SMILE (Specific Molecular Identification of Life Experiment): A Family of Molecular Recognition Sensor Instruments for Robust Detection of Life in the Solar System.

Mark Sims[1*] and David Cullen[2]

[1]Space Research Centre, University of Leicester, Leicester LE1 7RH, U.K., email mrs@star.le.ac.uk, [2]Cranfield Biotechnology Centre, Cranfield University, Silsoe, Bedfordshire MK45 4DT, U.K., email d.cullen@cranfield.ac.uk

---

The detection of life elsewhere in the Solar System is a central component of the astrobiology discipline. One approach to identify life is via (i) detection of molecular evidence of past or present life in the form of organic molecular biomarkers together with (ii) an understanding of the contextual abiotic organic environment in which biomarkers may be found. The latter is also of interest in the exploration of other bodies such as comets and asteroids.

For environmental and medical applications on Earth that desire *in situ* detection and characterisation of trace organic markers, molecular receptor based sensor technologies are receiving much attention. The current trends of multi-analyte sensor arrays, µ-fluidic and µ-system approaches, and transducer readout technology development is making remote analytical systems for astrobiology and planetary exploration a realistic practicality.

For life detection applications and information-critical terrestrial applications such as bio / chemical treat detection, the requirement for analytical robustness, *i.e.* lack of false positives / negatives, is vital. At present, the academic / commercial examples of molecular receptor based devices do not offer the level of analytical robustness desired for current life detection scenarios.

We have proposed an approach to molecular recognition sensor arrays, *i.e.* biosensors arrays, for the *in situ* detection of trace organic biomarkers that addresses the practical issues of analytical and physical robustness of such approaches. Thus, the "*Specific Molecular Identification of Life Experiment*" (SMILE) is based upon the concept of the integration of diverse molecular sensor materials in array formats and with multiple transduction readout technologies. Such an approach gives an information rich output both in the context of immediate sensor operation and contextual sample information. Such information will allow both analytical determination of the presence of given biomarkers, or classes of biomarkers, and a confidence level in the measurements to identify false readings.

The present SMILE concept has three major embodiments comprising:

- "*lite*" version (~ 500 g) involving multiple single-use µ-fluidic capillaries containing immobilised arrays of molecular materials appropriate for molecular recognition and other sensing assays with real-time fluorescent readout via optical evanescent excitation
- "*pro*" version (~1,500 g) involving multiple-use array of molecular sensing materials integrated on the surface of a hybrid optical and electrochemical readout transducer with surface plasmon resonance detection of interfacial refractive index and evanescent fluorescence excitation of molecular recognition assays together with electrode arrays for electrochemical measurement of additional sample parameters
- "*pro plus*" version (~ 3,000 g) that includes capillary electrophoresis and PCR modules

Present studies include integration of molecular sensing materials, mission and operational stability studies for molecular recognition materials, assessment of antibody and molecular imprinted polymer molecular recognition materials.