Micro-electro-mechanical system (MEMS) gas chromatography (GC) and comprehensive two-dimensional MEMS gas chromatography (GC×GC) coupled with mass spectrometry (MS)

Authors: Ryan Blase, Mark Libardoni, Katsuo Kurubayashi, Xudong Fan, Chris Glein, Kelly Miller, J. Hunter Waite

Our technology team has been working on the development of MEMS gas chromatographs (GCs) for the separation of complex organic mixtures, including biologically relevant molecules, to provide insight into habitability and the search for life. The MEMS GC platform is attractive for future planetary landed missions, probes, and even orbiter or flyby missions with the potential for sample enrichment due to the following:

- Compact size (3 cm x 3 cm silicon chip wafer provides 5 m length separation column, 3 cm x 6 cm silicon chip wafer provides 10 m length separation column)
- Low mass (1.95 g mass for 5 m column, 3.9 g mass for 10 m column)
- Low power consumption (27-44 W for entire GC operation analysis)

The MEMS GC can also be coupled to mass spectrometers (GC-MS) to provide higher confidence identification through mass spectral detection of the GC separated analytes. We have previously demonstrated this capability by coupling MEMS GC columns to the MAss Spectrometer for Planetary EXploration (MASPEX).[1,2] MASPEX is one option of a potential mass spectrometer, but many other mass spectrometers could also be coupled to our MEMS GC technology.

Finally, the MEMS GC columns can be coupled in series to create a comprehensive two-dimensional gas chromatograph (GC). In this setup, the two columns have different stationary phases for different analyte selectivity (*i.e.*, boiling point or volatility in the 1st dimension and polarity in the 2nd dimension) and therefore provide increased chromatographic resolution and peak capacity (the number of chromatographic signals that can be resolved in the separation window). We have previously demonstrated the utility of MEMS GC columns in GC×GC separations of complex organic mixtures including alkanes, amino and fatty acids, and polycyclic aromatic hydrocarbons.[2] An extra benefit of the GC×GC separation is the chemical speciation, or grouping of chemical families along trendlines, provided by the two-dimensional retention time plane that can be used as a chemical screening tool for the types of separated compounds.

References and Links for further information:

(1) Blase, R. C.; Libardoni, M. J.; Miller, G. P.; Miller, K. E.; Phillips-Lander, C. M.; Waite, J. H.; Glein, C. R.; Zhu, H.; Ghosh, A.; Venkatasubramanian, A.; Fan, X.; Kurabayashi, K. Experimental Coupling of a MEMS Gas Chromatograph and a Mass Spectrometer for Organic Analysis in Space Environments. *ACS Earth Sp. Chem.* **2020**, *4* (10), 1718–1729. https://doi.org/10.1021/acsearthspacechem.0c00131.

(2) Blase, R. C.; Libardoni, M. J.; Miller, G. P.; Miller, K. E.; Phillips-Lander, C. M.; Glein, C. R.; Waite, J. H.; Ghosh, A.; Venkatasubramanian, A.; Li, M. W.; Stephens, A.; Fan, X.; Kurabayashi, K. MEMS GC Column Performance for Analyzing Organics and Biological Molecules for Future Landed Planetary Missions. *Front. Astron. Sp. Sci.* **2022**, *0*, 19. https://doi.org/10.3389/FSPAS.2022.828103.