, cylindrical samples were formed in silicone molds, and compressive testing was performed until failure. To evaluate the adsorpance properties, the adsorption coefficient of each gel was determined by allowing fluorene (a solute that mimics fracking wastewater contaminants) and atrazine (a herbicide) partition into the gels over a period of time.

**TMOS (tetrafunctional)** **MTMS (trifunctional)**



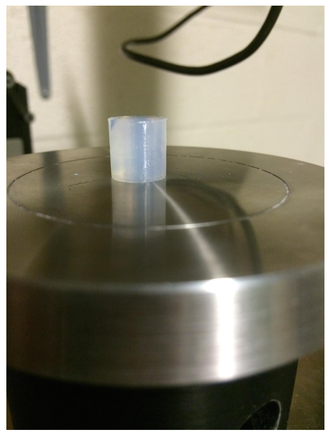



Figure 2: Cylindrical gel sample ready for compression testing

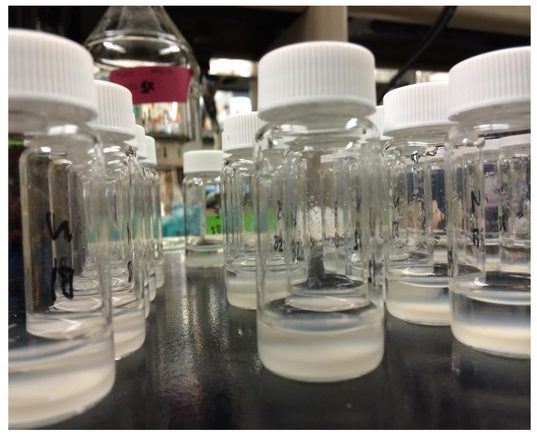
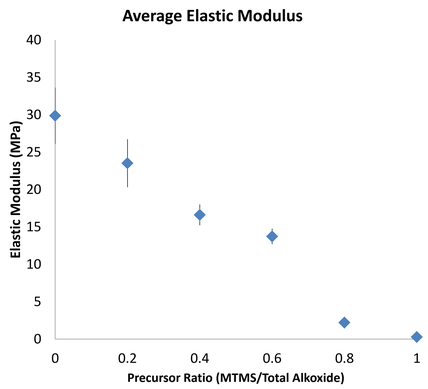
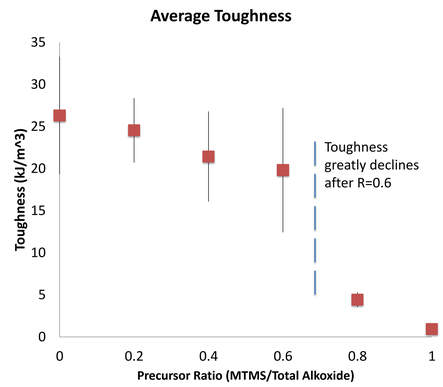


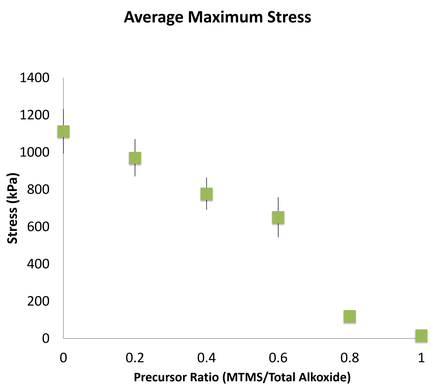
Figure 3: 1 mL gels formed at the bottom of 20 mL vials.

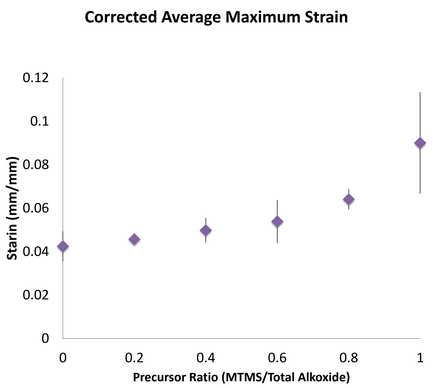
## Results

Mechanical Testing

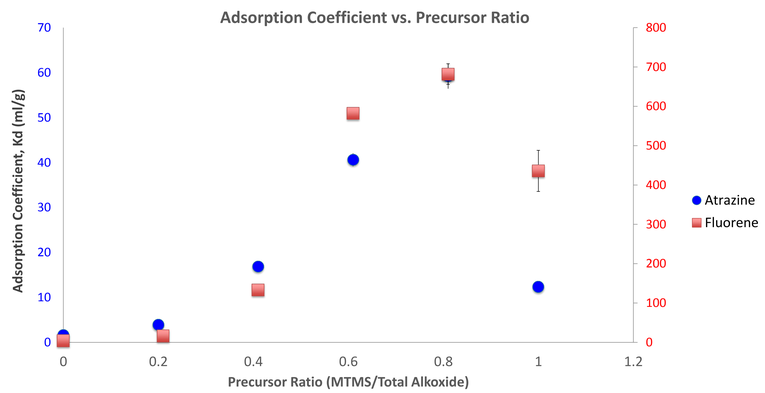



Adsorption Coefficient




## Discussion and Conclusion

The results of the adsorption coefficient experiments showed greater adsorption with increasing amounts of MTMS aside from gel R=1 where it was expected that low specific surface area actually decreases the adsorption coefficient. Higher adsorption coefficients were expected with increasing MTMS, as the gels were more hydrophobic. Unfortunately, making gels more hydrophobic by increasing the amount of MTMS decreased their mechanical integrity, and gels must retain sufficient mechanical integrity to be used for bacterial encapsulation. While there is not yet a standard of what is considered "sufficient" mechanical integrity, gels R=.8 and R=1 were very fragile, and were irreversibly damaged with slight agitation. With this in mind, it is essential that some TMOS precursor be retained in order to maintain sufficient mechanical integrity.

The decrease in mechanical properties and the increased gelation times that comes with increasing amounts of MTMS as compared to TMOS can be explained in terms of their structures, TMOS has four functional groups susceptible to hydrolysis whereas MTMS has only three. Although it is important to know how precursor ratios affect mechanical integrity and mass transport properties, it is more important to know how the ratio affects the rate at which bacteria degrade compounds in fracking wastewater. This is an area of further exploration.

## References

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2. Dickson DJ, Ely RL. Silica sol-gel encapsulation of cyanobacteria: lessons for academic and applied research. Appl Microbiol Biotechnol 97 (2013):1809–1819

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