SMART Researchers Design Novel Sensors to Detect Plant Hormones

Breakthrough study can transform screening process and enable rapid testing for herbicide resistance in the agricultural industry

- This is the first use of CoPhMoRe nanosensors to detect synthetic auxin plant hormones in real time, which is faster and safer than existing methods
- Novel sensor can revolutionise screening for herbicide resistance and could be applied in commercial settings such as urban farms
- Research improves understanding of plant growth dynamics and susceptibility to external conditions and opens the door for future development of real-time nanosensors for other dynamic plant hormones

Singapore, 2 September 2021 - Researchers from the Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP) Interdisciplinary Research Group (IRG) of Singapore-MIT Alliance for Research and Technology (SMART), MIT's research enterprise in Singapore and their local collaborators from Temasek Life Sciences Laboratory (TLL) and Nanyang Technological University (NTU) have developed the first ever nanosensor to enable rapid testing of synthetic auxin plant hormones. The novel nanosensors are safer and less tedious than existing techniques for testing plants' response to compounds such as herbicide, and can be transformative in improving agricultural production and our understanding of plant growth.

The scientists designed sensors for two plant hormones – 1-naphthalene acetic acid (NAA) and 2,4-dichlorophenoxyacetic acid (2,4-D) – which are used extensively in the farming industry for regulating plant growth and as herbicides respectively. Current methods to detect NAA and 2,4-D cause damage to plants, and are unable to provide real-time *in vivo* monitoring and information.

Based on the concept of corona phase molecular recognition (CoPhMoRe) pioneered by the Strano Lab at SMART DiSTAP and Massachusetts Institute of Technology (MIT), the novel sensors are able to detect the presence of NAA and 2,4-D in living plants at a swift pace, providing plant information in real time, without causing any harm. The team has successfully tested both sensors on a number of everyday crops including pak choi, spinach and rice across various planting mediums such as soil, hydroponic, and plant tissue culture.

Explained in a paper titled "Nanosensor Detection of Synthetic Auxins In Planta using Corona Phase Molecular Recognition" published in the prestigious journal *ACS Sensors*, the research can facilitate more efficient use of synthetic auxins in agriculture and hold tremendous potential to advance plant biology study.

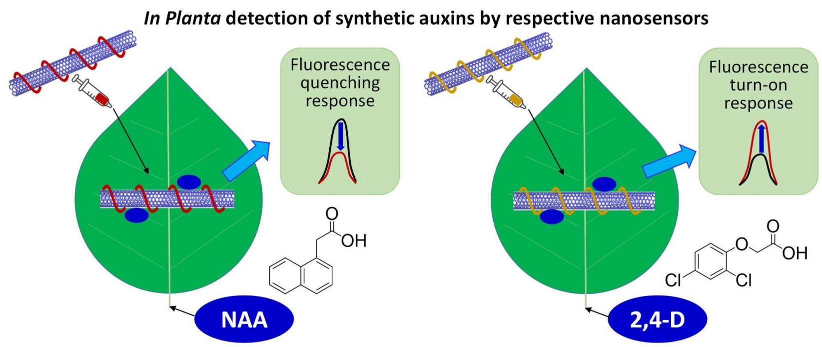

Illustration of novel in planta CoPhMoRe nanosensors for detection of synthetic auxin plant hormones, NAA and 2,4-D
Photo Credit: Singapore-MIT Alliance for Research and Technology (SMART)

"Our CoPhMoRe technique has previously been used to detect compounds such as hydrogen peroxide and heavy-metal pollutants like arsenic – but this is the first successful case of CoPhMoRe sensors developed for detecting plant phytohormones that regulate plant growth and physiology, such as sprays to prevent premature flowering and dropping of fruits," says DiSTAP co-lead Principal Investigator Professor Michael Strano and Carbon P. Dubbs Professor of Chemical Engineering at MIT, who leads The Strano Lab at MIT. "This technology can replace current state-of-the-art sensing methods which are laborious, destructive, and unsafe."

Of the two sensors developed by the research team, the 2,4-D nanosensor also showed the ability to detect herbicide susceptibility, enabling farmers and agricultural scientists to quickly find out how vulnerable or resistant different plants are to herbicides without the need to monitor crop or weed growth over days. "This could be incredibly beneficial in revealing the mechanism behind how 2,4-D works within plants and why crops develop herbicide resistance," says DiSTAP and TLL Principal Investigator Dr Rajani Sarojam.

"Our research can help the industry gain a better understanding of plant growth dynamics and has the potential to completely change how the industry screens for herbicide resistance, eliminating the need to monitor crop or weed growth over days," says Dr Mervin Chun-Yi Ang, Research Scientist at DiSTAP. "It can be applied across a variety of plant species and planting mediums, and could easily be used in commercial setups for rapid herbicide susceptibility testing, such as urban farms."

NTU Professor Mary Chan-Park Bee Eng says, "Using nanosensors for *in planta* detection eliminates the need for extensive extraction and purification processes, which saves time and money. They also use very low-cost electronics, which makes them easily adaptable for commercial setups."

The team says their research can lead to future development of real-time nanosensors for other dynamic plant hormones and metabolites in living plants as well.

The development of the nanosensor, optical detection system, and image processing algorithms for this study was done by SMART, NTU and MIT, while TLL validated the nanosensors and provided knowledge of plant biology and plant signalling mechanisms. The research is carried out by SMART and supported by NRF under its Campus for Research Excellence And Technological Enterprise (CREATE) programme.

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About SMART Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP) [精准农业技术研究中心]

DiSTAP is one of the five Interdisciplinary Research Groups (IRGs) of the Singapore-MIT Alliance for Research and Technology (SMART). The DiSTAP programme addresses deep problems in food production in Singapore and the world by developing a suite of impactful and novel analytical, genetic and biosynthetic technologies. The goal is to fundamentally change how plant biosynthetic pathways are discovered, monitored, engineered and ultimately translated to meet the global demand for food and nutrients. Scientists from Massachusetts Institute of Technology (MIT), Temasek Life Sciences Laboratory (TLL), Nanyang Technological University (NTU) and National University of Singapore (NUS) are collaboratively: developing new tools for the continuous measurement of important plant metabolites and hormones for novel discovery, deeper understanding and control of plant biosynthetic pathways in ways not yet possible, especially in the context of green leafy vegetables; leveraging these new techniques to engineer plants with highly desirable properties for global food security, including high yield density production, drought and pathogen resistance and biosynthesis of high-value commercial products; developing tools for producing hydrophobic food components in industry-relevant microbes; developing novel microbial and enzymatic technologies to produce volatile organic compounds that can protect and/or promote growth of leafy vegetables; and applying these technologies to improve urban farming.

The DiSTAP IRG at SMART is led by MIT co-lead Principal Investigator Professor Michael Strano and Singapore co-lead Principal Investigator Professor Chua Nam Hai.

For more information, please log on to: http://distap.mit.edu/

About Singapore-MIT Alliance for Research and Technology (SMART) [新加坡-麻省理工学院科研中心]

Singapore-MIT Alliance for Research and Technology (SMART) is MIT's Research Enterprise in Singapore, established by the Massachusetts Institute of Technology (MIT) in partnership with the National Research Foundation of Singapore (NRF) since 2007. SMART is the first entity in the Campus for Research Excellence and Technological Enterprise (CREATE) developed by NRF. SMART serves as an intellectual and innovation hub for research interactions between

MIT and Singapore. Cutting-edge research projects in areas of interest to both Singapore and MIT are undertaken at SMART. SMART currently comprises an Innovation Centre and five Interdisciplinary Research Groups (IRGs): Antimicrobial Resistance (AMR), Critical Analytics for Manufacturing Personalized-Medicine (CAMP), Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP), Future Urban Mobility (FM) and Low Energy Electronic Systems (LEES).

SMART research is funded by the National Research Foundation Singapore under the CREATE programme. For more information, please visit - http://smart.mit.edu

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