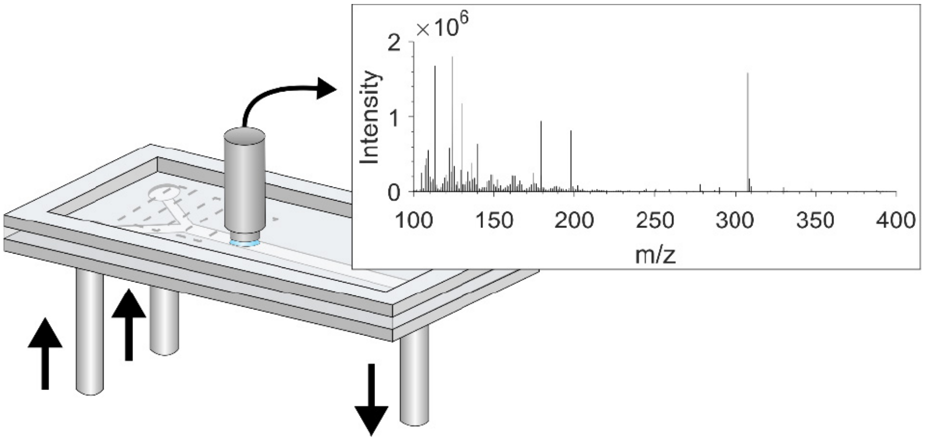
ChemSitu Microfluidic Imaging

Problem: Biology-on-a-chip devices are increasingly being used to mimic real-world biological systems with reduced cost and increased experimental control. However, current technologies provide limited chemical information, especially for small molecules, and often destroy the device in the process. Given the chemically complex and dynamic nature of biological lab-on-a-chip devices, new technologies are needed to enable in situ mass spectrometric characterization of components within microfluidic devices.

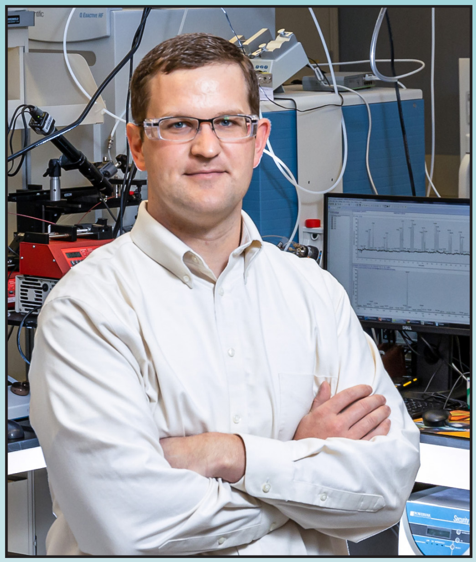
Solution: The ChemSitu microfluidic technology provides a new analytical capability to solve the problem of elucidating the complex chemistry occurring within microfluidic devices. This technology uses the combination of a porous membrane-microfluidic chip and a liquid microjunction-surface sampling probe with mass spectrometry to enable broad chemical characterization and chemical imaging of contents of microfluidic chips in situ, at any point within the device and without destroying the device in the process. Uniquely, the porous membrane layer on the device allows normal microfluidic operation, but when in contact with the sampling probe, it allows extraction of nanoliter volumes of liquid through the porous membrane at that location. The extracted liquid is then chemically characterized by mass spectrometry.

Impact: Knowledge of the chemical constituents (e.g., lipids, metabolites, proteins) inside microfluidic devices is valuable for understanding cell function and the mechanisms of molecular transport in living systems. Society and industry rely extensively on our chemical understanding of living systems to diagnose disease and to develop new and more effective therapeutics. Industries such as cancer diagnosis and pharmacokinetics need to evaluate therapeutic effectiveness in living systems, and biology-on-a-chip devices with a broad chemical analysis capability represent an ethical, cost-effective means to assess therapeutics. The collective features of the ChemSitu microfluidic technology make it more versatile than any other chemical analysis capability in the microfluidic device market, opening the door to numerous applications that require mass spectrometric chemical analysis of such devices.



Publications

- J. F. Cahill, M. Khalid, S. T. Retterer, C. L. Walton, and V. Kertesz, "In Situ Chemical Monitoring and Imaging of Contents within Microfluidic Devices Having a Porous Membrane Wall Using Liquid Microjunction Surface Sampling Probe Mass Spectrometry," *J. Am. Soc. Mass Spectrom.*, **2020,** 31 (4), 832–839. DOI: 10.1021/jasms.9b00093.



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Dr. Cahill is an associate research scientist in the Biosciences Division. His research focuses on the development and application of novel surface sampling and high-throughput mass spectrometry techniques to chemically characterize tissues, plant systems, bacterial colonies, and materials at small spatial scales. Dr. Cahill's work on elucidating metabolic chemistry in plant–microbial communities led to the development of the ChemSitu technology.

Intellectual Property

"Porous Membrane Enabled Mass Spectrometry Characterization of Microfluidic Devices," Invention Ref. No. 201904446

"Laser Sampling Liquid Microjunction Droplet Probe," Invention Reference Number 201904465; US Patent Application 16/797,712, February 21, 2020; US Patent Application 17/514,304, October 29, 2021

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