THE MARS ENVIRONMENTAL COMPATIBILITY ASSESSMENT (MECA) WET CHEMISTRY EXPERIMENT ON THE MARS '01 LANDER

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Introduction. The Mars Environmental Compatibility Assessment (MECA) is an instrument suite that will fly on the Mars Surveyor 2001 Lander Spacecraft. MECA is sponsored by the Human Exploration and Development of Space (HEDS) program and will evaluate potential hazards that the dust and soil of Mars might present to astronauts and their equipment on a future human mission to Mars. Four elements constitute the integrated MECA payload: a microscopy station, patch plates, an electrometer, and the wet chemistry laboratory (WCL).

The WCL consists of four identical cells, each of which will evaluate a sample of Martian soil in water to determine conductivity, pH, redox potential, dissolved CO_2 and O_2 levels, and concentrations of many soluble ions including sodium, potassium, magnesium, calcium, and the halides. In addition, cyclic voltammetry will be used to evaluate reversible and irreversible oxidants present in the water/soil solution. Anodic stripping voltammetry will be used to measure concentrations of trace metals including lead, copper, and cadmium at ppb levels. Voltammetry is a general electrochemical technique that involves controlling the potential of an electrode while simultaneously measuring the current flowing at that electrode.

The WCL experiments will provide information on the corrosivity and reactivity of the Martian soil, as well as on soluble components of the soil which might be toxic to human explorers. They will also guide HEDS scientists in the development of high fidelity Martian soil simulants. In the process of acquiring information relevant to HEDS, the WCL will assess the chemical composition and properties of the salts present in the Martian soil.

Salts in the Martian soil. Based on results from the two Viking landers and Mars Pathfinder, the Mars surface soil appears to consist of ~10% salts (dominated by sulfur- and chlorine-containing salts, presumed to be sulfates and chlorides). Salts are formed by the following processes:

- the water-based weathering of rocks;
- the action of volcanic gases; and
- biological activity.

Salts will therefore accumulate wherever the drainage water evaporates, wherever volcanic gases act upon the soil, and potentially in areas where microbial activity is found. Characteristic salts will be formed by each of the above processes. An analysis of the salts present at a given location can potentially provide information on the geochemical history of Mars, and in particular the history of liquid water on the planetary surface.

A single wet chemistry cell has a total mass of ~600 g including an upper Actuator Assembly built by Starsys Research and a lower Soil Analysis Beaker built by Orion Research, and will consume approximately 2-5 W of power during operation with a peak power requirement of 15 W. Each cell will evaluate a 1 cc soil sample combined with 30 cc of water using 25 sensors arrayed around the perimeter of the cell. The primary analytical tool of the wet chemistry laboratory is the ion-selective electrode (ISE). In addition, microelectrodes will be used to perform voltammetric analyses of the solution composition. All of the sensors are compact and rugged and are not subject to radiation damage.

Actuator Assembly. The actuator assembly shown in Figure 1 is used to deliver (1) soil, (2) solution, and (3) a calibration pellet to the soil analysis beaker as well as to (4) mix the soil/water solution.

(1) A paraffin actuator with a 25% volumetric expansion at T ~ 72 C is used to extend the sample drawer over a distance of 0.75" so that the robot arm can deposit a 1 cc soil sample into the drawer. This actuator requires 13 -15 W for approximately 3

minutes. When the power to the actuator is turned off, a spring is used to retract the drawer and create a vacuum seal between the inside of the unit and the Martian ambient. A brush is used to remove soil particles from the edges of the drawer.

(2) A second paraffin actuator is used to drive a puncture needle through a burst disk at the base of the water tank. The over-pressure in the tank relative to the pressure in the base of the unit drives 30 cc of water into the analysis chamber. This actuator requires 13-15 W for ~ 2 minutes.

(3) A third paraffin actuator is used to puncture a kapton disk and drop a calibrant pellet with a mass of 0.2 g into the soil/water solution.

(4) A MicroMo 8 mm motor is used to drive a mixing paddle at 2 Hz in order to stir the soil/water solution.

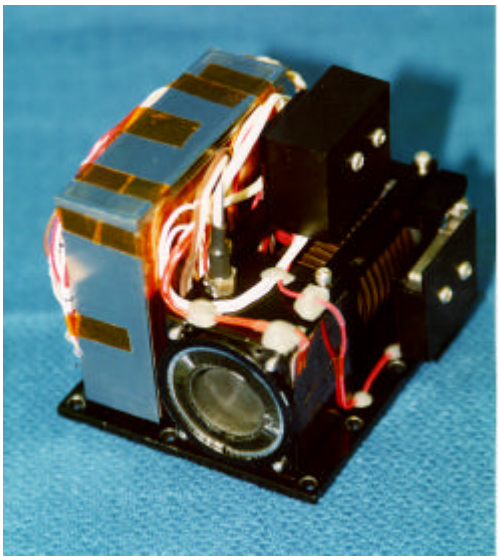

Figure 1. *Actuator Assembly built by Starsys Research for the Wet Chemistry Experiment.*

Soil Analysis Beakers. Complementary to the Viking experiments, the WCL analysis beakers will characterize the properties of the water/soil solution rather than evolved gases, using a suite of potentiometric, voltammetric, and conductimetric sensors. These sensors will provide information on the toxicity and reactivity of soluble components of the Martian soil in preparation for an eventual manned mission to Mars. Table 1 summarizes the sensors contained in each MECA Wet Chemistry Experiment analysis beaker.

Sensor *(Qty)*	**Type**	**Measurement Technique**
Conductivity Cell	4-electrode, planar chip	Conductimetric for measuring total ionic content
pH *(2)*	Polymer membrane	Ion Selective Electrode (ISE) (Potentiometric)
pH	Iridium dioxide	ISE (Potentiometric)
Membrane-Covered CV Electrode	3-Electrode, 0.25-mm gold cathode	Cyclic Voltammetry (CV) for measuring O_2 and other volatile oxidants
Platinum Macro-electrode	1.0-mm disc	ISE (Potentiometric) for measuring redox potential
Gold Macro-electrode	0.25-mm disc	Cyclic Voltammetry (CV) for evaluating oxidants and reductants
Gold Micro-electrode Array (MEA)	Planar chip, 512 10-μm elements	Anodic Stripping Voltammetry (ASV) for trace metal detection
Silver/ Sulfide	Solid-state pellet	ISE (Potentiometric)
Cadmium	"	ISE
Chloride *(2)*	"	ISE
Bromide	"	ISE
Iodide	"	ISE
Lithium *(3)*	Polymer membrane	ISE, used as reference
Sodium	"	ISE
Potassium	"	ISE
Magnesium	"	ISE
Calcium	"	ISE
Ammonium	"	ISE
Nitrate/ perchlorate	"	ISE
Perchlorate or bicarbonate	"	ISE
Carbon Dioxide	Membrane-covered gas sensor	ISE

Table 1. *Wet Chemistry Experiment sensors.*