Optimization of Biopolymer-Based Smart Materials

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Thursday, August 29th 2013
Smart materials can revolutionize drug delivery.
How can we make smart materials that respond to specific molecular cues?
We use biopolymer networks to create materials that respond to the specific molecular targets.
Aptamer technology makes this possible

Single Stranded DNA

Molecular Cue

Bound molecular cue in stem loop

Blue = Aptamer Strand  Red = Structural Strand
My goal is to optimize the tradeoff between strength and responsiveness for this material.
Monitoring the supersandwich

Fluorescent

Molecular

Dark
Step 1: Affinity of structural strand/apatmer duplex

Concentration of Structural Strand (M) vs. Fluorescence

Concentration of Probe (M) vs. Signal Intensity (AU)
Step 2: Sensitivity to ATP

Fluorescence vs. [ATP] (mM)

- Fluorescence axis
- [ATP] (mM) axis

Graph showing the relationship between fluorescence and ATP concentration.
Step 3: Dissociation rates
Results: Supersandwich

- We ran a series of experiments to characterize our system
- Determined experimental parameters
- Completed Proof-of-concept goals
Beyond the Supersandwich: 3D Hydrogels

Monomers → Formed Hydrogel → Monomers & molecular cue bound aptamers
The first challenge was to correctly form the monomers.
Hydrogel Monomer Formation

Slow 4 hour Gradient cooling

- Subunit only
- Low Concentration
- High Concentration

Formed Monomer
Partially Formed
Unformed

Quick 2 hour Gradient cooling

Band Quantification

- Higher Order
- Fully Formed
- Partially Formed
- Unformed

Fraction of Total Lane Content

- Single Stranded
- Low Concentration
- High Concentration
We test hydrogel formation by tracking fluorescent beads trapped in the gel.
Results: Hydrogel

Initial tests show that beads become trapped when the gelling process is activated at pH 5
Acknowledgements

Plaxco Group:
- Dr. Kevin Plaxco
- Anna Simon
- Dr. Camille Lawrence

Reich Group:
- Adam Pollock
- Clayton Woodcock

Equipment:
- Parson’s Group
- Materials Research Lab

Program Coordinators:
- Dr. Arica Lubin
- Dr. Maria Napoli
- Kevin Moore
- Dr. Galen Stucky

[Logos and images of institutions and people]
Nanopore Structure

No Transport

Network Breakdown

Transport Allowed
ACC TGG GGG AGT ATT GCG GAG GAA GGT

Aptamer technology functionalization

SuperSandwich (1D architecture)

Hydrogel (3D Architecture)

Goal: Optimize Strength and Responsiveness
Fluorescence resonance energy transfer
Aptamer-Probe Binding Study (40°C)

Binding of Molecular Beacon to Probe (39°C)

Concentration of Probe (M)

Signal Intensity (AU)
I use DNA as a building material

...to gate nanoscale channels that open in response to a specific molecular cue
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I use DNA as a building material to gate nanoscale channels that open in response to a specific molecular cue.
We look to Nature for our inspiration

Using Ligand gated ion channels as a model system to replicate
71.5mM ATP/2μM Sandwich Kinetic Trace (5 sec)

Concentration of Probe (M)

Signal Intensity (AU)

Signal (A.U.)

[ATP] (mM)

Aptamer-Probe Binding Study (25ºC)