Designing Electrochemical Sensors based on Ultrathin Biomolecular Films and Nano-materials

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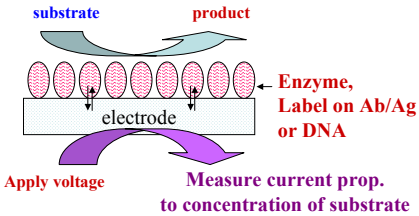
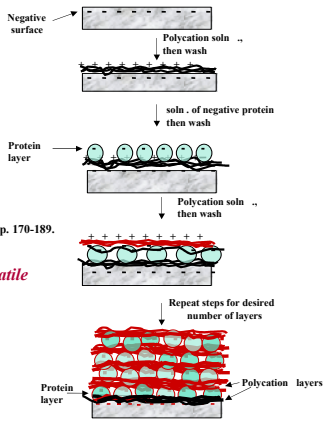
Electrochemical Biosensors



- nanoscale biosensing architecture
- patternable nanomaterials for arrays

Layer-by-layer Film assembly

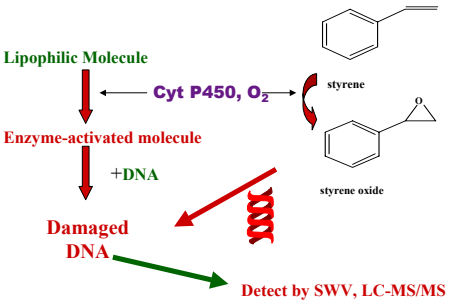
Lvov, Decher



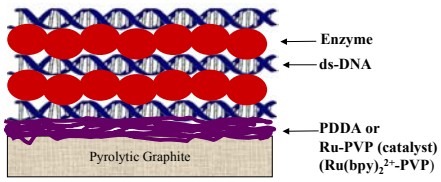
Lvov, Y. in Nalwa, R.W.; Ed.; *Handbook Of Surfaces And Interfaces Of Materials, Vol. 3.* Academic, 2001, pp. 170-189.

Stable, easily prepared, versatile

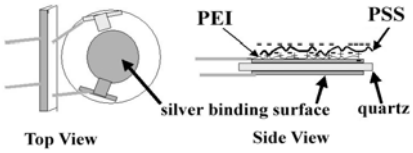
Toxicity Screening



Films for Toxicity Screening

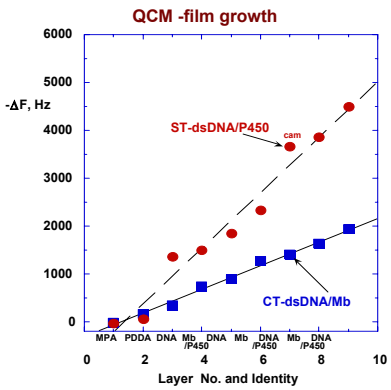


QCM Resonator



Mass: $M/A = -\Delta F/1.86 \times 10^8$

Thickness: $d = -(0.016)\ \Delta F$



Screening Chemical Toxicity

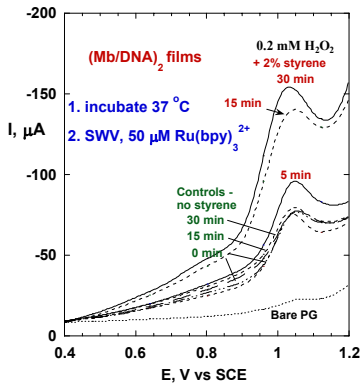
Enzyme reaction:
Incubate film with
Metabolite + H_2O_2

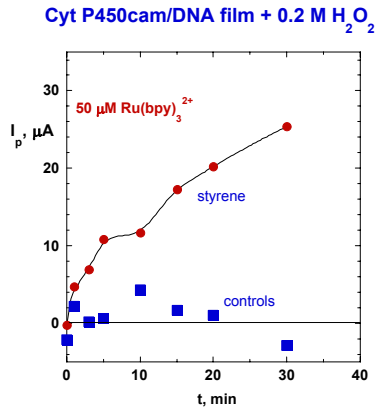
↓

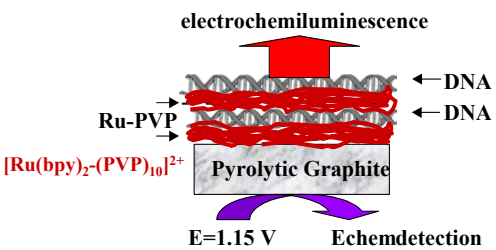
Analysis by catalytic SWV or
electrochemiluminescence

$RuL^{2+} = RuL^{3+} + e^-$

$RuL^{3+} + DNA\text{-}G \rightarrow RuL^{2+} + DNA\text{-}G\bullet$



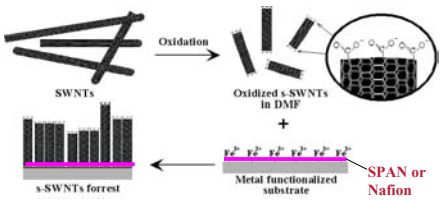




Lynn Dennany, Robert J. Forster and James F. Rusling, "Simultaneous Direct Electrochemiluminescence and Catalytic Voltammetry Detection of DNA in Ultrathin Films" *J. Am. Chem. Soc.* **2003**, *125*, 5213-5218.

Collaboration with NCSR, Dublin City Univ.

Single-Walled Carbon Nanotube Forests: Antigen-Antibody Sensing



Chattopadhyay, Galeska, Papadimitrakopoulos, *J. Am. Chem. Soc.* 2001, *123*, 9451.

End COOH groups allow chemical attachment to proteins (antibodies)

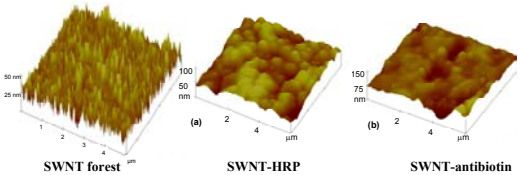
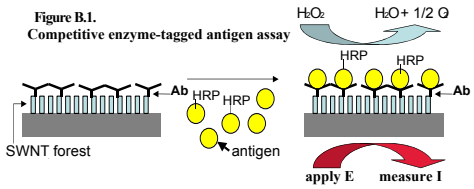
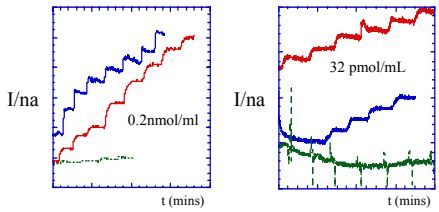


Figure B.1.
Competitive enzyme-tagged antigen assay

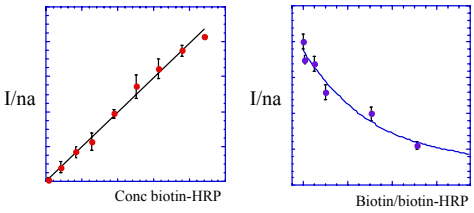


Anti-biotin/biotin-HRP test system



SWNT forest/Anti-biotin electrodes:
Amperometry at 2000 rpm in buffer with 4 mM H_2O_2 at -0.2 V measuring anti-biotin (Ab)–biotin-HRP binding on SWNT forests. Bovine serum albumin (BSA) used to inhibit non-specific binding.
(a) Addition of 0.2 or 0.3 nmol/mL biotin-HRP each step (b) additions Of 32 pmol/mL biotin-HRP, near detection limit.

Anti-biotin/biotin-HRP test system



SWNT forest/Anti-biotin electrodes:
Amperometry at 2000 rpm in buffer with 4 mM H_2O_2 at -0.2 V measuring anti-biotin (Ab)–biotin-HRP binding on SWNT forests.
(a) Calibration for Addition biotin-HRP; (b) calibration for competitive assay

Design approaches to future arrays

1. **Layer by layer approach general, simple**
2. **Stable films, complex architecture, any surface**
3. **Ambient T solution processable**
4. **SWNT forests patternable by solution process**
5. **Possibility of automation**
6. **Sensors for toxicity, oxidative stress, proteins, pathogens**
7. **Enhancement of sensitivity by electrochemical catalysis or conducting polymers**

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Thanks to all our coworkers and collaborators
http://sp.uconn.edu/~rusling/

Thanks to YOU for listening!

Thanks to intangible creative factors

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