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Cellular Silica Encapsulation for Development of Robust Cell Based Biosensors

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Bioenergy and Biodefense Technologies
Sandia National Laboratories

American Physical Society Meeting
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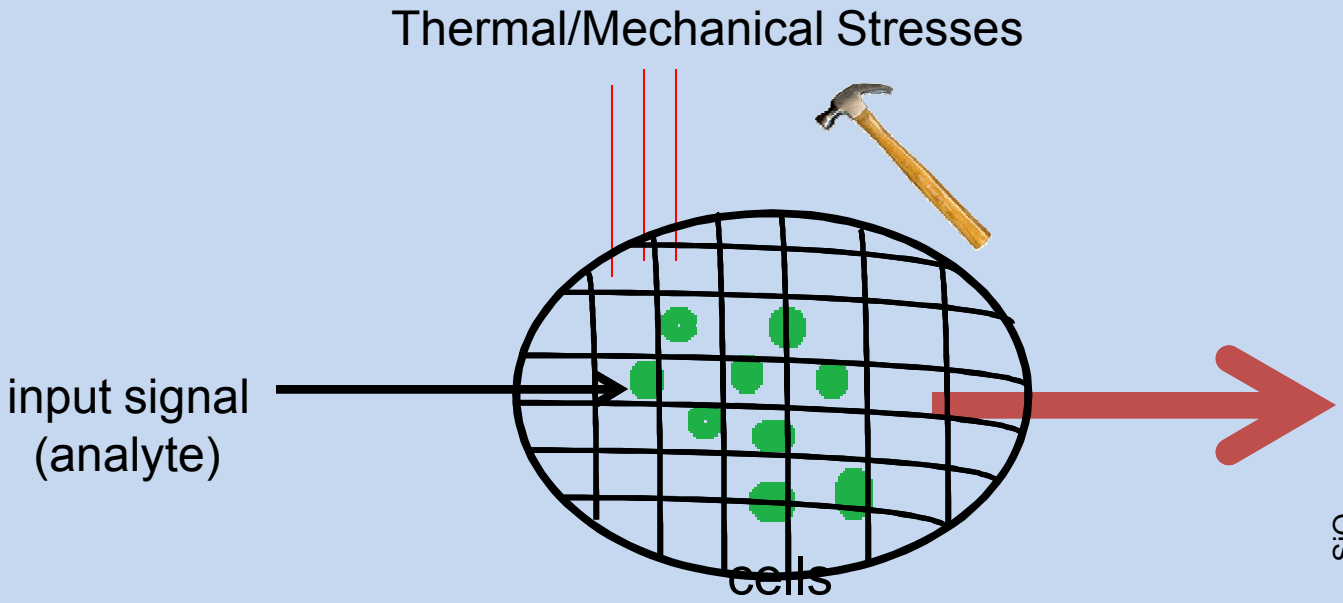
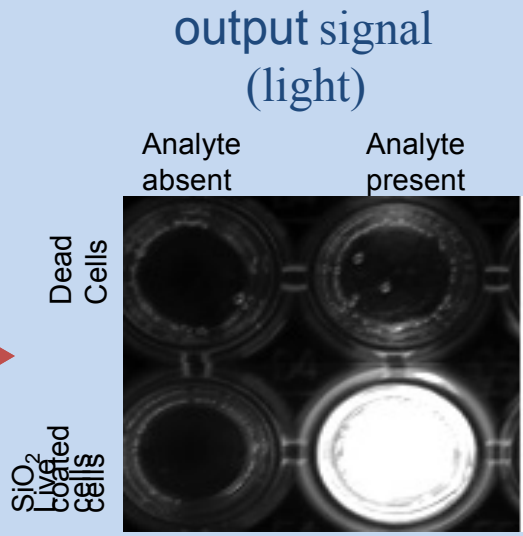
Project Goal

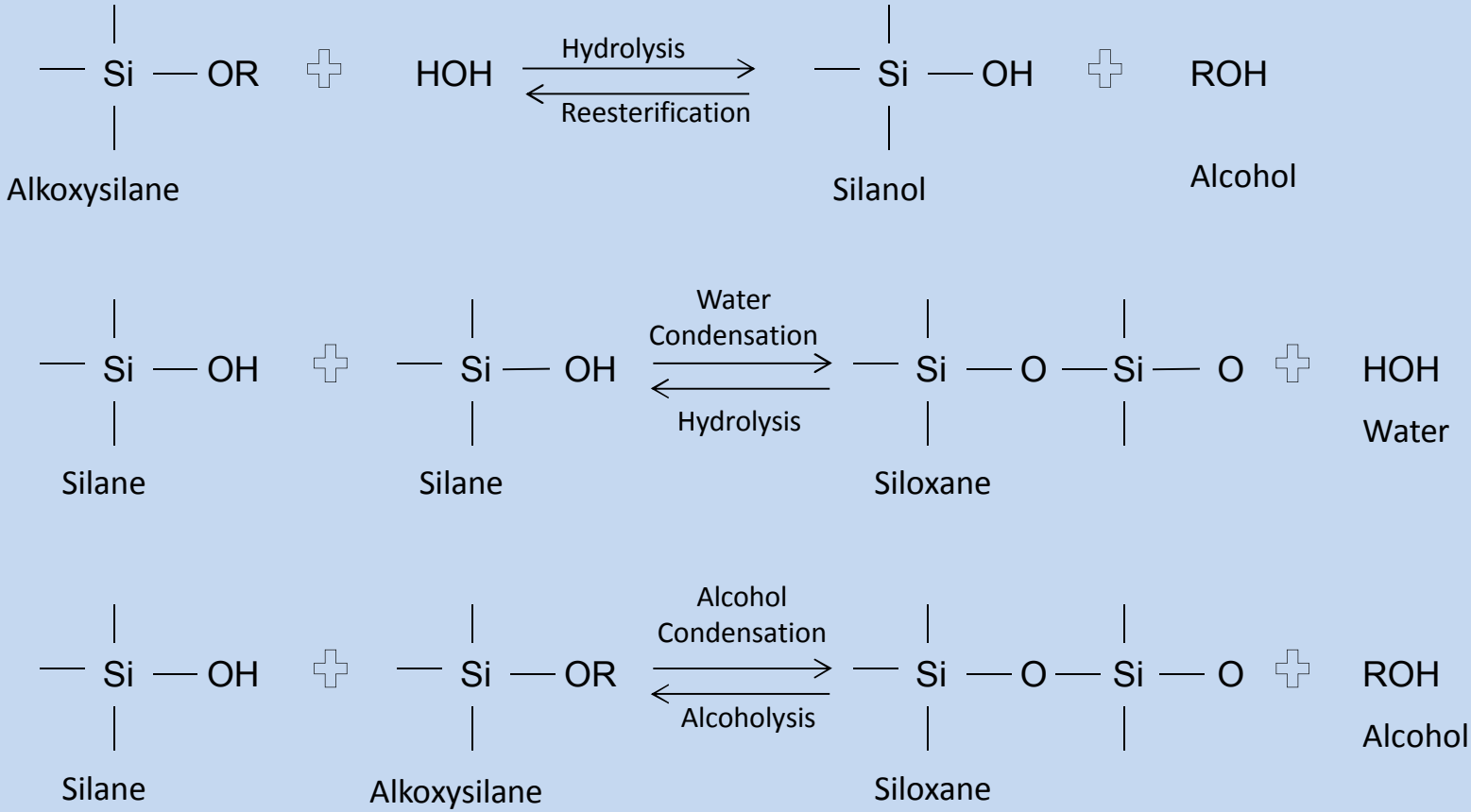
- Develop a biosensor for chemical and biological weapons detection on the battle field using cells as sensing components





Carturan G et. al (1989) *Journal of Molecular Catalysis* 57(1):L13-L16.
Carturan G et. al. (2004) *J. Mater. Chem.* 14(14):2087-2098

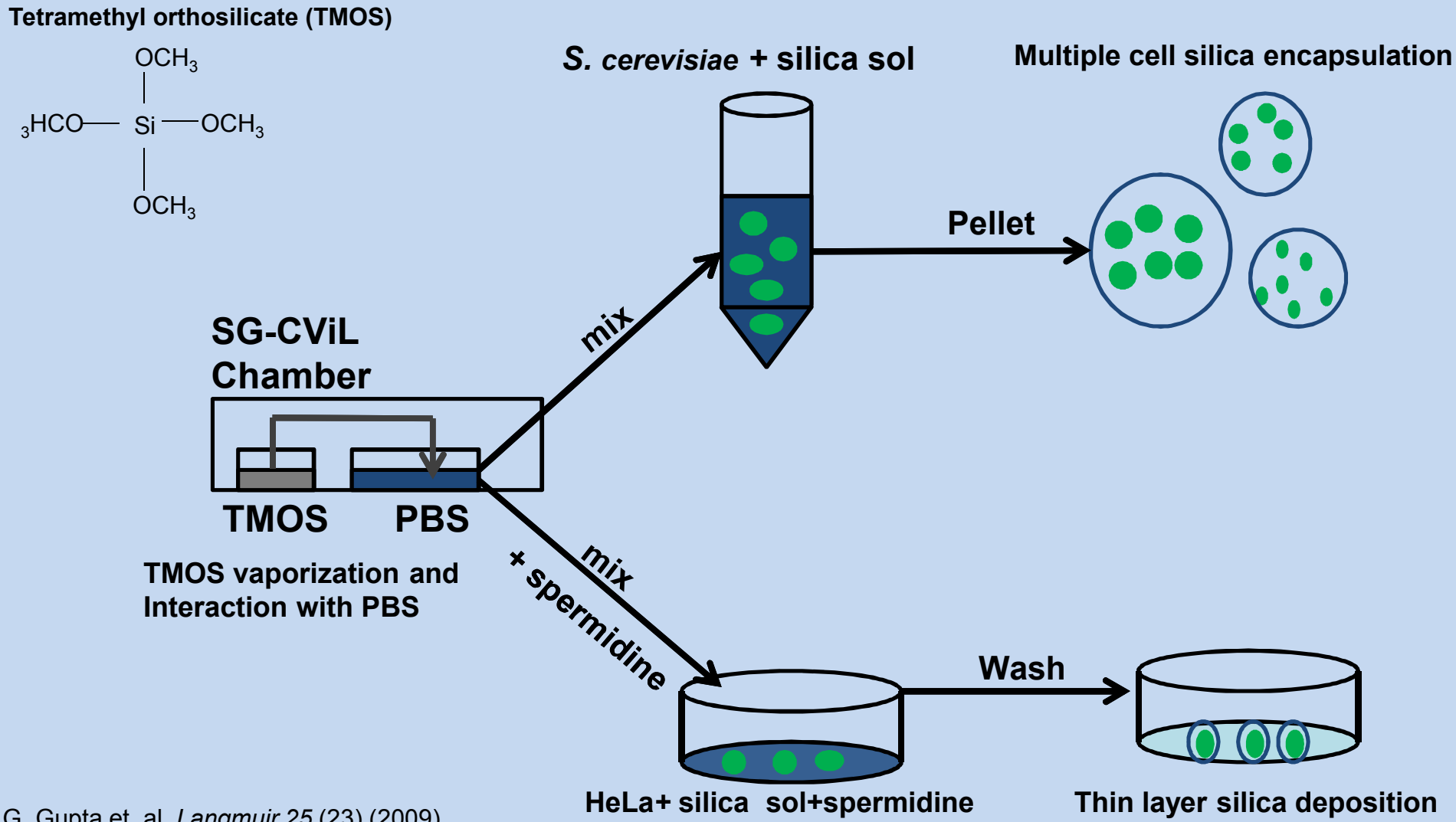
Silica Generation-Sol Gel



- Results from hydrolysis and condensation reaction between alkoxysilane precursor and water
- Produces alcohol (cytotoxic)
- Need harsh catalysts to speed reaction up (cytotoxic)

Brinker CJ (1994) Sol-Gel Processing of Silica.

How to Put Cells in Glass: Sol-Generating Chemical Vapor into Liquid (SG-CViL) Deposition



G. Gupta et. al. *Langmuir 25* (23) (2009)

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S. cerevisiae Silica Encapsulation

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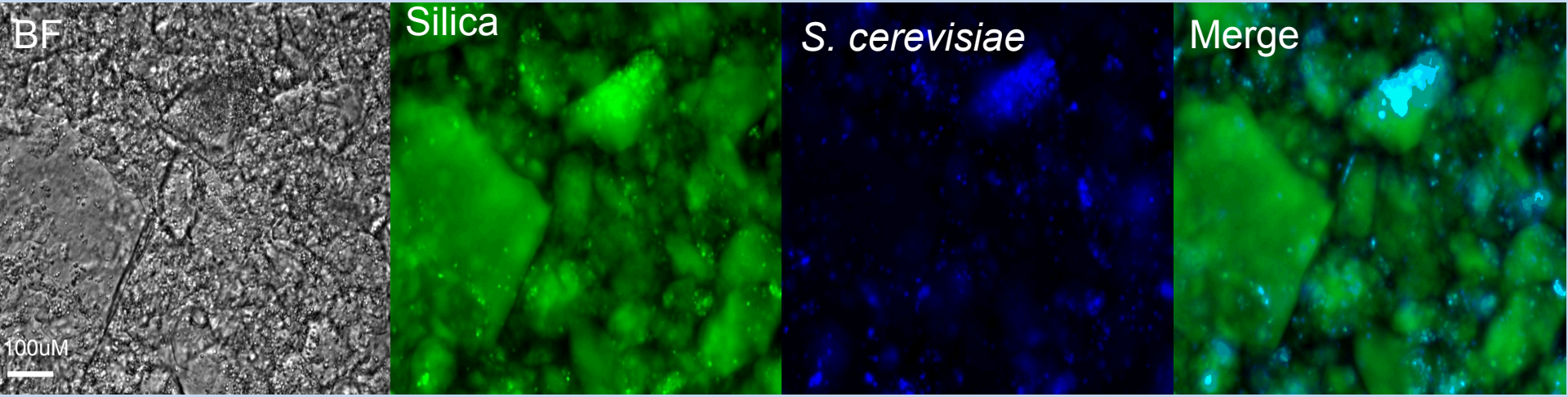
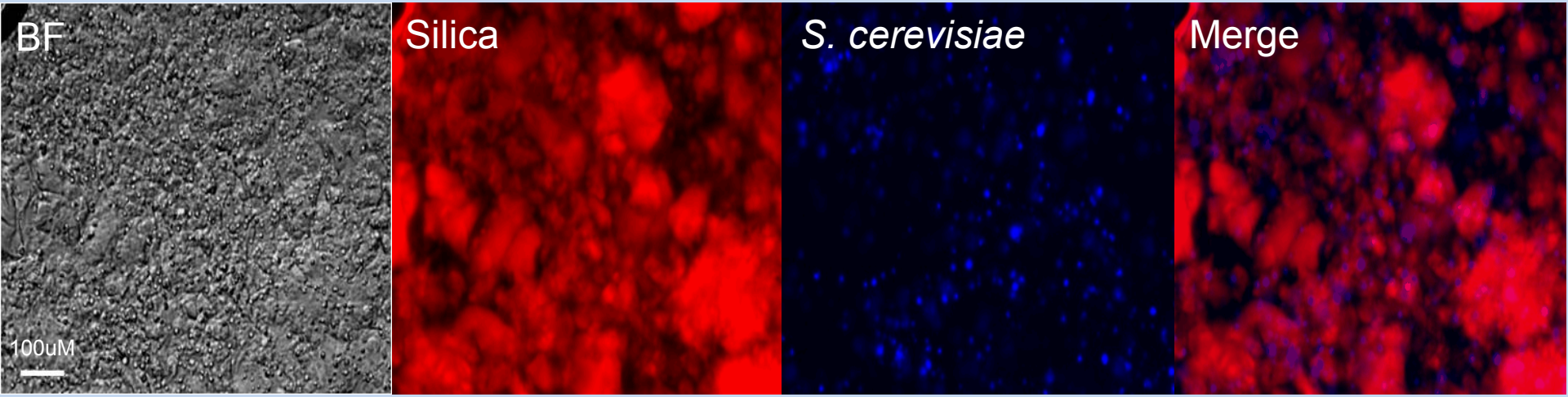
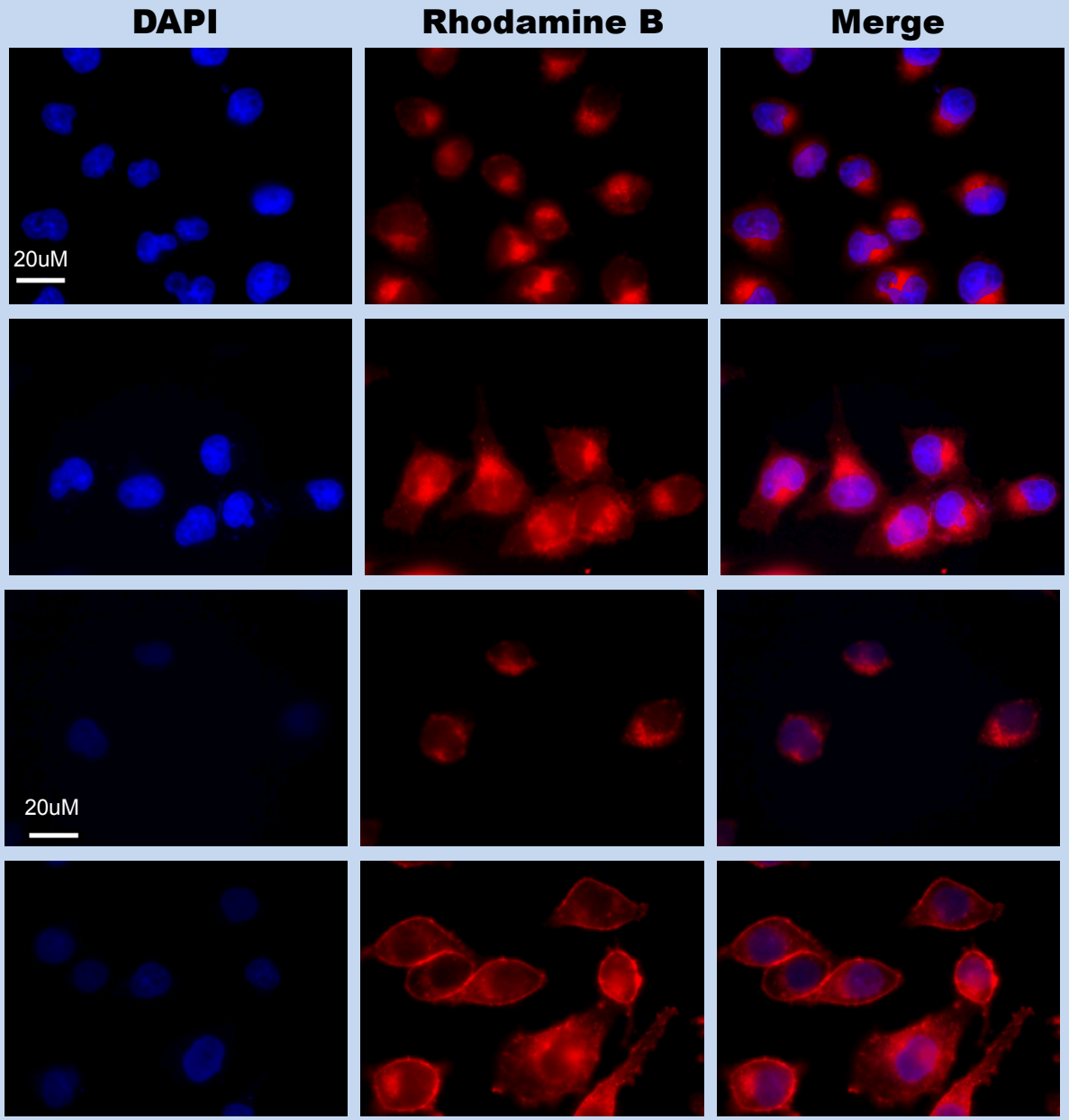
- SG-CViL reaction-1 hour at 40°C
- Silica labeled with PDMPO (green fluorescence) or Rhodamine B (red fluorescence)
- *S. cerevisiae* labeled with calcofluor white (chitin binding dye, blue fluorescence)





Silica Deposition on HeLa (cervical cancer) Cells

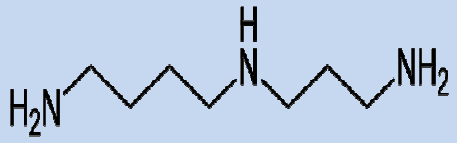


- SG CViL reaction-15 min at 40°C

-TMOS=Cells exposed to PBS control solution containing Rhodamine B

+TMOS=Cells exposed to SG-CViL solution

+Spermidine



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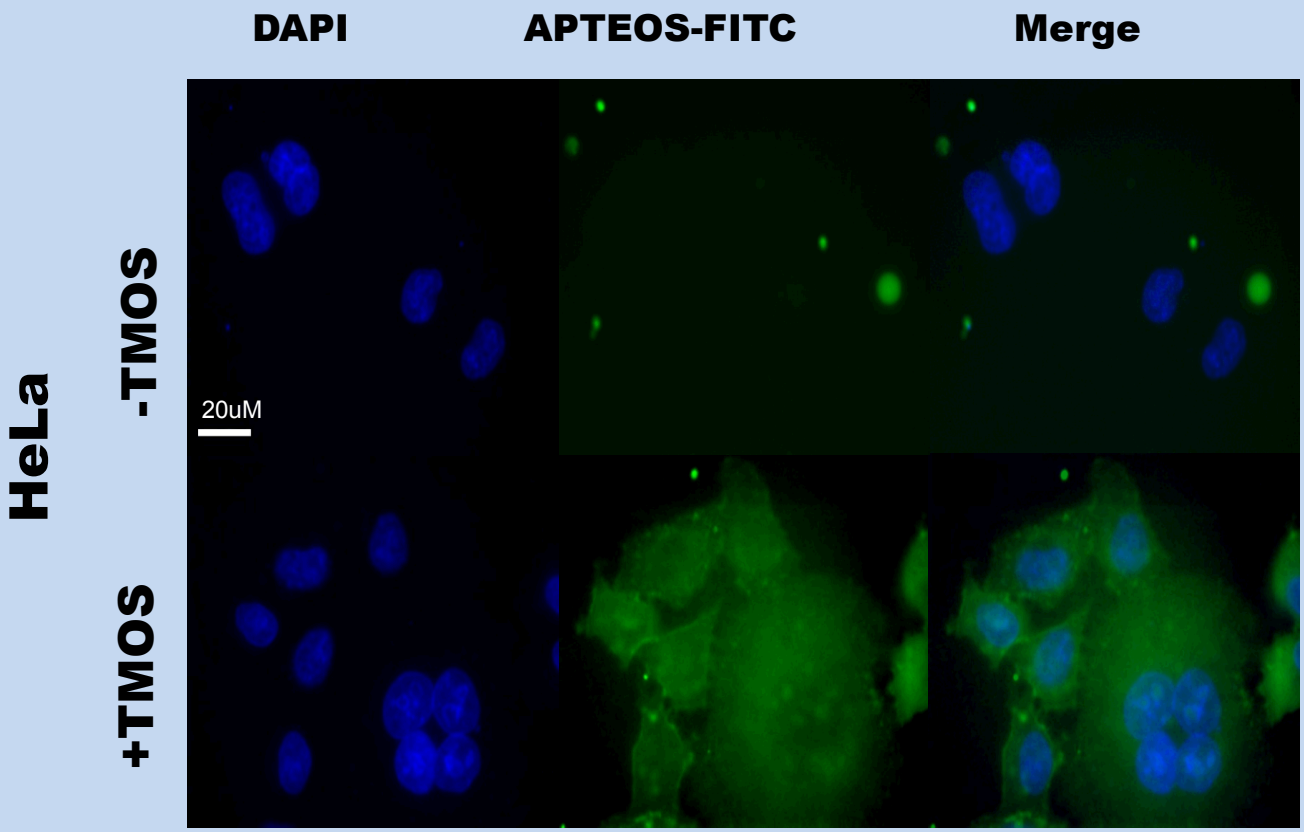
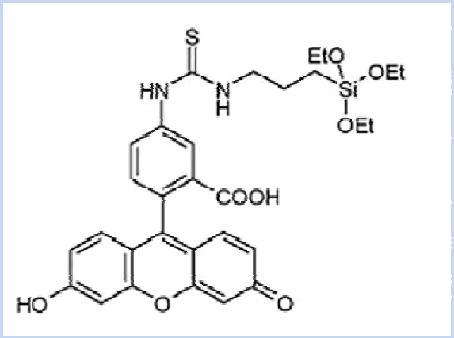
Silica Deposition on HeLa Visualized with APTEOS-FITC





APTEOS-FITC

Doussineau T, et. al. Advanced Functional Materials. 2009

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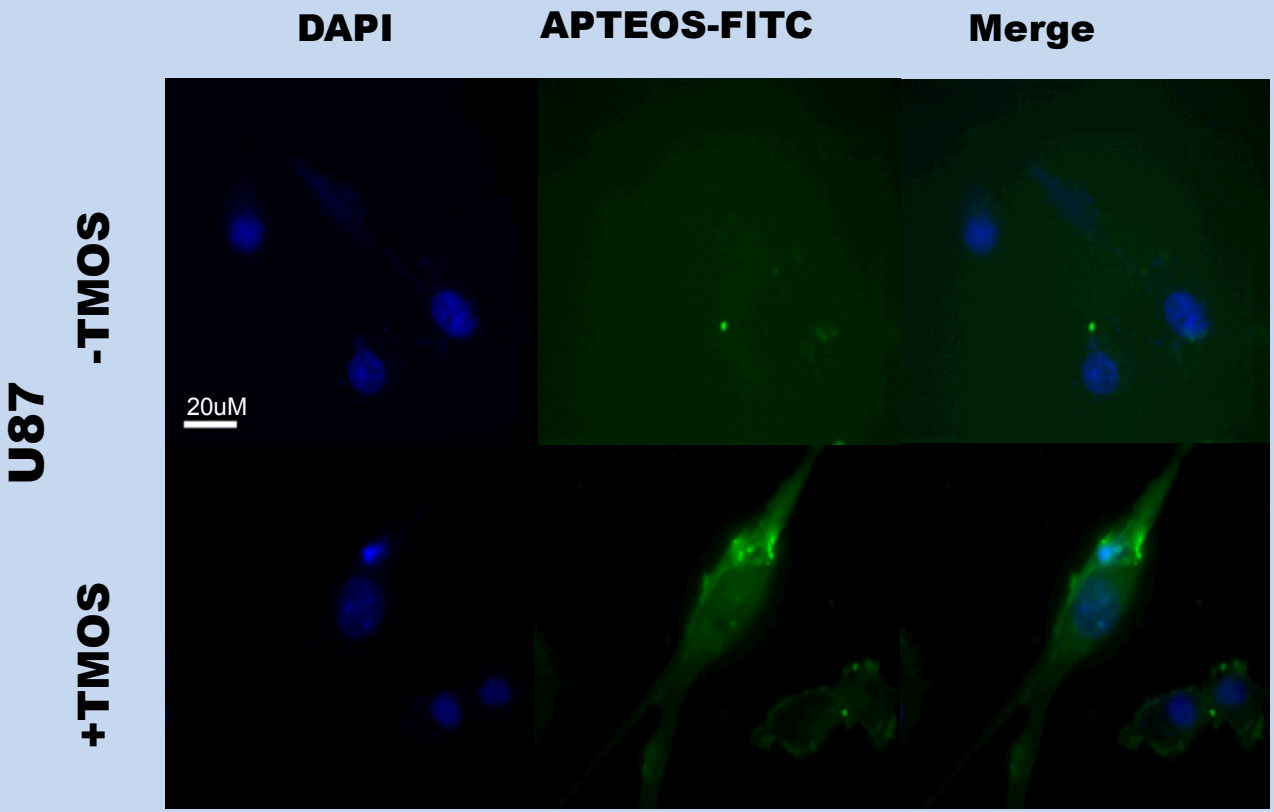
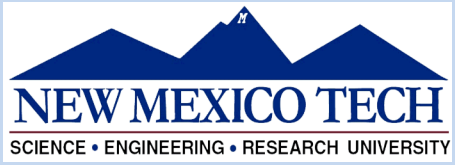
Silica Deposition on U87 (brain cancer) Visualized with APTEOS-FITC



Conclusions and Future work

- Conclusions
  - SG-CViL results in different sized silica species depending on reaction time (1 hr versus 15 min)
  - SG-CViL generated silica can be used to encapsulate multiple *S. cerevisiae* in silica or deposit a thin silica layer on HeLa and U87 cells
- Future Work
  - NMR studies for functionality of TMOS molecules at specific SG-CViL reaction times and temperatures
  - Kinetics
  - Viability and responsiveness analysis of HeLa and U87cells post SG-CViL

Acknowledgements



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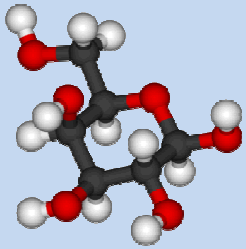
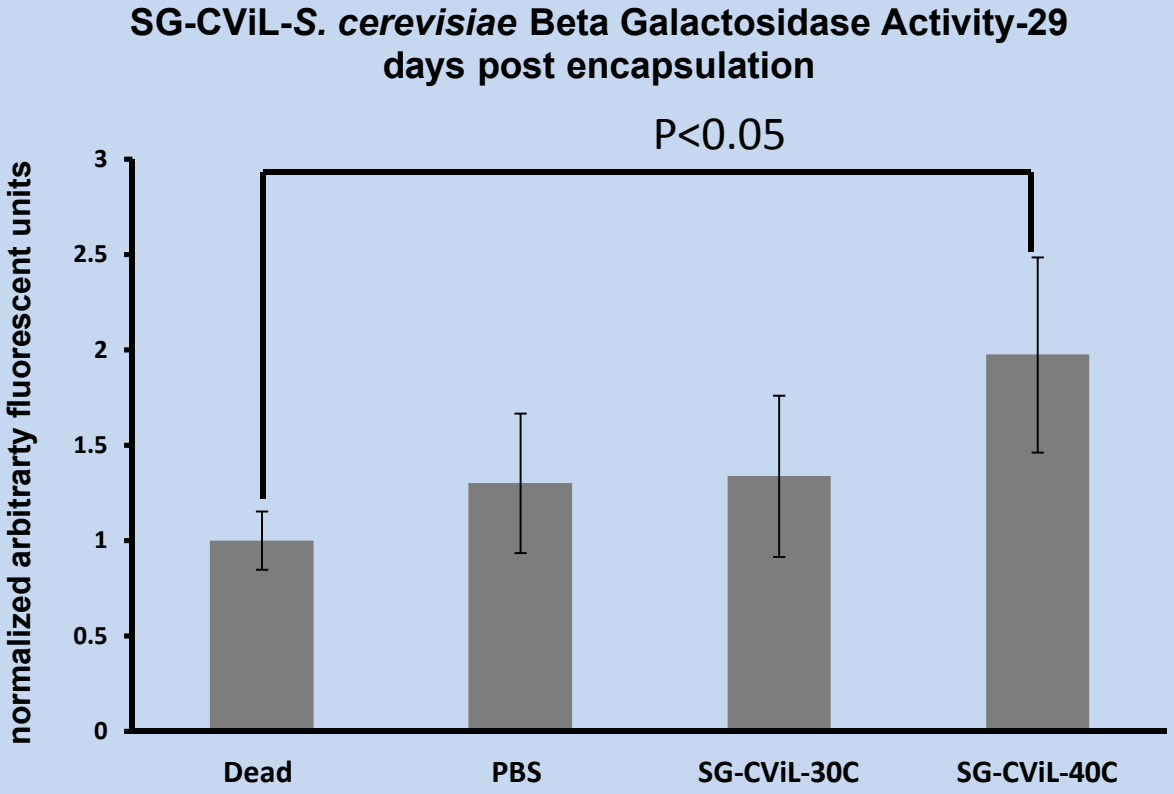
Responsiveness of Silica encapsulated *S. cerevisiae*

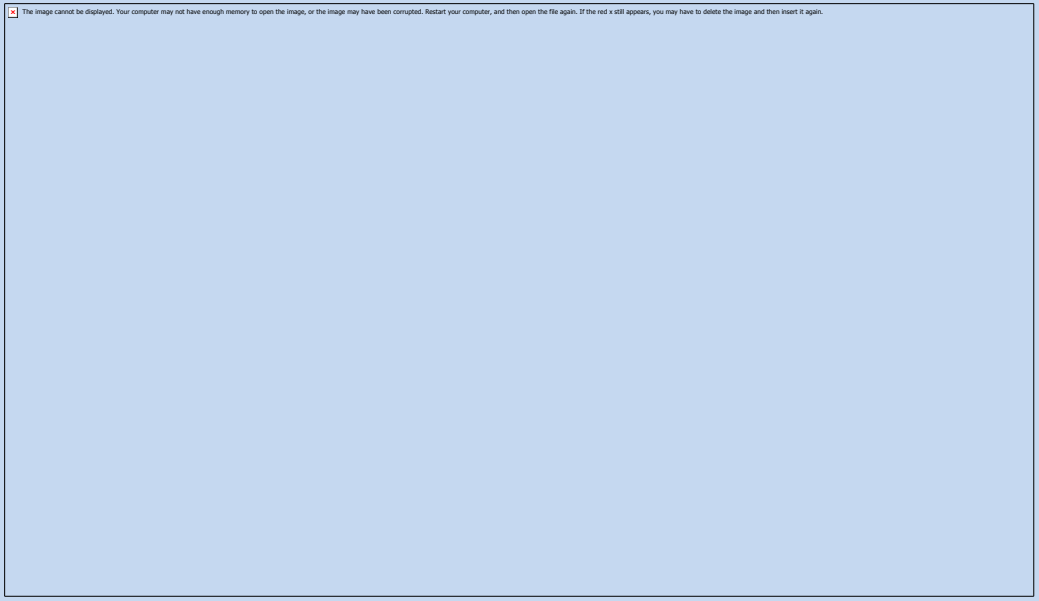
- SG-CViL reaction-1 hour at 30°C or 40°C
- Encapsulated *S. cerevisiea* engineered with galactose inducible beta-galactosidase gene (galactose "sensor")
- Cells exposed to galactose, beta-galactosidase level measured using fluorescent probe



Galactose
MW=180.2 g/mol



Silica Particle Size for SG-CViL Reaction at 40°C for 15 min)



Silica Encapsulation of Jurkat (T-Cell Lymphoma) cells