NASA-2 / MIR 21
30-DAY OPERATIONAL ACCOMPLISHMENTS
POSTFLIGHT REPORT

Performed under
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“Analysis of Volatile Organic Compounds on Mir Station”

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I. INTRODUCTION

The goal of this research is the characterization of volatile organic compounds (VOCs) in air samples from Mir Space Station using new technology based on ion trap mass spectrometry (ITMS). Twenty-four hour time-averaged samples will be collected onto cartridges using the US Solid Sorbent Air Samples (SSAS). Grab samples will be collected using US Grab Sample Containers (GSC). Samples will be transferred from Mir via the Space Shuttle, forwarded to the Toxicology Laboratory at NASA Johnson Space Center (JSC) for analysis and sample subdivision, and then sent on to San Francisco State University (SFSU) for the purposes of this work. Standard operating procedures, quality control samples, and confirmatory experiments will be employed to ensure reliable, high quality data. Analyses will be performed via a modified form of EPA-approved gas chromatography/mass spectrometry (GC/MS) methods [1] and new techniques based on direct sampling ion trap mass spectrometry (DSITMS). Significant effort will be put into developing, testing, and demonstrating DSITMS techniques with the requisite sensitivity, selectivity, and speed for real-time monitoring of trace-level contaminants in air. The results of this research will provide detailed information on the types and concentrations of VOCs in the Mir environment. Moreover, the demonstration of new technology and comparison against proven methods will yield valuable information on the feasibility of its use for monitoring air quality in advanced life support systems.

A. Hypotheses

1. The types and concentrations of VOCs in the Mir Station atmosphere are not well characterized. Detailed information on the types and concentrations of VOCs in the Mir Station atmosphere is required to assess the toxicological risks of long-term human exposure to this environment.
2. Detailed information on the types and concentrations of VOCs in the Mir Station atmosphere can be obtained through the use of the same proven methods employed for previous U.S. space missions. These methods, based on the use of both cartridges and grab samples for sampling, and GC/MS for analysis, represent the most reliable, cost-effective means for characterizing this environment.
3. New technology based on DSITMS shows excellent promise for on-line, real-time monitoring of VOCs. Demonstration of this technology on air samples collected from Mir Station can provide a means for intercomparison with conventional GC/MS methods and provide a measure of its potential for environmental health assessments and advanced life support applications.

B. Objectives of Experiment

1. Characterize Mir Station atmosphere via proven sampling and analysis strategies.
2. Demonstrate the use of DSITMS for direct monitoring of VOCs in air samples collected from Mir Station.
3. Document the types and concentrations of VOCs on Mir Station and analyze results in collaboration with other science investigators to further the goals of the NASA Research Announcement (NRA).

C. Previous Mission Experience
Palmer and the JSC Toxicology Lab have signed a Memorandum of Understanding (MOU) which documents collaborative research on characterization of VOCs in Mir air samples. The JSC Toxicology Lab has extensive experience on space station air analysis and flown SSAS and GSC containers on a variety of prior NASA missions ranging from the Apollo through the Shuttle programs [2-6]. Palmer’s mission experience includes a set of “practice” samples from the Mir 19 mission, whose analyses enabled the testing of analytical methods and instruments, and the garnering of practical experience on space station air samples. A preliminary report on Mir 19 samples has been generated and forwarded onto the JSC Toxicology Lab for review [7].

II. RESEARCH OPERATIONS

A. Pre-, In-, and Post-Flight Anomalies

None to report.

B. Completeness/Quality of Data

A number of GSC and SSAS samples were collected on the Mir 21 mission and sent to the JSC Toxicology Lab for analysis. Out of this set, 2 GSC and 2 SSAS samples were forwarded to the Palmer for analysis.

III. DISCUSSION

A. Status of Data Analysis

All samples were analyzed via conventional GC/MS methods [1]. Samples were not analyzed via DSITMS techniques, which are still under development in Palmer’s labs.

B. Preliminary Research Findings

Interpretation of GC/MS data is currently in progress. Library searching, retention time confirmation, and manual interpretation have been used to identify VOCs in the samples. Most of the compounds identified in the samples are common air contaminants (i.e., halocarbons, siloxanes, and aromatic compounds). Their concentrations appear to be lower than space maximum allowable concentrations (SMACs) where available [8].

Development of DSITMS methods is still in progress. Recent results indicated detection limits on the order of 50 ppbv for several chlorofluorocarbons using MS, selected ion monitoring, and MS/MS modes [9]. Current work focusing on monoterpenes indicate that although the various isomers cannot be differentiated from one another via MS/MS, they can be selectively monitoring as a compound class at detection limits on the order of 50 ppbv [10,11]. Additional research, development, and testing of new MS methods for various VOCs and air sampling systems will proceed over the course of this contract. Application of these methods to VOCs in Mir samples will be performed at a later date.

C. Conclusions
The analyses of these first set of Mir samples provided valuable experience and semiquantitative results. The Mir 21 samples represent the first set of samples to be analyzed under this contract (reference original proposal and monthly progress reports). Although these samples were originally intended for analysis by the co-investigator Warren Belisle) at NASA Ames Research Center, the equipment he planned to use for these analyses was not yet installed and operational at the time at which the samples were received in June 1996. Hence, the samples were analyzed in Palmer’s laboratory at San Francisco State University.

There were a number of known limitations to the methods employed and the analyses themselves. The Tekmar AeroTRAP module does not have a carbon dioxide management system, which complicated interpretation of the early eluting VOCs. The chromatographic separation was hindered by the lack of a high resolution column (greater than 25 m in length), a cryocooling capability on the GC oven, and the use of a proper temperature program for the column. The appropriate gas standards required for retention time confirmation and quantitation were not received in time for these analyses and hence the available gas standards in the laboratory were employed.

The results of these analyses will enable further refinement of methods for future analyses. It should be noted that Warren Belisle’s lab includes a Entech thermal desorption system which has several advantages over the Tekmar modules used in these analyses, including inlets for samples, standards, and surrogates and a carbon dioxide management system. The GC will include both a cryocooling capability to effect improved separation of low boiling compounds and a 150 m Petrocol column for better overall separation efficiency. Calibration curves will be established for target compounds using a combination of commercial and custom gas standards. Internal standards/surrogates will be used for daily quantitation. This equipment is now installed and operational, and will be employed for analysis of Mir 22 samples.

IV. BIBLIOGRAPHY


