AN OVERVIEW OF ELECTRICAL SPECTROSCOPY FOR ASTROBIOLOGY APPLICATIONS. K. Chin¹, J.-P. Jones¹, E. Brandon¹. ¹NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena CA 91109, USA (keith.b.chin@jpl.nasa.gov).

Introduction: Since the dynamics of real chemical systems involve multi-coupled processes, electrical spectroscopy (or impedance spectroscopy/EIS) can play a critical role to further the understanding of electrochemical and materials behavior in the coming years. Fundamentally, this technique analyzes the electrical properties of materials through relaxation phenomena whose relaxation times (or rate constants) vary over many orders of magnitudes. A single electrical perturbation sweep over a wide frequency bandwidth (Giga-Hz to milli-Hz) of low magnitude (<100mV) permits the investigation of a ride range of bulk and interfacial processes, including reaction mechanisms [1]. When combined with mathematical techniques including pattern recognition algorithms [2], many representations of the measurement and consequently more detailed interpretations of the results can be had as it relates to the materials physio-chemical processes emanating from the molecular level. This discussion will present an overview on the impedance spectroscopy background and applications to electrochemistry and instrumentation development at JPL.

Discussion: Recent advances in electrochemical instrument technologies have enabled fully integrated more portable, lower power EIS systems without compromising measurement sensitivity and robustness (Figure 1). Furthermore, variations of electrical spectroscopy designs have inherent advantages in terms of portability and scalability in pursuit of a non-destructive, in situ instruments ideally suited for many types of spacecraft platforms.

For the past few years, JPL have made efforts to take advantage of such new EIS technologies to develop more robust instruments for space exploration especially in challenging or extreme environments ranging from sub-zero temperatures to arid soils. One of the most important is the use of EIS for water/ice detection in planetary regolith [3]. Despite challenges with variations in chemical composition and heterogeneity of soils, results were obtained successfully across a large thermodynamic range (Figure 1, right) in many types of planetary soil analogs using only a benchtop system. This work was also demonstrated in the field and even under micro-gravity conditions in collaboration with Boise State University.

Currently, more advanced work using EIS is underway in the form of portable biosensor development and even in situ geochemical characterization within hydrothermal vents in support of life detection or origin of life programs. This work combines both instrument and electrode development. From such efforts to control and to enhance response signals at the interfaces [4], a larger database of analytic systems can be discerned based on the many electrical representations from a typical EIS sample response, as these electrical properties are intrinsic in all physical and chemical processes of the material system of interest. The relative success of this effort may demonstrate the full potential of EIS as a suitable flight instrument onboard the next generation of JPL/NASA spacecraft and rovers in search of pre-existing or extant life.


**Figure 1:** Top L: Benchtop EIS system. Center: Advanced portable COTS EIS system with measurement plot. Right: Example of water/ice characterization in regolith using EIS.