



**Nanosprings™: A Versatile Nanomaterial Platform
Applications in Life Sciences and Pharmaceutical Synthesis**

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World Class. Face to Face.

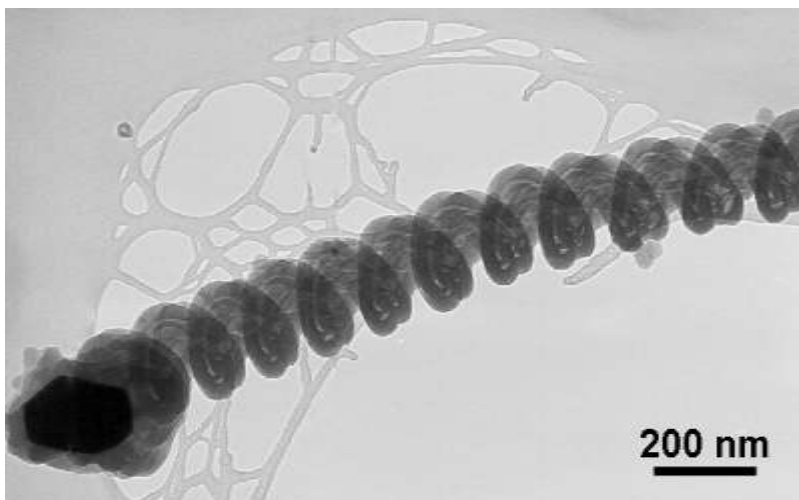


Company Background

- Underlying technology developed over 10 year period between WSU and UI
- Negotiated exclusive license with WSURF Summer 2007
- Incorporated Fall 2007
- Opened Innovation Center Spring 2008
- Series A Round Company - 3M
- \$510k in NSF SBIR grants awarded
- Recent NIH SBIR with BioTracking
- 10 employees
- Collaborations – industry and academia



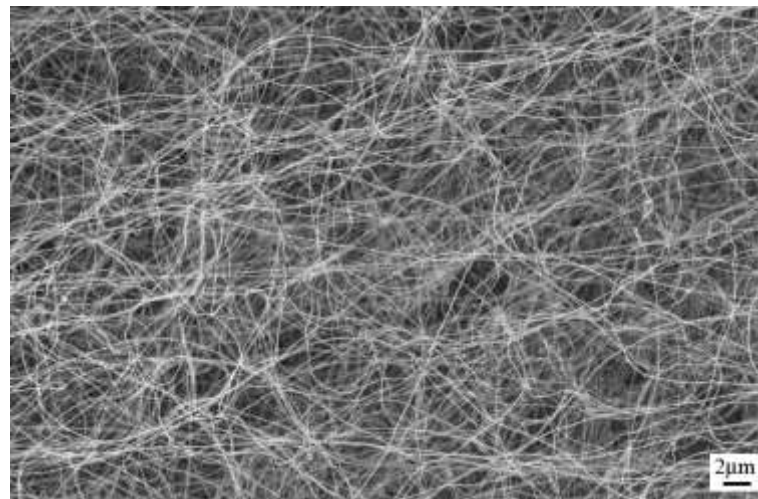
Silica NanospringsTM



An individual SiO₂ Nanospring

Advantages of Nanosprings:

- Low growth temperature (< 350°C)
- Atmospheric pressure process
- Mat thickness 3 – 300µm
- Hydrophilic
- 100% accessible surface area (>350m²/g)
- Easy to functionalize, e.g., using silane chemistry

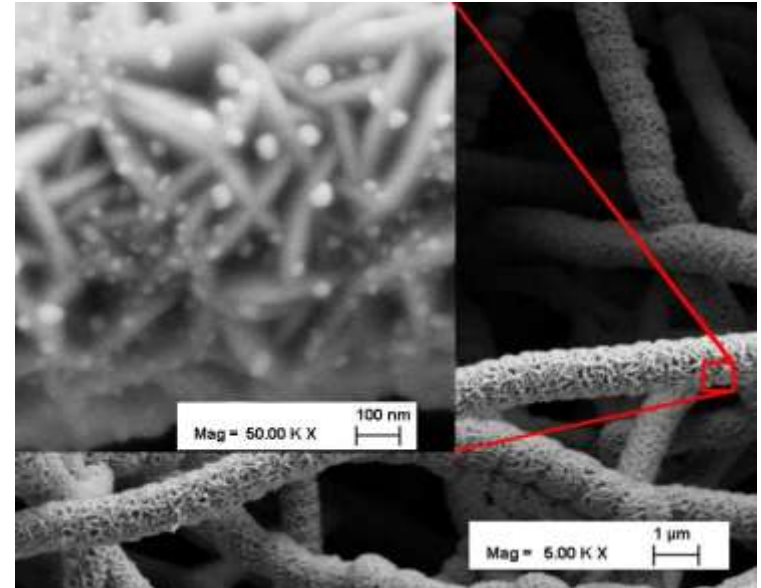
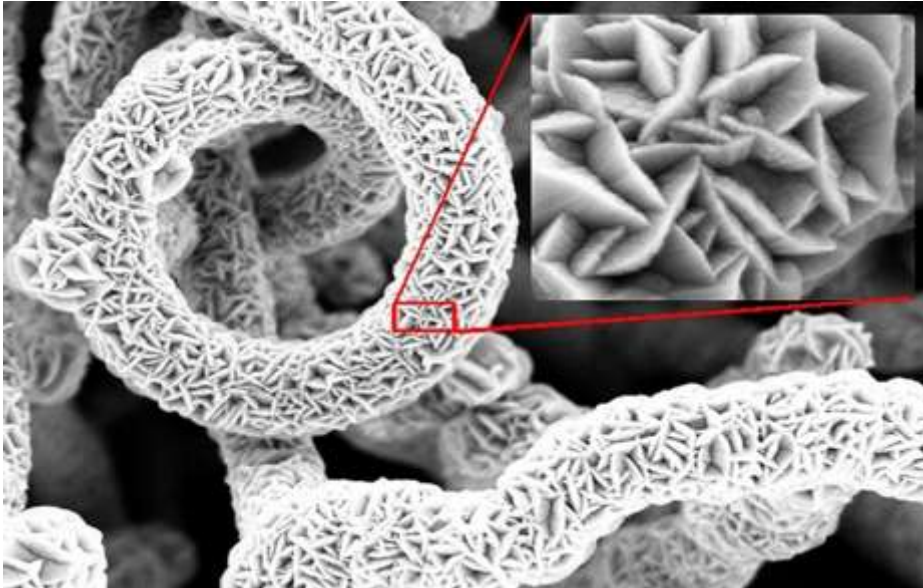


A mat of Nanosprings

Substrate Flexibility:

- Aluminum foil
- Glass (including Pyrex®)
- Ceramics
- Fiberglass
- Silica beads
- Stainless steel
- High T_g polymers

Coatings Capabilities

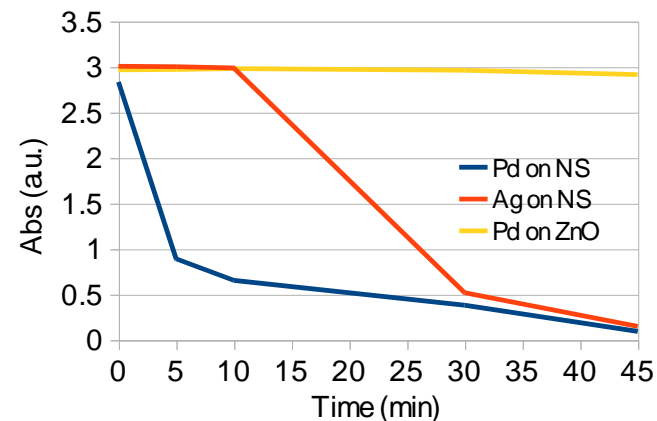
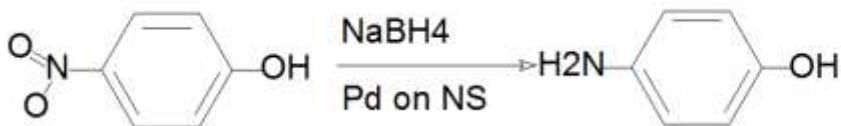


- Cu on Silica Nanosprings
- ZnO on Silica Nanosprings
- TiO₂ on Silica Nanosprings
- Cu on ZnO on Nanosprings
- Au on Silica Nanosprings
- Ag on Silica Nanosprings
- Pt on Silica Nanosprings
- Pd on Silica Nanosprings

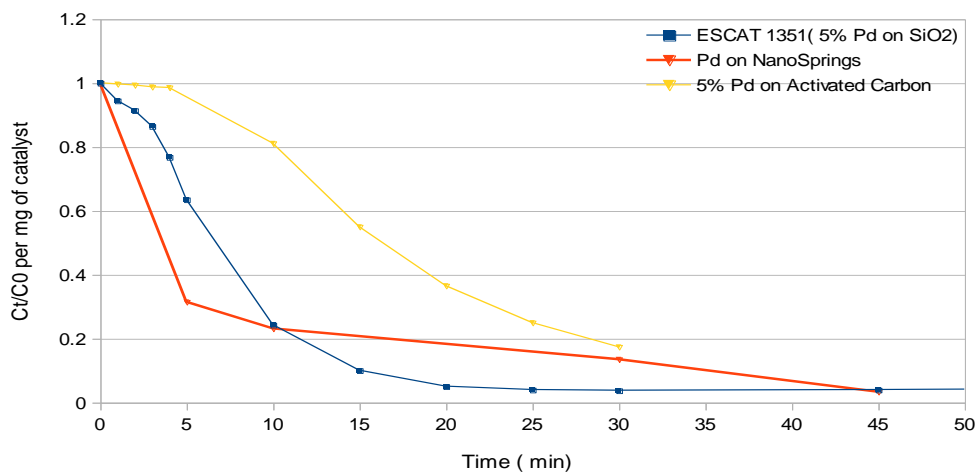
Application: Chemical Synthesis

CFR Preliminary Results

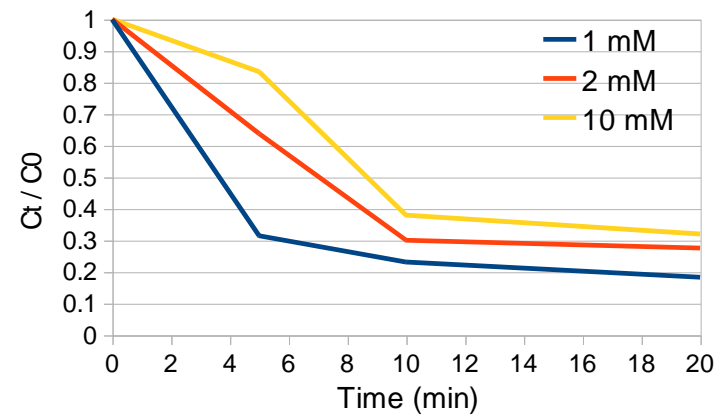
- 0.5 ml of 1.12 mM 4-nitrophenol in a cuvette
- 10 X 5 mm² samples immersed in the solution
- 0.5 ml of 10 mM NaBH₄ solution in a cuvette
- Absorbance measured at 400nm
- Concentrations of nitrophenol varied



Disappearance of 4-Nitrophenol due to different catalysts



Decrease in 4-nitrophenol concentrations over time
Comparison with other catalyst supports



Variation of reaction rates at various nitrophenol concentration

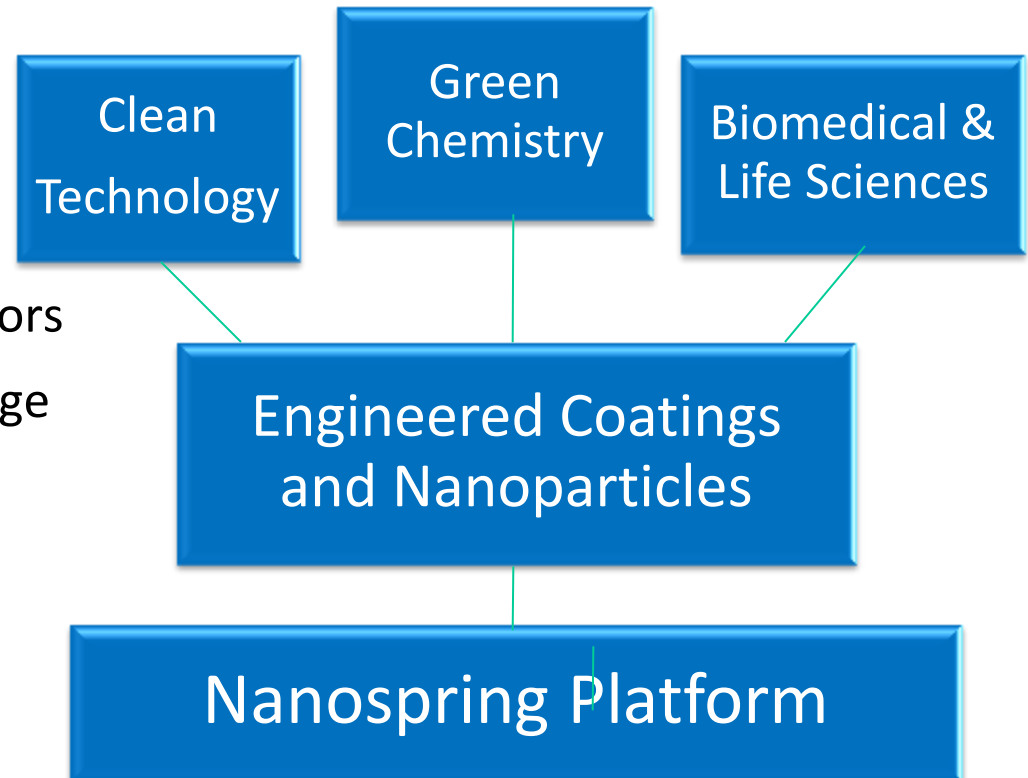
NanospringTM Platform

Emerging Opportunities with Partners

- Hydrogen Storage
- Ultracapacitors
- Biomedical Devices
- Biological and Chemical Sensors
- Energy Generation and Storage

Internal Focus Areas

- Continuous Flow Chemistry
- Catalytic Converters
- Carbon Capture & Recycle



Biomedical and Life Sciences Applications

- Enhanced enzyme-linked immuno-sorbent assay (ELISA) for animal diagnostics

Partner: BioTracking in Moscow, ID (NIH – SBIR)



- Circulating tumor cell capture

Partner: Cancer Targeted Technology (CTT) in Bothell WA

Cancer Targeted Technology

- Immobilized enzyme continuous flow reactors for pharmaceutical synthesis

Partner: Technische Universiteit Eindhoven (TU/e) (part of EU ProAChim project)

- Biosensors

Partner: University of Idaho

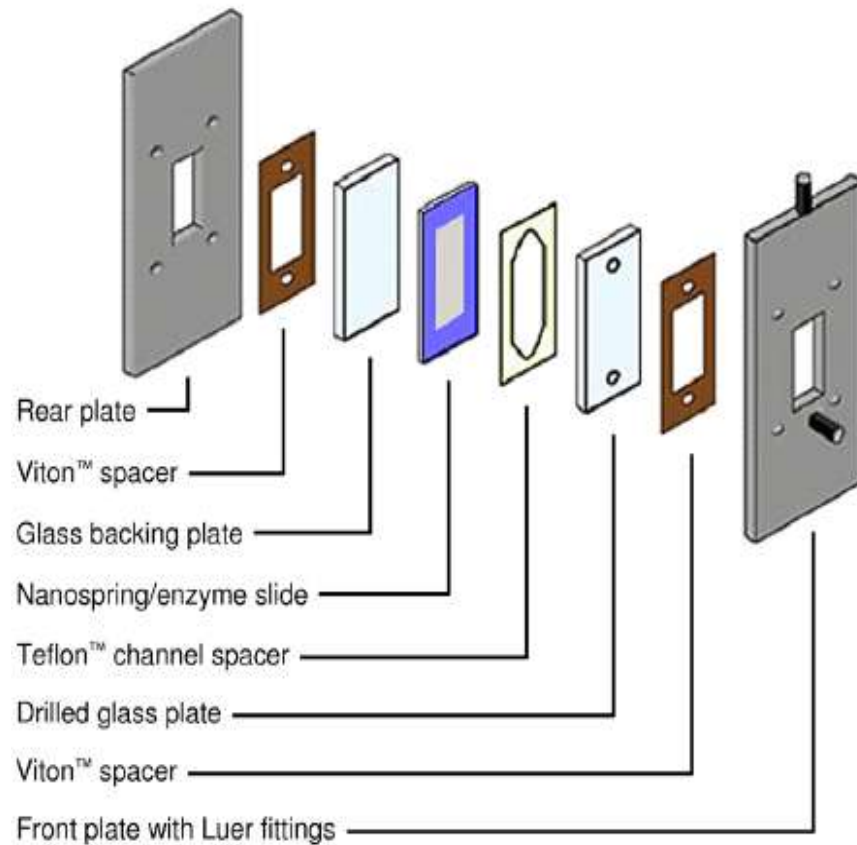


University of Idaho

Application: Immobilized Enzymatic Reactors



- Nanospring matrix formed on fiberglass
- Mat thickness $\sim 80\mu\text{m}$
- Simple plate reactor geometry



Advantages: Continuous flow vs. Batch

- Product inhibition can be avoided because product is continuously removed from the reaction
- Enzyme is continuously recycled, eliminates the need for a recovery step
- Temperature, pH, and other reaction components can be more precisely controlled
- Reactors can be numbered up as opposed to scaled up.

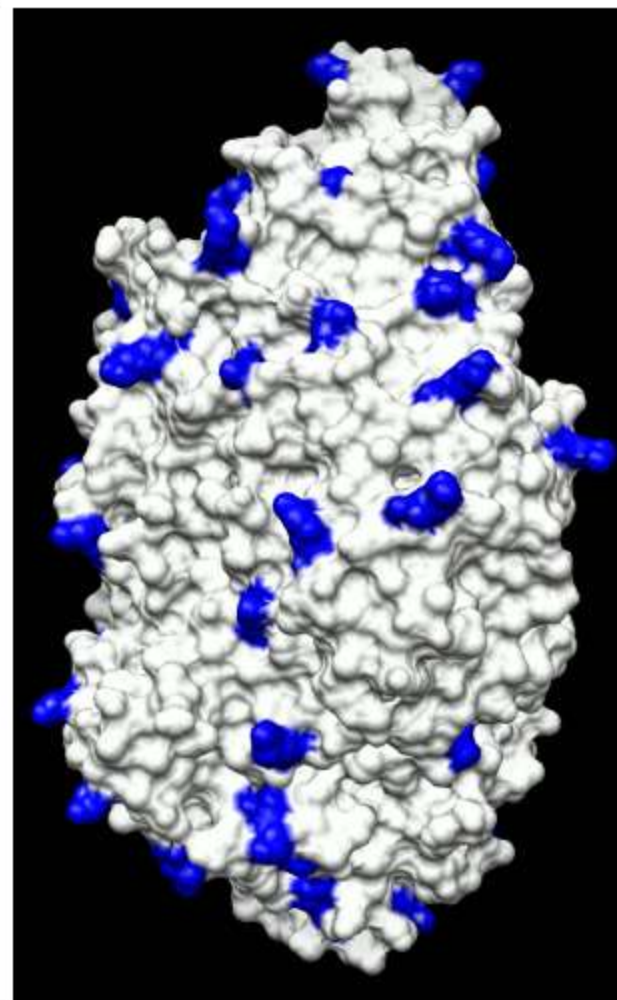
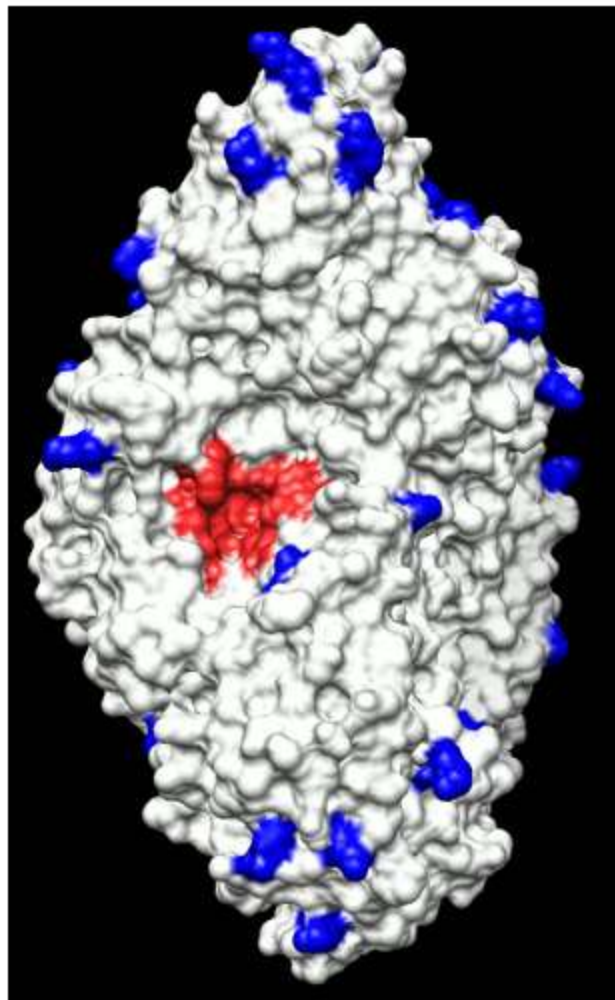
The red spot is the active site

The active site needs to remain accessible upon immobilization

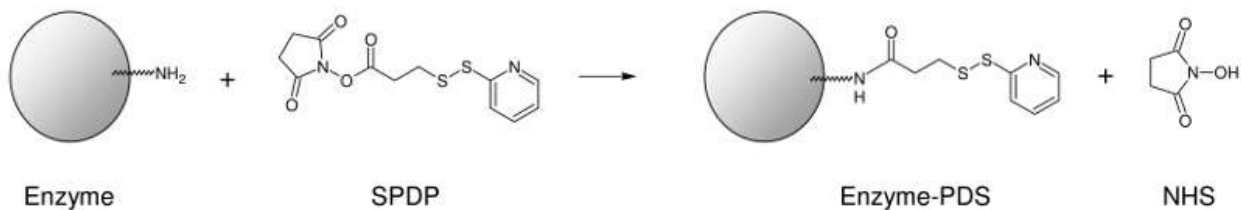
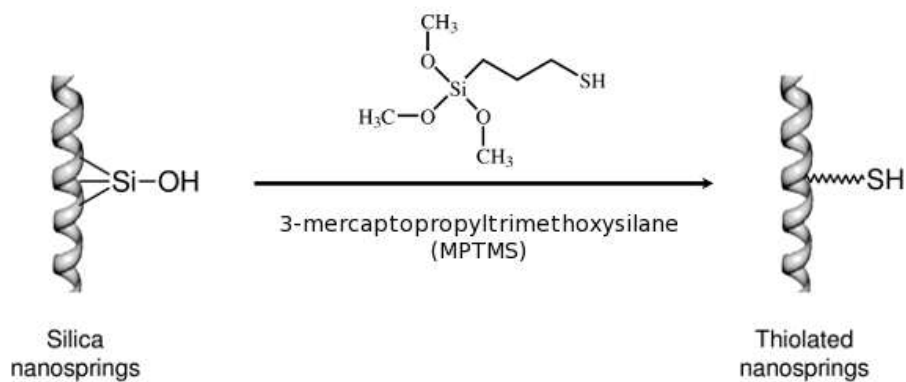
The attachment points are the lysine side chains, shown in blue

Most attachment sites are on the side opposite to the active site

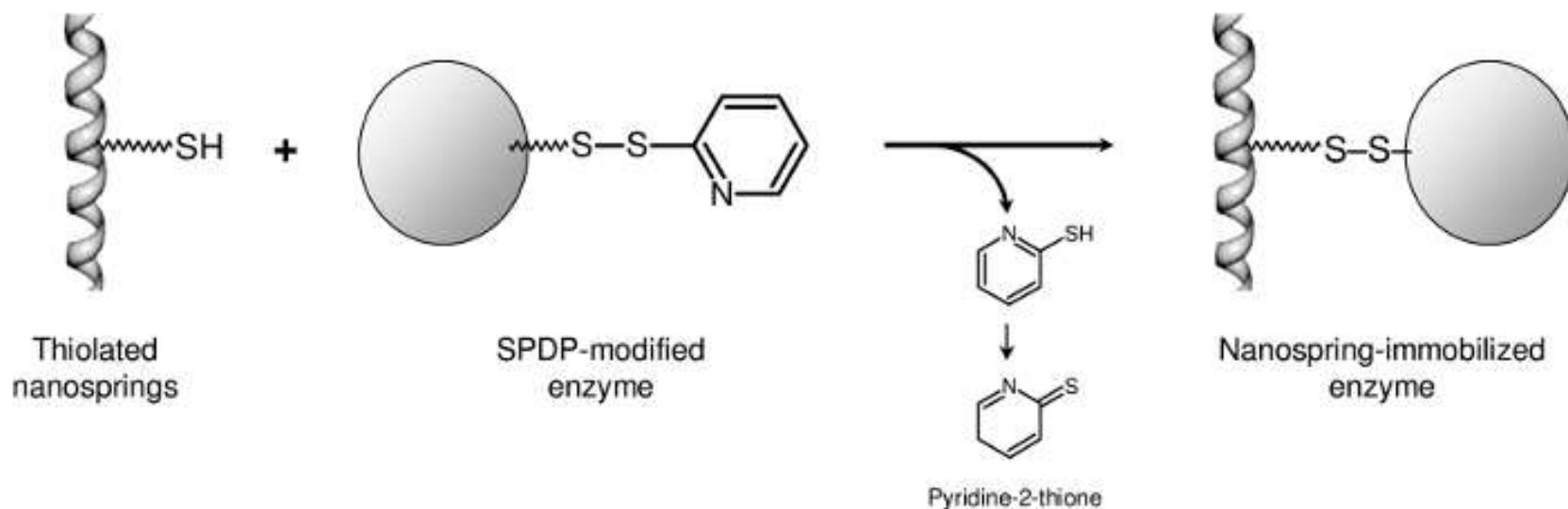
This enzyme is well suited for immobilization studies



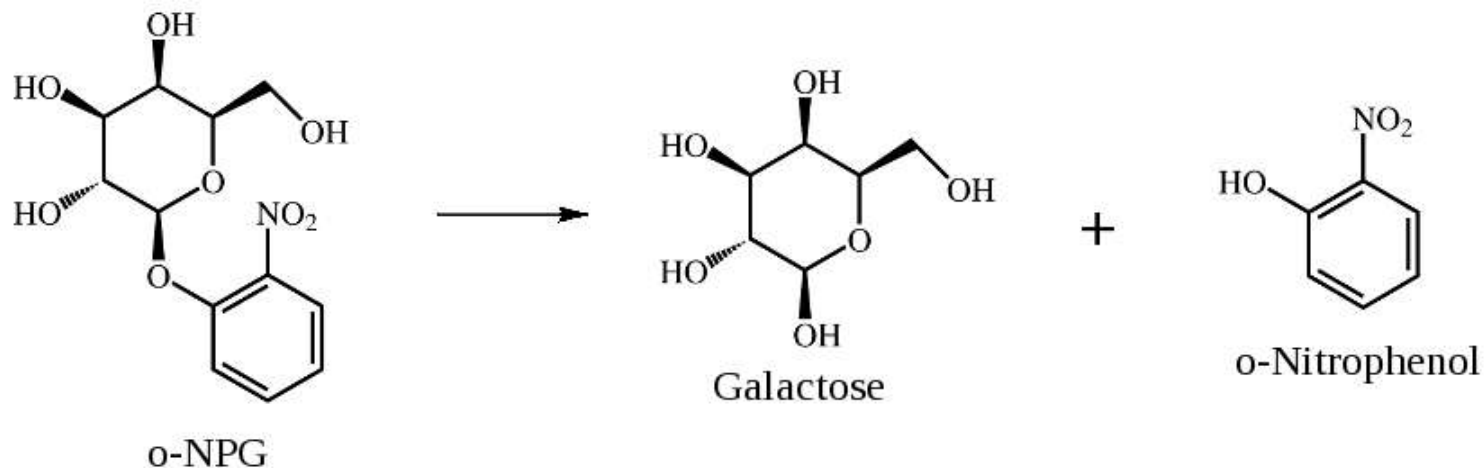
Example Procedure for Immobilizing β -galactosidase on Nanosprings - I



Example Procedure for Immobilizing β -galactosidase on Nanosprings - II



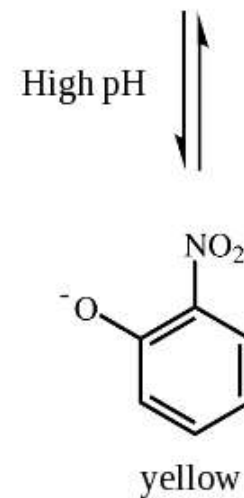
Model Reaction



Beta-galactosidase cleaves o-(nitrophenol β-D-galactosylpyranosid)NPG into galactose and o-nitrophenol.

At high pH, o-nitrophenol is converted to a colored compound with an absorbance maximum at 415 nm.

The reaction can be monitored by spectrophotometrically measuring the amount of yellow compound produced.



Series Reactors

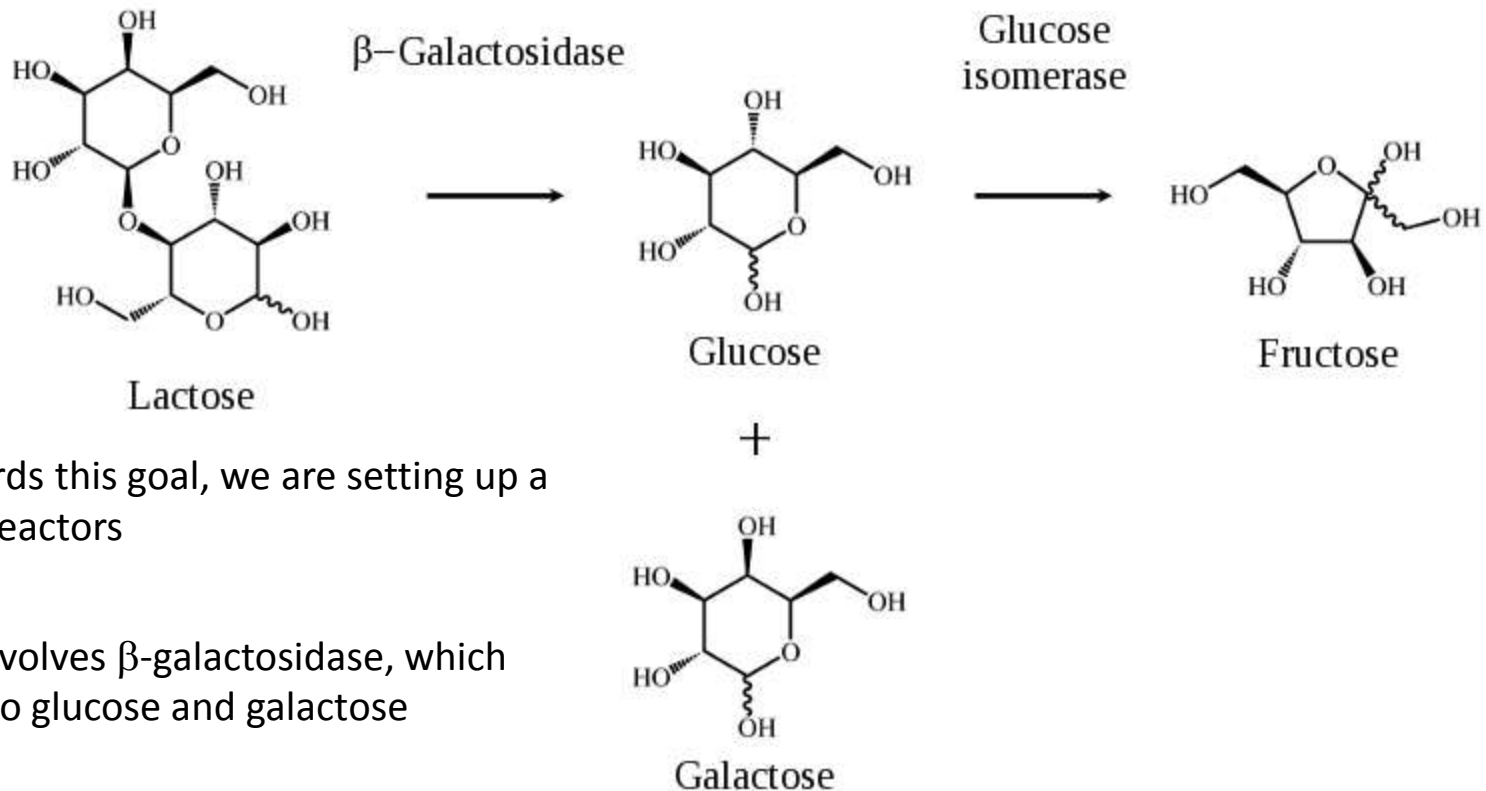


Objective: Create multiple reactors system with multiple enzymes for production of synthetic compounds.

Outcome: Load precursor material at one end of the reactor series and retrieve a multistep reaction product from the last reactor.

The compact nature of Nanospring enzyme reactors makes this feasible

Two-Step Reactor

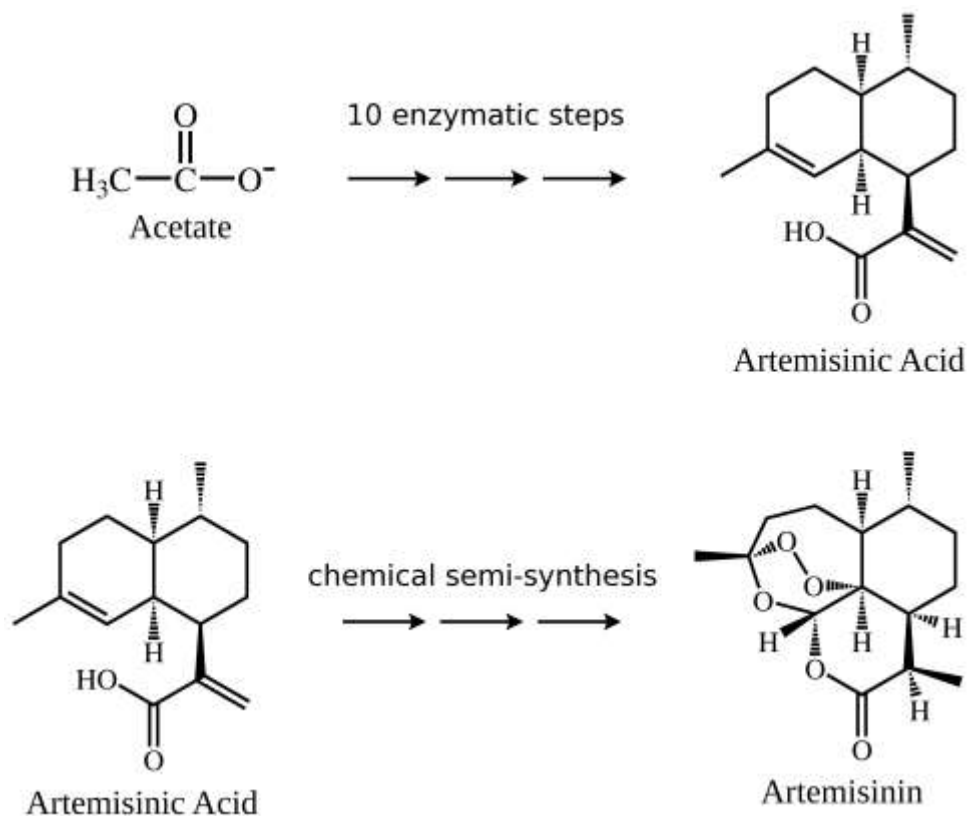


As a first step towards this goal, we are setting up a two-step series of reactors

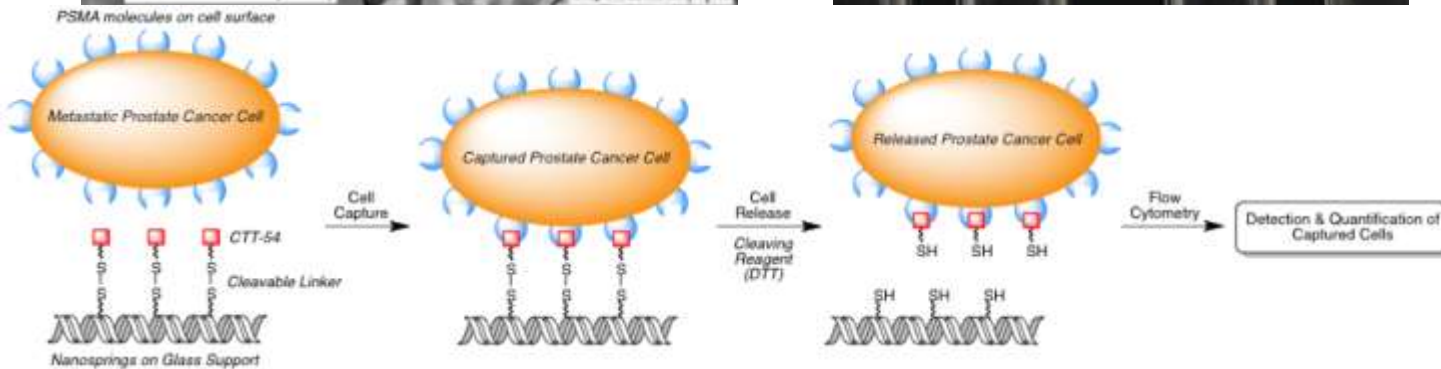
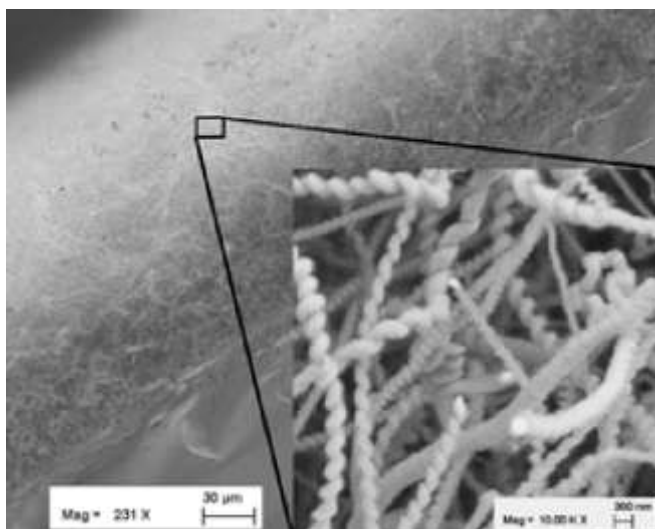
The first reaction involves β -galactosidase, which converts lactose into glucose and galactose

The second reaction involves glucose isomerase, which converts glucose into fructose

Multi-Step Reactor Concept



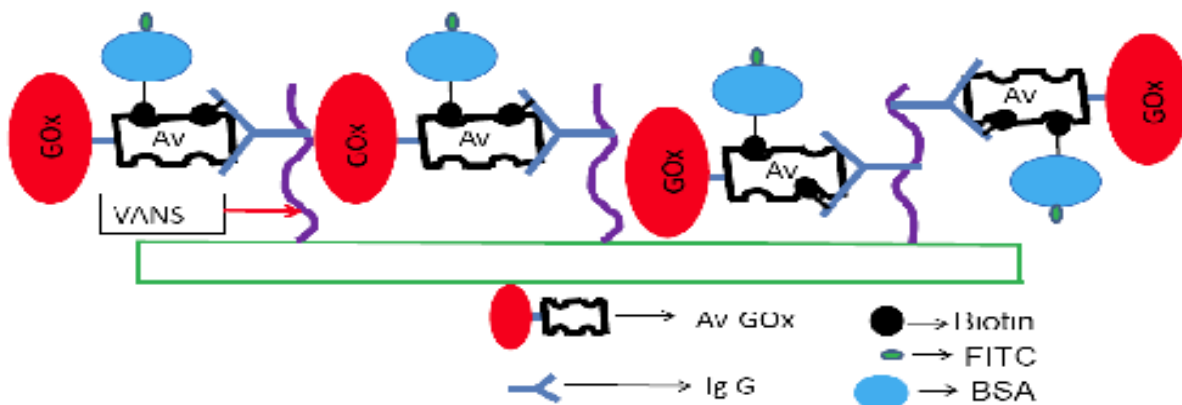
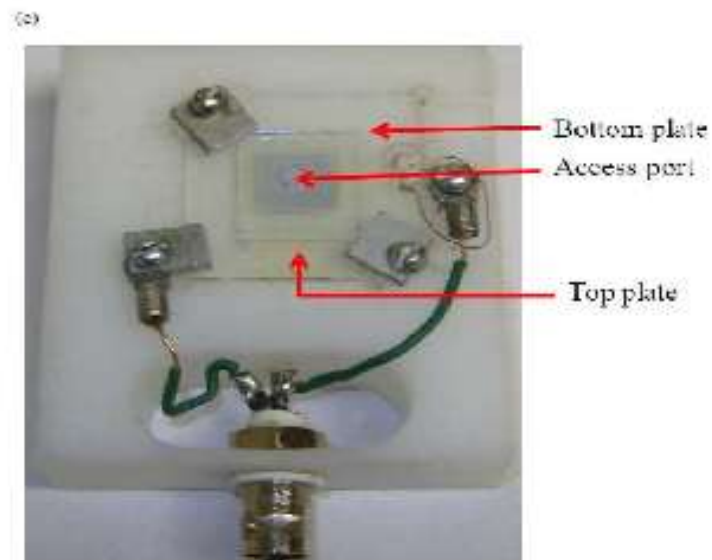
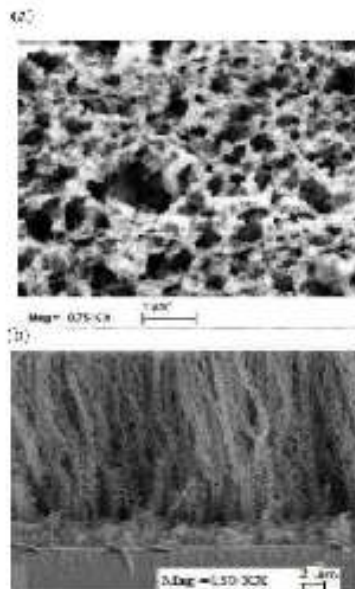
Functionalize Nanosprings with PSMA inhibitors

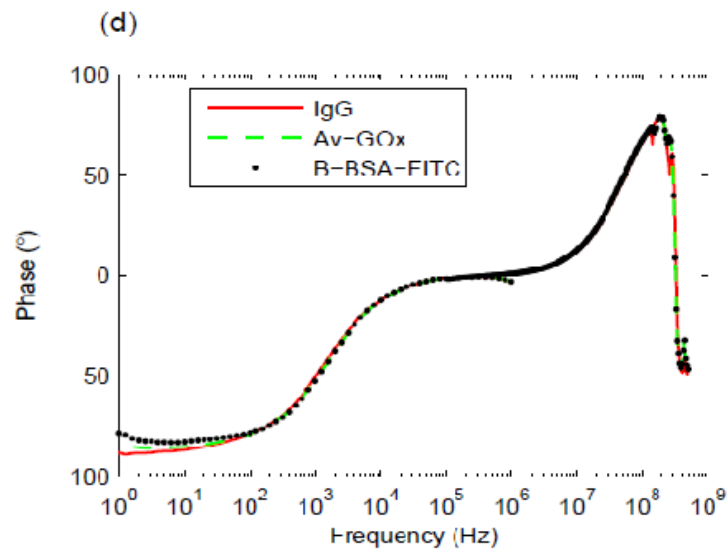
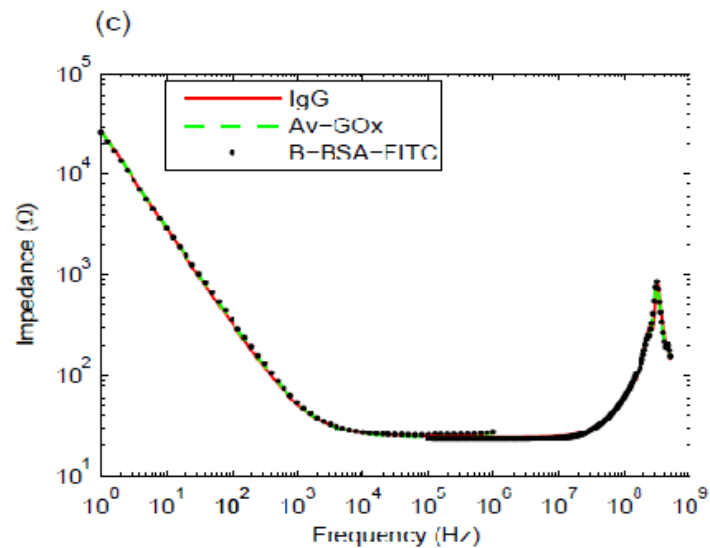
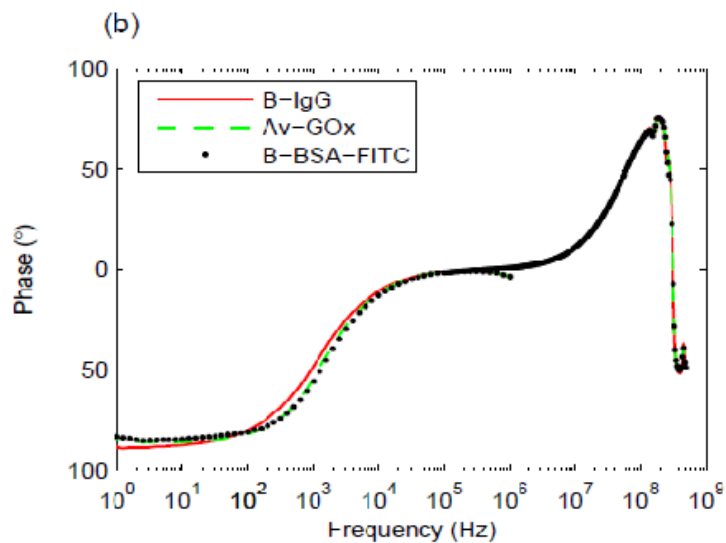
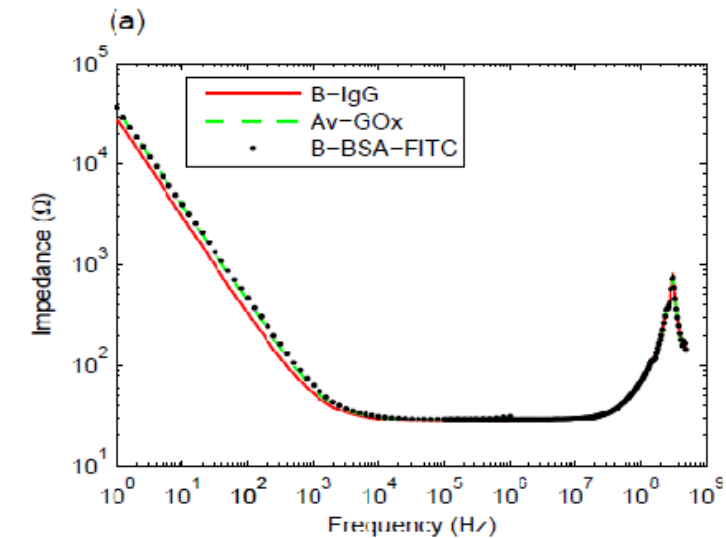


Glucose Biosensor

Vertically-aligned
Nanospring mat – VANS –
grown on conductive glass
substrate

Narrow spacing between
adjacent Nanosprings







GoNano[™]
technologies, inc.