Reversible Antibody Trap for Selective Sensor Devices

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**ABSTRACT**

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Reversible Antibody Trapping For Selective Sensor Devices

Tethered Antibodies

selective, but static

Switchable PNIPAM Film

programmable, but non-selective

Combined Antibody Trap

programmable and selective

New Laboratory Directed Research and Development Project for FY’04:

• Develop Programmable, Selective Biomaterial Interfaces.
• Integrate Bio-Active Materials into Sensors for Homeland Defense
Selective Surfaces via Antibody Trapping

PNIPAM grabs antibodies to create highly selective protein monolayer.

Antibody layer captures bioactive agents.

PNIPAM releases active agents, resets to adsorb new proteins.

Materials Issues: Interactions of Proteins with Bioactive Surfaces
1) Reversibility of species adsorption/desorption.
2) Activity of antibodies in adsorbed films (packing, orientation).
3) Competition for active surface sites in complex biofluids.
Program Components

Antibody Interactions

Active Films
Dale Huber
Antibodies/Antigens
George Bachand

Characterization

Surface Spectroscopy
Interfacial Force Microscopy
Bruce Bunker

Neutron Reflectivity (LANSCE)

Integrated Sensors

Thermal Switching
Ron Manginell
SH-SAW Sensors
Susan Brozik
Properties of Poly(NIPAM) Gels

- Swollen with water--heavily hydrogen bonded
- Hydrophilic surface
- Resists protein adsorption

- Hydrogen bonding disrupted--deswelled
- More hydrophobic surface
- Does not resist protein adsorption

HN

O

\( H_n \)

\( \text{Hydrophobic} \)

\( \text{Hydrophilic} \)

\( \text{H-bond donor} \)

\( \text{H-bond acceptor} \)

LCST ~ 35 °C

30°C

40°C
Variable Temperature Contact Angle Measurements Show Reversible Switching in Tethered PNIPAM Films

- Receding contact angle constant at 40°C
Trend: Hydrophobic Surfaces Adsorb Proteins
Hydrophilic Surfaces Don’t

Ellipsometry Results, Human Serum Albumin Adsorption

PNIPAM resists protein adsorption at 25°C. Adsorption is extensive on PNIPAM at 55°C.
Native Myoglobin Desorbs When PNIPAM Switches

1 hr adsorption/55°C
0.5mg/ml myoglobin
Poly(NIPAM) Functionalized Microchip

> 35°C

< 35°C

Programmed adsorption and release of proteins in a microfluidic device
Huber, Manginell, Samara, Kim, and Bunker
Science 301, no.5631, p.352-354
Integrated Sensor Devices

Thermally-Activated Protein Trap

Shear-Horizontal Surface Acoustic Wave (SH-SAW) Sensor

Rapid Switching:
Adsorption/desorption of protein monolayers in < 1 sec.

Exceptional Mass Sensitivity:
500 pg/cm² (0.15% IgG monolayer)
(800 spores/ml detected)

Materials Issues:
Integration of thermal and acoustic properties.
1) Acoustic Issues - PNIPAM on waveguiding, acoustics on phase transition
2) Thermal Issues - LiTaO₃ behavior vs. T, thermal response times
Preliminary Results

- Achieved total reversibility of protein adsorption on pNIPAM films.
- Can capture protein from very dilute solutions.
- Adsorption behavior of antibodies on pNIPAM is similar to other proteins, except there is a tendency to form multilayers.
- Antibody adsorption is reversible.
- Currently quantifying binding activity as a function of surface coating for a series of antibodies (native and engineered).
- Designs for integration of heating, SAW devices are being developed.
Conclusions

- Developing a small, reusable, highly selective sensor
- Can be programmed for just one antigen or a series of antigens by using a sensor array.
- May be programmed on the spot for any antigens for which antibodies are available.
- After use, the spent antibodies can be flushed, and the same or different antibodies can be adsorbed.
- Can be integrated into existing Sandia Micro-chemlab platform.

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