

THE SECOND GENERATION JPL ELECTRONIC NOSE

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INTRODUCTION

The Electronic Nose is a broadband air quality monitor which relies on the response of an array of weakly specific chemical sensors to identify and quantify compounds in the air. The pattern of response of the array is analyzed to determine species and quantity of a group of target compounds at the 24 hour Spacecraft Maximum Allowable Concentration (SMAC) level. The ENose was tested in a flight experiment on STS-95, and operated continuously for six days. Post-flight comparison of the results of the ENose monitoring and of air samples analyzed in an analytical laboratory showed no contradictions. The ENose program is now in its second phase.

CURRENT STATUS OF RESEARCH

Phase II of the Electronic Nose program at JPL, development of the second generation ENose for crew quarters air quality monitoring, focuses on optimizing the response of the array of conductometric sensors and on extensive ground testing. The sensors are films of polymers which have been loaded with carbon to make them conductive. After the ENose Flight Experiment on STS-95, it was clear that confidence in the ability of JPL's ENose to identify and quantify compounds cannot be developed during flight. Such confidence must be developed on the ground, with an optimized device and test conditions which will challenge the sensors and the identification software.

Work during the first year of this program is directed primarily toward optimization of the polymer sensing films by focusing on stability, sensitivity and response to compounds. We are taking three approaches to film optimization by studying film composition and morphology, data acquisition methods, and polymer selection for maximum accuracy in identification and quantification. In addition, several compounds have been added to the list of target analytes. The original list included common solvents such as alcohols, benzene, and toluene as well as other compounds which might be found in crew quarters, such as ammonia and hydrogen. New analytes include hydrazine and compounds associated with incipient electrical fires.

Sensor optimization work has included studies of noise, reaction time, and sensor recovery by studies of conductive medium, film thickness and sensor size. Data acquisition work has focused on the use of AC measurements of the sensor response to ppm levels of contaminant. AC methods may allow the use of very thin films and thus increase sensitivity while decreasing noise. Finally, we are studying polymer-analyte interactions to determine the best suite of polymer sensors for particular suites of contaminants.

AC data acquisition methods are under consideration because of the possibility of removing noise in responses by selecting the frequency of measurement. The first ENose measured the changes in DC resistance in a film deposited between two electrodes. As the film changed in response to a change in the environment, the resistance changed, too. An AC method under investigation is measuring the impedance at the interface between the electrodes and the film,

which will allow the use of very thin sensor films. Thinner films may lead to increased sensitivity.

Figure 1 shows plot of sensor response as change in impedance (I/I_0) vs. time, at several frequencies. Change in impedance is normalized to initial impedance, I_0 . The sensor, a film of carbon-loaded polyethylene oxide, responds to an injection of 4700 ppm ethanol. Figure 2 shows how frequency dependent measurements can be used to turn a single sensor into a virtual array. For a particular polymer film, the response at different frequencies to different compounds will result in a pattern such as can be made from Figure 2.

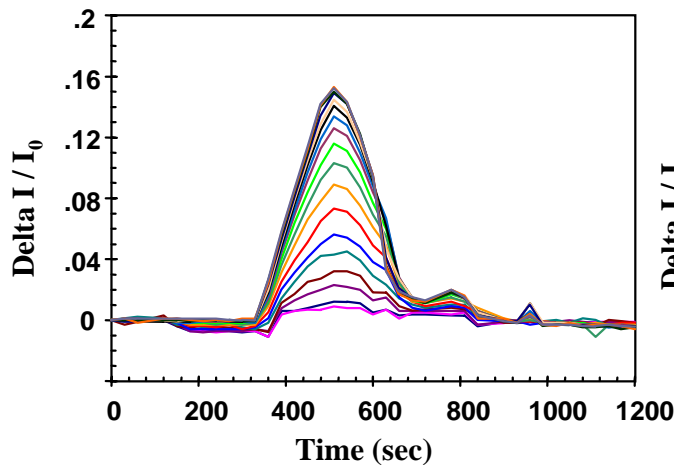


Figure 1. Response as I/I_0 of a film of carbon-loaded polyethylene oxide to an injection of 4700 ppm ethanol at 325 sec.

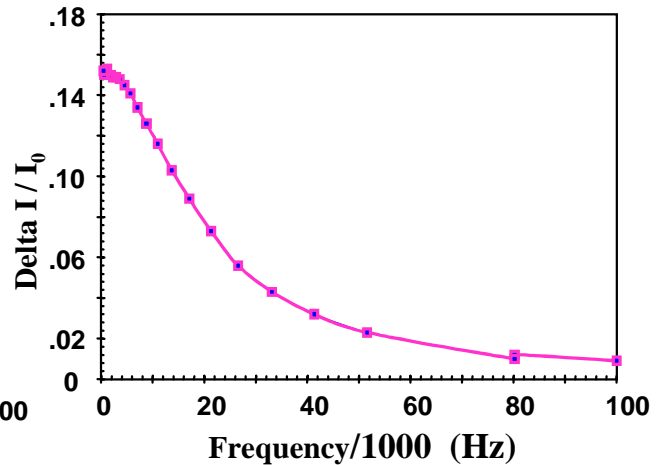


Figure 2. Response as I/I_0 vs. Frequency at 510 seconds in the plot shown in Figure 1.

FUTURE PLANS

Work in AC data acquisition and other approaches to sensor film optimization is ongoing. At the conclusion of the optimization portion of this program, the second generation ENose will be subjected to extensive ground testing in which the ENose and the data analysis software can be challenged. Successful completion of ground testing will give confidence in the ability of the JPL ENose to act as an event monitor in crew quarters.

It is possible that an additional flight experiment will be done on a developmental model of the second generation ENose.

INDEX TERMS

Electronic Nose, ENose, air quality, polymer sensors, chemiresistors, chemical sensor