PREPARATION OF A SIMULATED MARTIAN PRIMITIVE ATMOSPHERE AT THE UNDERGRADUATE LABORATORY. K.F. Navarro¹, R. Navarro-González¹, J. de la Rosa², and P. Molina³. ¹Laboratorio de Química de Plasmas y Estudios Planetarios, Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Ciudad de México 04510, Mexico, navarro@nucleares.unam.mx.

Introduction: A course on the search for life on Mars with laboratory demonstrations is offered to undergraduate students at the Universidad Nacional Autónoma de Mexico at Ciudad Universitaria in Mexico City. This course is open to any undergraduate student enrolled in space sciences but students majoring in other disciplines can also register (e.g., physics, chemistry, biology, and engineering). Fifty percent of the course work is devoted to laboratory work, which is conducted at the Laboratorio de Química de Plasmas y Estudios Planetarios using state-of-the-art analytical instrumentation. After an introductory session of laboratory safety, the first experiment is the preparation of a simulated Martian primitive atmosphere. The laboratory demonstration is carried out in two sessions, each of 3 hrs length.

Early Martian Atmosphere: The early atmosphere was composed of carbon dioxide (CO₂), molecular nitrogen (N₂) and water vapor (H₂O), but their relative abundance is uncertain [1]. The composition of the atmosphere was of paramount importance for the origin of life [2], and to sustain a habitable environment [3]. Multiple lines of geologic evidence now point to an episodically warm surface during the late Noachian and early Hesperian periods 3–4 Ga [4]. Climate models that consider only the greenhouse gases carbon dioxide (CO₂) and water (H₂O) have been unable to recreate warm surface conditions, given the lower solar luminosity at that time [5]. Recently it has been suggested that hydrogen (H₂) in the Martian atmosphere could have caused warming by collision induced absorption with CO₂ [6]. A similar warming effect is expected in H₂-N₂ atmospheres by collision-induced absorption [7]. It is predicted that 5–20% H₂ in a CO₂ and water atmosphere at ≥ 1 bar is required to keep the surface temperature above the freezing point of water [6].

Laboratory objective: This demonstration is designed to provide the necessary knowledge for the storage, transport and handling of vacuum and pressurized cylinders in the laboratory, and (2) to prepare a complex gas mixture that simulates a primitive Martian atmosphere.

Procedure: A simulated Martian atmosphere is prepared with a gas mixture composed of H₂ (20%), CO₂ (70%) and N₂ (10%) using a Linde mass flow measuring and control gas blending system (FM4660) equipped with fast response mass flow control modules of 20 cm³ min⁻¹ capacity (see Figure 1). Each gas line is composed of stainless steel tubing, and is equipped with a 2 µm particle filter, a pneumatic switch valve connected to the mass flow control, and a check valve at the end of the tubing which merges into a 4 liter stainless steel container for filling up the simulated atmosphere. The mass flow measuring and control gas blending console is connected into a manifold gas line with vacuum, pressure and temperature meters.

Figure 1. Mass flow measuring and control gas blending system for the preparation of simulated atmospheres and gas calibration standards.

The system is evacuated to 8.6×10⁻³ mbar, and then the compressed gas cylinders required for the preparation of the atmosphere are open and gas lines are regulated at 60 psi. The gas blending system is programmed to blend the gases and is filled the 4-liter cylinder that will contain the atmosphere. The procedure takes about three hours, and the system operates overnight preparing the atmosphere.

Analysis of the atmosphere: In a second laboratory session, the simulated atmosphere is sampled using a round borosilicate glass (Pyrex) flasks of 1 liter capacity connected to a manifold vacuum system. The
flask is equipped with threaded high vacuum stopcocks. The stopcock is composed of a PTFE plug with an UHMWPE handle, and double PTFE O-rings seals for smooth valve adjustment. The simulated atmosphere is then analyzed by gas chromatography (GC) coupled to mass spectrometry (MS) using electron impact. The atmosphere was introduced into the injection port of an Agilent Technologies 7890A GC system held at 250°C by an automatic six-port gas-sampling valve with a gas loop of 5 ml. A styrene-divinylbenzene-based porous polymer column was used (CP-Porabond Q fused-silica) of 50 m x 0.32 mm I.D. with a 5 µm polymer thickness coating. The column program temperature was isothermal at 50°C for 5 min, and then a rate of 10°C min⁻¹ up to 240°C and finally isothermal for 6 min. The carrier gas used was helium (chromatographic grade from Praxair, Inc.) with a flow of 1.2 ml min⁻¹ and a split ratio of 1:100. The GC was interfaced at 250°C with a mass detector (Agilent Technologies 5975C inert XL EL/CI MSD with Triple Axis detector). The mass spectrometer operated in scan mode from 10 to 150 m/z with a mass resolution of 1 unity using electron impact at 70 eV. The ion source and quadruple were maintained at 230°C and 150°C, respectively.

Figure 2 shows the total and extracted ion chromatograms to monitor nitrogen (m/z 28) and carbon dioxide (m/z 44). Hydrogen cannot be detected with the mass spectrometer used. Figure 3 shows the mass spectra of these gases. The identification is aided with the use of the NIST/EPA/NIH mass spectral library.

**Conclusions:** This laboratory demonstration can be used to introduce concepts of atmospheric chemistry, prebiotic chemistry, and atmospheric evolution.

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**References:**