Title: Remote Autonomous Plant Sensing for Space Exploration Enabled by Wearable Printed Electronics

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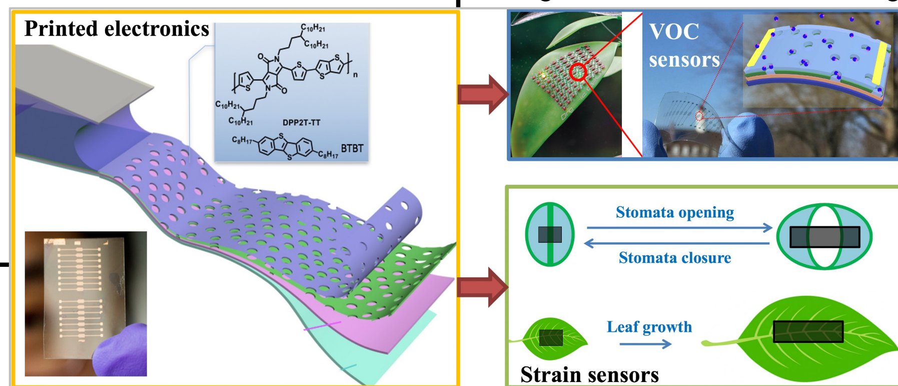
Research Objectives

- We propose to develop light-weight, flexible and stretchable organic-electronics-based chemical and strain sensors mountable on individual plant leaves, across the stomata, on stems and the chamber wall for autonomous plant stress and growth sensing.
- The proposal is innovative as we will be bridging two previously unrelated fields of organic electronics and plant biology. Lightweight, high performance, and printed on demand, organic electronics is ideally suited for space missions.
- Organic electronics can attain ultrahigh sensitivity (ppb level), ultrafast response (msec), and high stretchability (upto 2000%) not demonstrated before for plant wearable sensors.
- Starting from TRL of 1, we will attain TRL of 2-3 at the end.

Approach

- For VOC sensing, we will adopt an e-nose approach that directly correlate environmental stressors and VOC fingerprint without the need to identify specific VOCs. Organic-field-effect-transistor based chemical sensors will be fabricated into 14 sensor arrays.
- For tracking plant growth, highly stretchable organic resistive sensors will be directly printed across stomata which stretches the sensor when opening causing current change in sensor readout. Same approach will be applied to tracking long-term leaf growth.
- To realize autonomous, remote sensing, we will construct a chemical/strain sensor-wireless link hybrid device that integrates sensors with a lightweight power module and a wireless reporting system for data storage and transfer.



Overview figure: printed wearable electronics for plant stress sensing via VOC detection and for tracking plant growth and stomata opening via strain sensing.

Potential Impact

Our technology will enable

- Continuous monitoring and early detection of plant responses to environmental stressors and nutrient deficiencies at both the individual plant level and the ensemble level.
- Self-optimization of LED lighting, nutrient release, and environmental conditions for reducing plant stress and maximizing plant growth under space-exploration-limited conditions.
- Autonomous identification of desired crop traits for selecting stress-tolerant varieties for maximizing photosynthetic efficiencies.