

lengths and intensities of which are a characteristic of each atom. The oxygen emission is dominated by two peaks at 777 and 844 nm.

For testing, a quartz capillary tube with stainless steel end fittings forms the glow discharge tube. The sample gas is introduced into the glow discharge cell using an adjustable vacuum leak valve. From the glow discharge cell, the sample gas passes a vacuum gauge, the downstream valve, and then the vacuum pump. During operation, the pressure in the glow discharge cell is maintained between 0.5 and 10 Torr using the adjustable leak valve and the downstream valve. Light from the discharge is collected by a lens and coupled to a UV-visible fiber-optic cable. This cable directs the light from the glow discharge into a

spectrometer. The spectrometer detects in the 200- to 850-nm region with a spectral resolution of 1.5 nm using a 25- μ m entrance slit. The spectrometer is connected to a data acquisition computer via a USB cable. For this work, Ocean Optics' SpectraSuite[®] software was used for the data acquisition, setting parameters such as wavelength range, integration times, and scans to average.

For a peak to be at the detection limit, it must be recognizable as a peak, be resolved from other peaks, and have a peak intensity three times the standard deviation of background noise in the region of the peak. The peak corresponding to 0.01% argon is just above the baseline of pure oxygen (see Figure 2), and the signal-to-noise ratio is 2.6, indicating the detection limit is between

0.05 and 0.01%.

This work represents a proof-of-concept investigation into using a glow discharge emission system to detect and quantitate trace amounts of argon in pure oxygen. A similar analysis will need to be done for nitrogen. Optimization of experimental parameters such as operating pressure, discharge current, voltage, and spectrometer integration time needs to be further investigated. A redesigned discharge cell that will use a lower-voltage DC power supply with a higher discharge current is being designed to provide a spectrally brighter, lower-noise glow discharge.

This work was done by Steven Hornung of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-25116

Method of Separating Oxygen From Spacecraft Cabin Air to Enable Extravehicular Activities

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Extravehicular activities (EVAs) require high-pressure, high-purity oxygen. Shuttle EVAs use oxygen that is stored and transported as a cryogenic fluid. EVAs on the International Space Station (ISS) presently use the Shuttle cryo O₂, which is transported to the ISS using a transfer hose. The fluid is compressed to elevated pressures and stored as a high-pressure gas. With the retirement of the shuttle, NASA has been searching for ways to deliver oxygen to fill the high-pressure oxygen tanks on the ISS.

A method was developed using low-pressure oxygen generated onboard the ISS and released into ISS cabin air, filtering the oxygen from ISS cabin air using

a pressure swing absorber to generate a low-pressure (high-purity) oxygen stream, compressing the oxygen with a mechanical compressor, and transferring the high-pressure, high-purity oxygen to ISS storage tanks. The pressure swing absorber (PSA) can be either a two-stage device, or a single-stage device, depending on the type of sorbent used. The key is to produce a stream with oxygen purity greater than 99.5 percent. The separator can be a PSA device, or a VPSA device (that uses both vacuum and pressure for the gas separation). The compressor is a multi-stage mechanical compressor. If the gas flow rates are on the order of 5 to 10 lb (\approx 2.3 to 4.6 kg)

per day, the compressor can be relatively small [3 \times 16 \times 16 in. (\approx 8 \times 41 \times 41 cm)].

Any spacecraft system, or other remote location that has a supply of low-pressure oxygen, a method of separating oxygen from cabin air, and a method of compressing the enriched oxygen stream, has the possibility of having a regenerable supply of high-pressure, high-purity oxygen that is compact, simple, and safe. If cabin air is modified so there is very little argon, the separator can be smaller, simpler, and use less power.

This work was done by John C. Graf of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-24806-1

Atomic Force Microscope Mediated Chromatography Trace-chemical and microfluidic analyses are taken to higher precision.

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The atomic force microscope (AFM) is used to inject a sample, provide shear-driven liquid flow over a functionalized substrate, and detect separated components. This is demonstrated using lipophilic dyes and normal phase chromatography. A significant reduction in both size and separation time scales is achieved with a 25-micron-length col-

umn scale, and one-second separation times. The approach has general applications to trace chemical and microfluidic analysis.

The AFM is now a common tool for ultra-microscopy and nanotechnology. It has also been demonstrated to provide a number of microfluidic functions necessary for miniaturized chromatography.

These include injection of sub-femtoliter samples, fluidic switching, and shear-driven pumping. The AFM probe tip can be used to selectively remove surface layers for subsequent microchemical analysis using infrared and tip-enhanced Raman spectroscopy. With its ability to image individual atoms, the AFM is a remarkably sensitive detector that can be

used to detect separated components. These diverse functional components of microfluidic manipulation have been combined in this work to demonstrate AFM mediated chromatography.

AFM mediated chromatography uses channel-less, shear-driven pumping. This is demonstrated with a thin, aluminum oxide substrate and a non-polar solvent system to separate a mixture of lipophilic dyes. In conventional chromatographic terms, this is analogous to thin-layer chromatography using normal phase alumina substrate with shear-driven pumping provided by the AFM tip-cantilever mechanism. The AFM detection of separated components is accomplished by exploiting the variation in the localized friction of the separated components. The AFM tip-cantilever provides the mechanism for producing shear-induced flows and rapid pumping.

Shear-driven chromatography (SDC) is a relatively new concept that overcomes the speed and miniaturization limitations of conventional liquid chromatography. SDC is based on a sliding plate system, consisting of two flat surfaces, one of which has a recessed channel. A fluid flow is produced by axially sliding one plate past another, where the fluid has mechanical shear forces imposed at each point along the channel length. The shear-induced flow rates are very reproducible, and do not have pressure or voltage gradient limitations.

SDC opens up a new range of enhanced separation kinetics by permitting the sample confinement with sub-micron dimensions. Small, highly confined liquid is advantageous for chromatographic separation because the separation rate is known to scale according to the square of the confined

sample diameter. In addition, because shear-driven flows are not limited by fluid velocity, shear-driven liquid chromatography may provide up to 100,000 plate efficiency.

This work was done by Mark S. Anderson of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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