

MEASURING THE CHEMICAL POTENTIAL OF THE MARTIAN REGOLITH TO GENERATE AND SUSTAIN LIFE. S. P. Kounaves¹, M.G. Buehler², and K.R. Kuhlman², ¹Tufts University, Department of Chemistry, Medford, MA 02155, skounave(at)tufts.edu, ²Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, martin.g.buehler(at)jpl.nasa.gov

A critical component for identifying chemical biosignatures is the ability to assess in-situ the potential of an aqueous geochemical environment to generate and sustain life. On Mars or other solar bodies, in-situ chemical characterization could provide evidence as to whether the chemical composition of the regolith or evaporites in suspected ancient water bodies have been biologically influenced or possess the chemical parameters within which life may have existed, or may still exist. [1-3]

A variety of analytical techniques have been proposed for use in detecting and identify signatures of past or present life.[4,5] These techniques fall into two groups; *visual observation* with instruments such as cameras or optical/atomic-force microscopes; or *elemental chemical analysis* with such instruments as X-ray fluorescence (XRF) and diffraction (XRD), α -proton backscatter (APX), γ -ray, Mössbauer, Raman, IR, UV/VIS spectroscopies, gas chromatography (GC), or mass spectrometry (MS). Direct observation of an identifiable lifeform by the first set of instruments in a single sample is highly unlikely, especially for extinct organisms or on the surface. The later instruments can provide vital data as to the elemental mineralogy and geological history of the planet, but are highly inadequate for understanding the chemistry of the planet in terms of indigenous life or interactions with human explorers. Techniques such as XRD, XRF, and APX, provide elemental composition at high limits of detection. Some of this data can be extrapolated or interpolated to provide chemical parameters such as oxidation state or composition. Gas chromatography (GC) without standards and non-specific detectors, has little chance of identifying a mixture of unknown components. Combined with GC or by itself, mass spectrometry (MS) can provide identification of compounds, but in both cases the sample must be appropriately prepared for accurate and reliable analysis.

Life as we know it, and probably identify it as such, requires an aqueous environment. Deciphering the chemical speciation of this aqueous environment is the key to recognizing therein the biosignatures of any extinct or present life forms. Identifying the soluble (ionic and nonionic) components by reacting a currently dormant environment can provide a "picture" of the thermodynamics and chemical components of a possibly bioactive environment. The only devices which can provide such information are electrochemical sensors based on the potentiometric *ion selective electrodes* (ISEs) and on dynamic techniques such as *cyclic voltammetry*

(CV) and *stripping voltammetry* (SV). Such an array of devices can provide not only the chemical composition of a water-soluble Martian soil sample, but also several other vital chemical parameters such as pH, conductivity, redox potential, and dissolved gases.

To address these issues we have been investigating the possible use of an electrochemically-based ion sensor array as a new integrated approach to quantitative analytical and chemometric electrochemical measurements. The sensor array will consist of specific and semispecific ion selective and amperometric transducers, which can simultaneously and continuously identify and semi-quantitatively determine over 50 organic and inorganic analytes in water-based environments. Several individual sensors, based on the same principle, have been flight-tested and have been installed as part of the MECA instrumentation on the Mars 2001 Lander for in-situ analyses. However, the microfabrication, integration and multiplexing of such a large number of these sensors on a single substrate have not been previously attempted.

The Chemometric Neural Network Approach. Application of multi-sensor arrays is critically dependent on the ability to process and interpret raw sensor data and to model the sample chemistry. Development of chemometric processing technology to ISE-based sensor arrays in aqueous systems has not been attempted or reported. The combination of an ISE array and neural networks can provide rapid and correct *identification and quantification* of multiple ionic species. Multiple sensors for the same ion as well as multiple ions will allow for accurate dynamic recalibration of the individual sensors as well as for quantification of the ionic species present. Self-diagnosis of performance *in-situ* and dynamic recalibration are highly desirable for treatment of changing operating conditions and shifting baselines in the individual ISE sensors. Such a sensor array can possess both the ability to *recognize* the presence of a chemical species and also provide quantitative information.

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