Microchip Electrophoresis Instrumentation for Determination of Chemical Distributions of Organic and Inorganic Ions on Future Spaceflight Missions

M. F. Mora[1], N. Bramall[2], F. Kehl[1], A. Noell[1], and P. A. Willis[1]
[1]Jet Propulsion Laboratory, California Institute of Technology.
[2]Leiden Measurement Technology LLC.

Introduction: The search for evidence of life beyond Earth is among the highest level goals in planetary exploration. However, despite multiple orbiter and landed missions to extraterrestrial bodies in the solar system, we still haven't found evidence of life. An powerful and highly unambiguous approach in the search for life involves seeking biochemical signatures of life at the molecular level, as expressed in distributions of geometric and stereochemical properties of organic molecules.[1] Microchip electrophoresis (ME) has tremendous promise for aiding in this search. [2, 3] ME has minimal mass/power/volume requirements, which is essential for instrument payloads on spaceflight missions. However, in terms of spaceflight implementation, this technique is relatively new, and there are still many challenges to be addressed for future implementation on spaceflight missions. Here we will describe the status of ME instruments at JPL and the steps we are taking to someday enable the implementation of this technology on other worlds.[4]

Approach: We focus here on microchip electrophoresis coupled to two detection methods: laser-induced fluorescence (LIF) and capacitively coupled contactless conductivity detection (C^4D). We describe a ME-LIF system we dub The Chemical Laptop (Figure 1), which would provide the sample processing capabilities required for *in situ* analysis on extraterrestrial destinations with parts-per-billion sensitivity in a compact, low-mass, and low-power package. This instrument concept could be adapted to the environmental requirements of a variety of astrobiologically interesting targets like Europa, Enceladus, or Titan. Although fluorescence detection provides the highest sensitivity for amino acids and it is a powerful tool in the search for life, this technique doesn't allow the direct determination of inorganic ions on the sample. Inorganic ionic species are important because they determine the chemical environment of the sample (i.e. soil on Mars, or subsurface ocean on Europa). The soluble constituents (i.e. salts) are of primary importance to biological activity, prebiotic organic synthesis, and the thermophysical properties of any liquid mixture. The characterization of the distribution of inorganic ions is also essential to assess the habitability of an extraterrestrial environment.[5, 6] Additionally, the presence of salts in combination with biomarkers in soil can sometimes hinder their detection so it is essential to identify the ions present in the sample in order of select the proper technique to successfully detect organic biomarkers. Towards this end, we are developing ME-C^4D methods to simultaneously analyze inorganic and organic ions (i.e. calcium, sodium, perchlorate, amino acids, carboxylic acids etc.), as they are likely to be present at the same time on samples collected from other worlds.

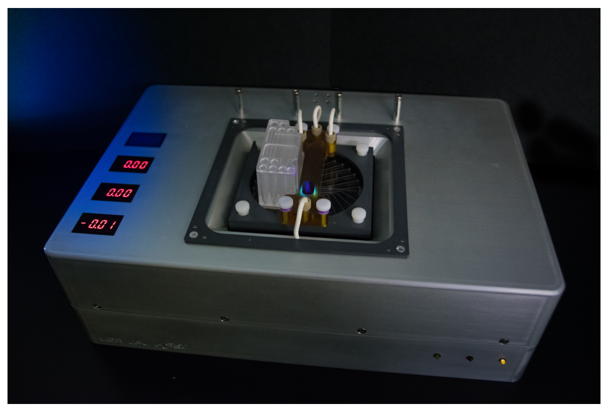

Figure 1. The Chemical Laptop is a portable, automated, and reprogrammable microchip electrophoresis instrument.

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