Agilent Case Study

Interview: Using Agilent Resolve to Support Agricultural Research

Describe the main focus of your research in agricultural science

Digital agriculture is an emerging farming philosophy that aims to increase crop yields with minimal environmental impact. This requires the development of sensing technologies that can work directly in the field to provide information about plant health. Our group develops an innovative sensing approach for confirmatory diagnostics of biotic and abiotic stresses in plants; this approach is based on Raman spectroscopy (RS), an analytical technique that provides information about molecular vibrations and, consequently, the structure of samples. Our findings show that RS can identify viral, fungal, and bacterial diseases in plants by detecting pathogen-induced changes in plant biochemistry. RS also has unique sensitivity and specificity in diagnosing abiotic stresses such as drought and salinity stresses.

Why is Raman spectroscopy well suited for this type of research?

The innovativeness of the Raman-based sensing approach arises from the label-free, non-invasive, and non-destructive nature of RS. Consequently, Raman-based identification of plant biotic and abiotic stresses requires no chemicals, which substantially reduces the direct costs of the analysis. The innovativeness of RS also originates from its portable nature, which eliminates the need to ship the samples, reducing the possible spread of pathogens and further decreasing analysis costs. Raman-based sensing is also innovative in the way it allows elucidation of changes in plant biochemistry.[1,2]

Our own research findings[3–13] and results reported by other groups[14–17] show that plant biochemistry drastically changes upon the development of biotic and abiotic stresses. These changes can be used for non-invasive, non-destructive and label-free detection and identification of plant biotic and abiotic stresses.[3–12;14–17] Specifically, using RS, fungal diseases in corn, wheat, and sorghum can be diagnosed with nearly 100% accuracy.[3,5] RS is also capable of detecting viral diseases in wheat and roses[4,8] as well as the bacterial Huanglongbing (HLB) or Citrus Greening disease in citrus.[11–13] Our findings suggest that pathogen-induced changes are likely to be unique for different pathogens.[2] Thus, RS is likely to provide species-level sensitivity for pathogen diagnostics.

Professor Dmitry Kurouski

Texas A&M University
Biochemistry & Biophysics,
Biomedical Engineering

Agilent
Trusted Answers

What are some of the challenges you have encountered?

The biggest challenge is to demonstrate that Raman-based sensing is pathogen specific. To prove this, my group investigated the extent to which RS could be used to identify biotic and abiotic stresses in wheat and corn. We found that Raman-based sensing can detect and identify these stresses, as well as distinguish between biotic and abiotic stresses.

How has the Agilent Resolve helped you overcome these challenges?

The Agilent Resolve handheld Raman spectrometer has been the workhorse of our lab during the past five years.

Image 1. Isaac Juarez, 2nd year PhD student, collecting data with the Agilent Resolve. Image courtesy of the Kurouski Lab

It has certain features that make it an excellent tool for this type of work. The unique 830 nm acquisition wavelength allows for overcoming chlorophyll fluorescence, whereas the optical design and high laser power enable acquisition of high-quality spectral data in just one second.

The portability of the spectrometer is also an advantage, allowing for on-site analysis in the field. There's no need to take the plant to the lab, we can take the "lab" to the plant.

Are there other areas of research where you have used the Agilent Resolve?

My group used the Agilent Resolve to identify the chemical composition of tick frass – that is, tick manure. Ticks are blood-feeding parasites linked to many diseases; timely detection of certain tick species on cattle can halt the spread of these diseases. We showed that frass from different tick species has drastically different chemical composition.[18] As a result, optical sensing of tick frass can be used for on-site analysis of the tick species present on cattle.

We have also used the Agilent Resolve Raman spectrometer to demonstrate the potential of RS for analysis of the nutritional composition of foodstuffs such as potatoes, maize,[19] ramen noodles,[20] and baked goods.[21]

What is in the future for your research?

Once it has been developed into a robust and reliable sensing approach, RS can be used for detection and identification of diseases in wheat and corn. Such analyses can be performed in a greenhouse or a field using a handheld spectrometer. These analyses can inform site- and dose-specific administration of fungicides, antibiotics, and pesticides to cease threat proliferation and minimize crop losses associated with these biotic stresses. The precise administration of chemical agents minimizes the environmental impacts of treatments and optimizes the economics of farming. The Raman-based approach for diagnostics of plant stresses is also innovative and significant because RS can be used for confirmatory detection and identification of abiotic stresses caused by nutrient deficiencies in macro elements in wheat and corn. This information can be used for site- and dose-specific application of water and fertilizers.

About the author

Dmitry Kurouski earned an MS in biochemistry from Belarusian State University, Belarus and a Ph.D. (Distinguished Dissertation) in analytical chemistry from SUNY Albany, New York. After completing a postdoctoral fellowship in the laboratory of Professor Richard P. Van Duyne at Northwestern University, Illinois, Dr. Kurouski joined Boehringer Ingelheim Pharmaceuticals, where he worked as a senior research scientist. In 2017, Dr. Kurouski joined the Biochemistry and Biophysics Department of Texas A&M University as an associate professor. He was recently honored with the 2023 Emerging Leader in Molecular Spectroscopy Award.[22]

Learn more about the Kurouski Lab at **https://kurouskilab.com/research/**

References

1. Farber C, Mahnke M, Sanchez L, Kurouski D (2019). Advanced Spectroscopic Techniques for Plant Disease Diagnostics. A Review. Trends Analyt Chem 118:43–49.

2. Payne WZ, Kurouski D (2021). Raman-Based Diagnostics of Biotic and Abiotic Stresses in Plants. A Review. Front Plant Sci 11:616672.

3. Egging V, Nguyen J, Kurouski D (2018). Detection and Identification of Fungal Infections in Intact Wheat and Sorghum Grain Using a Hand-Held Raman Spectrometer. Anal Chem (in press).

4. Farber C, Bryan R, Paetzold L, Rush C, Kurouski D (2020). Non-Invasive Characterization of Single-, Double- and Triple-Viral Diseases of Wheat With a Hand-Held Raman Spectrometer. Front Plant Sci 11:01300. PMID: 33013951 {Medline}

5. Farber C, Kurouski D (2018). Detection and Identification of Plant Pathogens on Maize Kernels with a Hand-Held Raman Spectrometer. Anal Chem 90:3009–3012. PMID: 29461798 {Medline}

6. Farber C, Sanchez L, Rizevsky S, Ermolenkov A, McCutchen B, Cason J, Simpson C, Burrow M, Kurouski D (2020). Raman Spectroscopy Enables Non-Invasive Identification of Peanut Genotypes and Value-Added Traits. Sci Rep 10:7730.

7. Farber C, Shires M, Ong K, Byrne D, Kurouski D (2019). Raman spectroscopy as an early detection tool for rose rosette infection. Planta 250:1247-1254. PMID: 31222494 {Medline}

8. Sanchez L, Ermolenkov A, Biswas S, Septiningshih EM, Kurouski D (2020). Raman Spectroscopy Enables Non-invasive and Confirmatory Diagnostics of Salinity Stresses, Nitrogen, Phosphorus, and Potassium Deficiencies in Rice. Front Plant Sci 11:573321.

9. Sanchez L, Ermolenkov A, Tang XT, Tamborindeguy C, Kurouski D (2020). Non-Invasive Diagnostics of Liberibacter Disease on Tomatoes Using a Hand-Held Raman Spectrometer. Planta 251:64. PMID: 32048047 {Medline}

10. Sanchez L, Farber C, Lei J, Zhu-Salzman K, Kurouski D (2019). Noninvasive and Nondestructive Detection of Cowpea Bruchid within Cowpea Seeds with a Hand-Held Raman Spectrometer. Anal Chem 91:1733–1737. PMID: 30620572 {Medline}

11. Sanchez L, Pant S, Irey MS, Mandadi K, Kurouski D (2019). Detection and Identification of Canker and Blight on Orange Trees Using a Hand-Held Raman Spectrometer. J Raman Spectrosc 50:1875–1880.

12. Sanchez L, Pant S, Mandadi K, Kurouski D (2020). Raman Spectroscopy vs. Quantitative Polymerase Chain Reaction In Early Stage Huanglongbing Diagnostics. Sci Rep 10:10101. PMID: 32572139 {Medline}

13. Sanchez L, Pant S, Xing Z, Mandadi K, Kurouski D (2019). Rapid and Noninvasive Diagnostics of Huanglongbing and Nutrient Deficits on Citrus Trees with a Handheld Raman Spectrometer. Anal Bioanal Chem:10.1007/s00216-00019-01776-00214.

14. Yeturu S, Vargas Jentzsch P, Ciobotă V, Guerrero R, Garrido P, Ramos LA (2016). Handheld Raman Spectroscopy for the Early Detection of Plant Diseases: Abutilon Mosaic Virus Infecting Abutilon sp. Analytical Methods 8:3450–3457.

15. Altangerel N, Ariunbold GO, Gorman C, Alkahtani MH, Borrego EJ, Bohlmeyer D, Hemmer P, Kolomiets MV, Yuan JS, Scully MO (2017). In Vivo Diagnostics of Early Abiotic Plant Stress Response via Raman Spectroscopy. Proc Natl Acad Sci U S A 114:3393–3396. PMID: 28289201 {Medline}

16. Gupta S, Huang CH, Singh GP, Park BS, Chua N-H, Ram RJ (2020). Portable Raman Leaf-Clip Sensor for Rapid Detection of Plant Stress. Sci Rep 10:20206.

17. Mandrile L, Rotunno S, Miozzi L, Vaira AM, Giovannozzi AM, Rossi AM, Noris E (2019). Nondestructive Raman Spectroscopy as a Tool for Early Detection and Discrimination of the Infection of Tomato Plants by Two Economically Important Viruses. Anal Chem 91:9025–9031. PMID: 31265250 {Medline}

18. Dou T, Ermolenkov A, Hays SR, Rich BT, Donaldson TG, Thomas D, Teel PD, Kurouski D. Raman-Based Identification of Tick Species (Ixodidae) by Spectroscopic Analysis of Their Feces. Spectrochim Acta A Mol Biomol Spectrosc. 2022 Apr 15;271:120966. doi: 10.1016/j.saa.2022.120966. Epub 2022 Jan 29. PMID: 35123191.

19. Krimmer M, Farber C, Kurouski D. Rapid and Noninvasive Typing and Assessment of Nutrient Content of Maize Kernels Using a Handheld Raman Spectrometer. ACS Omega 2019 4 (15), 16330–16335. DOI: 10.1021/acsomega.9b01661

20. Rodriguez, A., Serada, V., Stover, P., Kurouski, D., Raman on Ramen: Nutritional Analysis and Brand Identification. J Raman Spectrosc 2023, 54(8), 806. https://doi.org/10.1002/jrs.6505

21. Rodriguez, A., Kurouski, D., Raman Spectroscopy Enables Non-Invasive and Quantitative Assessment of Macronutrients in Baked Foods, J Raman Spectrosc 2023, 54(9), 899. https://doi.org/10.1002/jrs.6528

22. https://www.spectroscopyonline.com/view/spectroscopy-magazine-announces-the-2023-emerging-leader-in-molecular-spectroscopy

www.agilent.com

DE.91892623

This information is subject to change without notice.

© Agilent Technologies, Inc. 2024

Published in the USA, February 12, 2024
5994-7147EN

Agilent
Trusted Answers