LONG CHAINED POLYMERS, THE ULTIMATE BIOSIGNATURE! FURTHERING A TECHNIQUE FOR IN-SITU DETECTION K. L. Craft[1], M. Hagedon, J. Tiffany, K. Verratti, and C. Bradburne, Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, ([1]Kate.Craft@jhuapl.edu)

Introduction: *In-situ* detection of biosignatures in a planetary plume, soil, atmosphere or water/ice sample will be challenging, requiring a capability for automated processing of low quantities of highly complex samples. One biosignature that would definitively detect life, including that which did not necessarily originate in the same fashion as life on Earth, is long chained polymers such as DNA. Previous work by [1] and [2] on Mars-analogue Atacama desert samples and by [3] on Norweign ice glacier samples showed that Synchronous Coefficient of Drag Analysis (SCODA) [5] coupled with removal of inhibitors, enables concentration and purification of extremophile DNA from these low-biomass environments.

High salinity is expected to exist in many planetary samples, including in icy moon plumes and oceans. To use SCODA and other polymer separation and concentration techniques, salinity levels must be lowered such that conductivity is below about 300 µS/cm in 5 mL [6]. Past methods of salt removal included centrifuges and dialysis [1,2], which are not easily amenable to automation for a planetary probe. Here we describe a microfluidics-SCODA system proposed for development at JHU/APL for desalination of samples and polymer concentration and extraction. Coupled together, this device would provide a robust and definitive way to detect life in planetary samples.

Advantages of the microfluidics-SCODA technique for *in-situ* biosignature detection over other techniques include a minimal number of moving parts, excellent rejection of contaminants, improved purification and extraction, amenity to system miniaturization, and potential automation for use on a planetary probe. A plus of searching for long chained polymers over other biosignatures is that, if detected, further analyses with a latest-generation, flash-drive-sized DNA sequencer could be done to sequence and separate true extraterrestrial DNA detections from any resulting from human or terrestrial contamination.

System Design: *Microfluidics* (Figure 1): To remove salts with minimal polymer loss, the microfluidics system passes the sample (1) in solution to a chamber containing silica coated carboxyl beads (under red magnets). A strongly charged solution is then added (2) which repels any similarly charged polymers (e.g. DNA), causing it to cling to the beads. Next, a magnetic field is applied that captures and immobilizes the bead/polymer complexes (3). The solution is then flushed several times (4-7), reducing salinity and inhibitors. Removal of the magnetic field then allows resuspension of the ploymers and transfer into the SCODA system for further contaminant removal and polymer concentration (8-9). The system is then flushed clean for processing additional samples (10-11).

SCODA: The SCODA system concentrates long chained polymers by utilizing the dependence of nucleic acid electrophoretic mobility on field strength [5]. Applied electric fields focus the polymers into the center of a gel, while leaving other molecules rotating in an outside circular orbit. This system has allowed the concentration and purification of DNA from many low-biomass soil matrices [e.g. 7]. Unlike the Polymerase Chain Reaction (PCR) technology used to amplify and detect/characterize DNA, SCODA makes no assumptions about the exact biochemistry of the DNA it is concentrating, allowing for the detection of life forms that share no common ancestor with those on Earth, but that may share the use of long, charged polymers for retaining genetic information through generations.

Discussion: The results of our DNA extraction from a Norwegian glacier indicate the capability of the salinity bead cleansing and SCODA concentration & extraction, where previous studies could not detect DNA [3]. Through the clever microfluidics and magnetic carboxyl bead system design that allows removal of salinity and the projected miniaturization of the SCODA technique, detection of polymers will be possible by future probes collecting samples captured in water/ice plume material, digging in Martian permafrost, sampling Venus's atmosphere and exploring the oceans of icy moons or lakes of Titan.

References: [1]Neish et al. (2012), *AbSciCon*, GA. [2]Bradburne et al. (2012), *LPSC 43*, abstract #6043. [3]Craft et al. (in prep). [4]Craft et al. (2014), *LPSC 45*, abstract #2929. [5]Pel et al. (2009) *PNAS, 106, no. 35*, 14796. [6]Boreal Genomics Aurora User Manual (BG-2002-07-004 v2.09). [7] Broemeling et al. (2008), *J Lab Autom, 13*, 40-48.

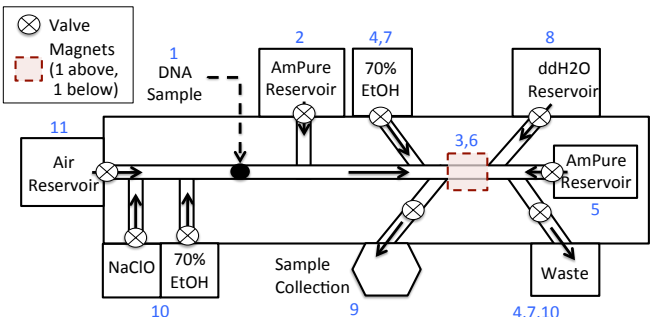

Figure 1. Overhead view of microfluidics desalination and inhibitor removal system design (about 3.8 cm x 5 cm). Process steps in blue.