Development and Evaluation of Colorimetric-Solid Phase Extraction as a Rapid Approach to In-flight Water Quality Monitoring

Daniel B. Gazda, *Wyle Laboratories*
Jeffrey A. Rutz, *Wyle Laboratories*
John R. Schultz, *Wyle Laboratories*
Robert J. Lipert, *Iowa State University*
Lorraine Siperko, *Arizona State University*
Marc D. Porter, *Arizona State University*
Torin McCoy, *Johnson Space Center*
Jose Limardo, *Johnson Space Center*
Paul D. Mudgett, *Johnson Space Center*

Spacecraft drinking water quality is currently evaluated by acquiring samples on the International Space Station (ISS) or shuttle and returning them to Earth for workup and analysis. This archival approach often results in a significant time lapse between sample collection and analysis, which delays implementation of effective countermeasures in the event of contamination and raises questions about sample degradation. These factors underscore the need for rapid, onboard methods that are capable of monitoring critical water quality parameters or trace levels of contaminants in spacecraft drinking water supplies.

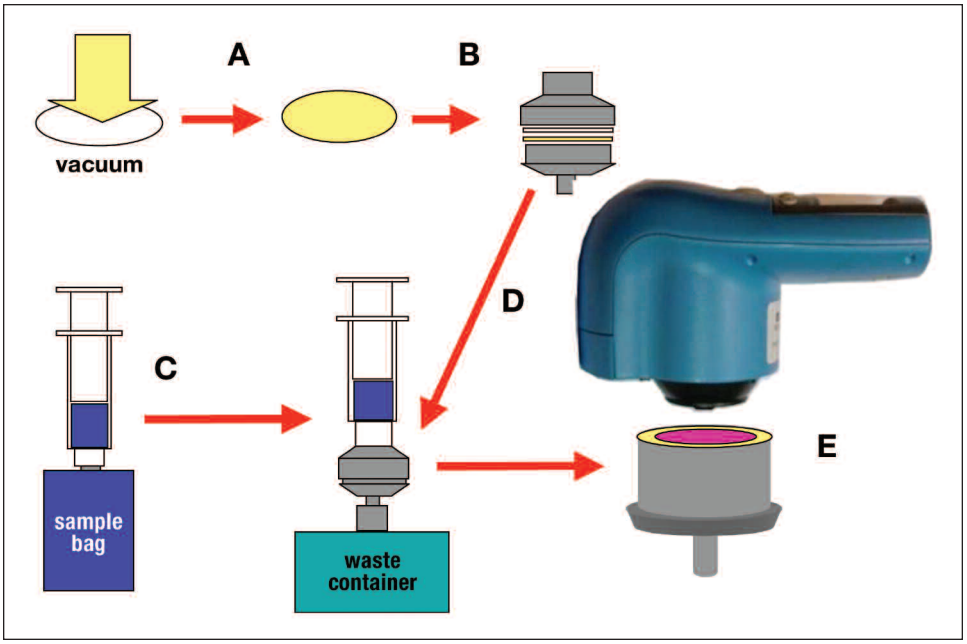
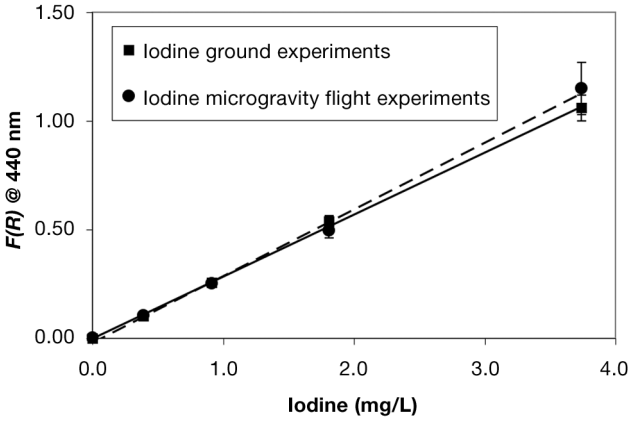


Illustration of entire C-SPE process.
(A) Membranes are impregnated with colorimetric reagents.
(B) Impregnated membranes are cut into 13-mm disks and loaded into filter holders.
(C) Sample is collected into syringe.
(D) Pre-loaded filter holder is connected to sample syringe and sample is passed through C-SPE disk.
(E) Diffuse reflectance spectrum of disk is collected with handheld spectrophotometer.

The development of environmental monitoring platforms for deployment on orbit presents a wide range of unique challenges. Monitoring systems must meet strict mass and power consumption requirements, require minimal consumables and crew time, contain minimal or no hazardous reagents, and, most importantly, use microgravity-compatible technology. One system that possesses many of these characteristics and has demonstrated the ability to meet several of NASA's current water quality monitoring requirements is Colorimetric Solid Phase Extraction (C-SPE).

The C-SPE platform uses colorimetric reagents on pretreated filter disks to detect target analytes in water. Water samples are analyzed by forcing a fixed volume of sample through the C-SPE filter disk with a syringe; the target analyte reacts with the reagents impregnated on the filter disk and causes a color change. A handheld diffuse reflectance spectrophotometer is used to detect the magnitude of the color change, which is directly proportional to the amount of analyte in the sample volume. The entire C-SPE analysis, including sample

collection, membrane exposure, and readout of the color change is extremely rapid; it can be completed in only 1 to 2 minutes. Notably, the use of impregnated and immobilized reagents eliminates the need to handle chemicals throughout sample workup and allows C-SPE to function in an essentially "reagentless" format. These attributes are ideal for use in closed-loop environments, such as ISS, because it minimizes the potential for crew exposure to hazardous reagents and minimizes waste. Methods for the determination of iodide, iodine, total iodine (sum of I_2, I^-, and I_3^-), and silver(I) were developed and evaluated in both terrestrial and microgravity environments. Additional methods to monitor other water quality indicators such as pH, copper(II), iron(III), chromium(VI), nickel(II), formaldehyde, and biolytes (bacteria and viruses that pose health concerns) are under development. Currently, a Station Development Test Objective experiment that will use C-SPE technology to measure silver(I) and total iodine in ISS water samples is being designed and will be ready for launch in the summer of 2009.



C-SPE iodine response plots obtained from ground and microgravity flight experiments.