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Potentiometric Nitrate Sensors in the Form of Plant Roots

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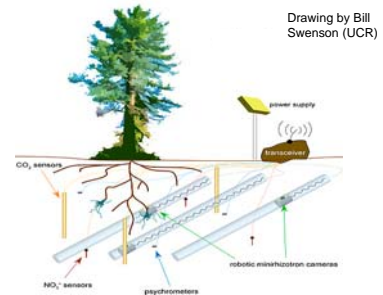
# Potentiometric Nitrate Sensors in the Form of Plant Roots

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## Introduction: Sensor fabrication in an environmentally relevant form factor

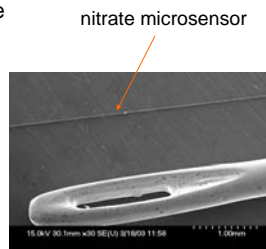
### Nitrate sensors for deployment in soils

- **Regulatory driver:** Nitrate levels in rivers, lakes and groundwater are regulated. Excessive levels pose a threat to human health and the environment
- **Sources of nitrate:** Nitrate is relatively ubiquitous and is released from point sources (wastewater treatment plant discharges) and nonpoint sources (agricultural fertilizer, atmospheric deposition)
- These factors point to a **need for scalable nitrate sensors** (small, inexpensive) for distributed, embedded deployments



## Problem Description: Can scalable nitrate microsensors be fabricated for soils?

- We are working on a novel concept, that of scalable nitrate sensors created in a form appropriate for dense soil deployments--**mimicking root fibers**
- Our sensors will be **inexpensive and environmentally benign** and minimally disturb the soil moisture propagation and chemical transport regime during observations
- **proof of concept** with nitrate-doped polypyrrole ion selective electrodes (Bendikov *et al.* 2005 *Sensors and Actuators B: Chemical*)

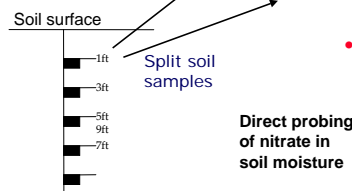


- Sensors suitable for long-term, low maintenance deployment will require further refinement, including:
- incorporation of **conductive rubbery polymers** with longer life cycles
- incorporation of materials **resisting biofouling** and/or develop systems for **sample pretreatment** (e.g., automated microfluidic prefiltration)

## Proposed Solution: Nitrate ion selective electrodes on carbon microfibers

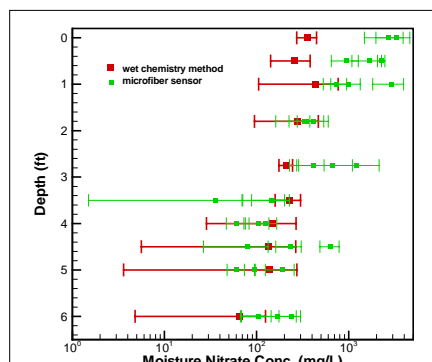
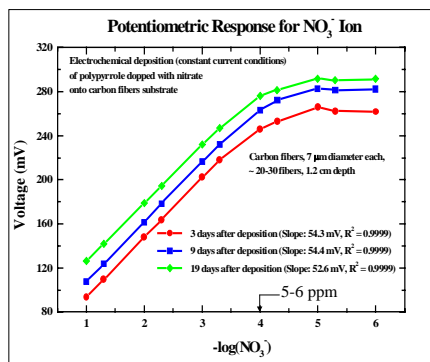
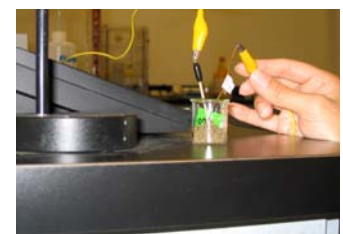
### Testing microsensor utility: direct soil moisture probing

- Nitrate microsensors were fabricated by electropolymerizing pyrrole onto 7 micron diameter graphite carbon filters in a nitrate solution.
- Soil samples were collected at depths ranging from 0 to 3 m at the Palmdale test bed where irrigation water contains elevated nitrate levels.
- **Conventional sampling entails extraction of the nitrate from soil into an aliquot of water followed by "wet chemistry and spectrophotometry"**
- **Conventional sampling requires time and effort, and results in hazardous chemical waste (cadmium reactant)**



### Results for real soil samples

- 1st split of core sample
- extract soil in water
- analysis by Griess-Romijn method (Hach reagent kit)
- **15-20 min/sample**
- 2nd split of core sample
- direct measure by contact with nitrate microsensor
- **5-10 sec/sample**



Calibration curve for nitrate microsensors (left) and results for direct probing of nitrate levels in 12% (by weight) moisture content on Palmdale sandy soil (right).

- **Direct probing technique successfully quantifies soil nitrate** levels in a fraction of the time without wet chemistry waste
- **Heterogeneity of nitrate levels** observed that is unobservable by conventional techniques
- Next step is to **deploy the nitrate microsensors in situ** and **explore more robust sensor designs**