Singapore's SMART researchers pioneerÂ method to detect dehydration in plants

25 November 2024 | News

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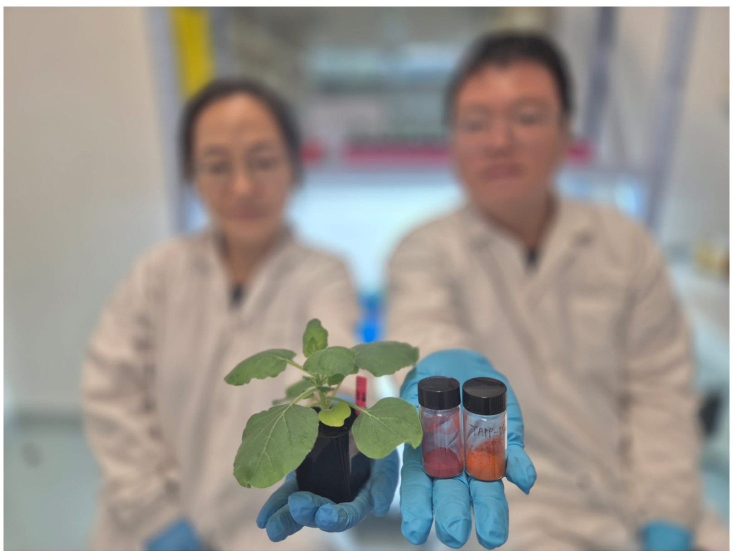

Covalent Organic Framework (COF) sensors integrated within silk fibroin (SF) microneedles capable of detecting pH changes in plant xylem tissues

Singapore's SMART researchers have pioneered the first Covalent Organic Framework (COF) sensors integrated within silk fibroin (SF) microneedles capable of detecting pH changes in plant xylem tissues. These pH changes provide an early indication of drought stress in plants, which, if unmitigated, can lead to reduced plant growth and yield, and eventual death. The technology enables farmers to detect drought stress in plants up to 48 hours before visible physical symptoms manifest, enabling early intervention before irreversible damage occurs and thus reducing crop yield loss to climate or environmental factors.

Researchers have been working on sensors to detect a wide range of chemical compounds, and a critical bottleneck has been developing sensors that can be used within living biological systems. This is all set to change with new sensors by the Singapore-MIT Alliance for Research and Technology (SMART) that can detect pH changes in living plants â?? an indicator of drought stress in plants â?? and enable the timely detection and management of drought stress before it leads to irreversible yield loss.

Drought â?? or a lack of water â?? is a significant stressor that leads to lower yield by affecting key plant metabolic pathways, reducing leaf size, stem extension and root proliferation. If prolonged, it can eventually cause plants to become discoloured, wilt and die. As agricultural challenges â?? including those posed by climate change, rising costs and lack of land space â?? continue to escalate and adversely affect crop production and yield, farmers are often unable to implement proactive measures or pre-symptomatic diagnosis for early and timely intervention. This underscores the need for improved sensor integration that can facilitate *in-vivo* assessments and timely interventions in agricultural practices.

â??This type of sensor can be easily attached to the plant and queried with simple instrumentation. It can therefore bring powerful analyses, like the tools we are developing within DISTAP, into the hands of farmers and researchers alike,â? saidÂ Professor Michael Strano, co-corresponding author, DiSTAP Co-Lead Principal Investigator and Carbon P. Dubbs Professor of Chemical Engineering at MIT.Â

SMARTâ??s breakthrough addresses a long-standing challenge for COF-based sensors, which were - until now - unable to interact with biological tissues. COFs are networks of organic molecules or polymers - which contain carbon atoms bonded to elements like hydrogen, oxygen, or nitrogen - arranged into consistent, crystal-like structures, which change colour according to different pH levels. As drought stress can be detected through pH level changes in plant tissues, this novel COF-based sensor allows early detection of drought stress in plants through real-time measuring of pH levels in plant xylem tissues. This method could help farmers optimise crop production and yield amid evolving climate patterns and environmental conditions.

*â??*The COF-silk sensors provide an example of new tools that are required to make agriculture more precise in a world that strives to increase global food security under the challenges imposed by climate change, limited resources and the need to reduce the carbon footprint. The seamless integration between nanosensors and biomaterials enables the effortless measurement of plant fluidsâ?? key parameters, such as pH, that in turn allows us to monitor plant health,â? said Professor Benedetto Marelli, co-corresponding author, Principal Investigator at DiSTAP, and Associate Professor of Civil and Environmental Engineering at MIT.

DiSTAP researchers designed and synthesised four COF compounds that showcase tunable acid chromism â?? colour changes associated with changing pH levels â?? with SF microneedles coated with a layer of COF film made of these compounds. In turn, the transparency of SF microneedles and COF film allows in-vivo observation and visualisation of pH spatial distributions through changes in the pH-sensitive colours. This study sets the foundation for future design and development for COF-SF microneedle-based tomographic chemical imaging of plants with COF-based sensors. Building on this research, DiSTAP researchers will work to advance this innovative technology beyond pH detection, with a focus on sensing a broad spectrum of biologically relevant analytes such as plant hormones and metabolites.