Detection of Outgassing Species from the Electrical Insulators Using Cyranose E-Nose

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Abstract: The Cyranose™ electronic nose (e-nose) has been used for the first time to detect species out gassed from overheated electrical wire insulation. Out gassing occurs due to overheating as a result of the passage of high currents through the wire. This results in significant heat dissipation within the vicinity of high power electronic package boards. The Cyranose™ can be used to detect the gassed species prior to the occurrence of either fire or incipient fire detection. The Cyranose e-nose has detected the outgassing species within 5-20 seconds in our tests, which provides a significant advantage over other methods.

Introduction: The Cyranose™ electronic nose has been developed utilizing conductive polymer (CP) composite materials to recognize a variety of chemical vapors or classes of vapors by creating a fingerprint of each vapor. The principle of detecting chemical vapors is not new. However, its use for incipient fire detection or detection of gaseous species as a result of the onset of fire, due to heat generated as result of high current flow, in an electrical wire, is novel. What is being assessed and evaluated is the reliability of commercial-off-the-shelf (COTS) electronic noses and their respective advanced electronic packages in various environments. The goal of this work is to infuse these technologies into NASA projects and missions to assure the safety of personnel aboard the International Space Station (ISS). It can also be utilized to monitor air-quality in the cabins of the space shuttle, as a part of the Integrated Vehicle Health Management (IVHM) project and other related NASA projects. In addition, this E-nose technology can be used to assess the quality and reliability of high power electronic package modules with respect to fire event detection or organic contaminant detection. The initial goal was to assess the reliability of COTS E-noses for use future space applications. While engaged in this effort, findings showed its ability to detect out gassed contaminants that are generated in high power electronic packages due to overheating of electrical interconnects or wires.

Mechanism: An electrical wire consists of copper strand(s) or other electrically conductive material sheathed in a layer of insulating material. The materials used to insulate wires are synthesized using a variety of organic compounds and solvents. Every copper wire, depending on its gauge and resistance, has a maximum safe limit to the current that will flow through it. This is due to the resistive heating (I^2R) that occurs as a result of the current flowing through an electrical wire. The wire dissipates this heat to its surroundings and in doing so heats the insulator. The temperature of the insulator increases and at a certain temperature out gassing begins to occur. Finally, the insulator melts over the wire. If heating continues, the eventual result will be burning of the insulator and melting of solder joints etc.

Experimental Results: Figure 1 shows a schematic of the test set-up utilized to detect the out gassing species using the electronic nose. We have used a variable power supply to control the voltage across the electrical wire. The current flow was limited via a resistor. The applied voltage was gradually increased. Meanwhile, the Cyranose™ e-nose was aligned close to the electrical wire that is under test, several inches away. The Cyranose™ E-Nose was turned on with a baseline purge as shown in Figure 3. Baseline response was parallel to the x-axis for all the sensors (32 CP sensors) since the background contaminant level was too low to obtain a response by the e-nose. When the voltage was increased significantly, the wire overheated producing high concentrations of volatile contaminants out gassed from the insulators. Figure 3 shows the response of an E-nose as a function of time. Baseline purge response was independent of time, until the beginning of out gassing. At the onset of out gassing there was a considerable response by

the e-nose with reference to out gassed species. Figure 2 is an optical photograph of an electrical wire showing the condition of the insulation after the overheating test.

Conclusion: The Cyranose™ E-Nose has been used to detect various organic species out gassed as a result of overheating of electrical wires and their insulators. This suggests that the Cyranose E-Nose may have use for detecting the contaminants that occur as a result of events that occur prior to ignition in electronic packages or any other similar applications.

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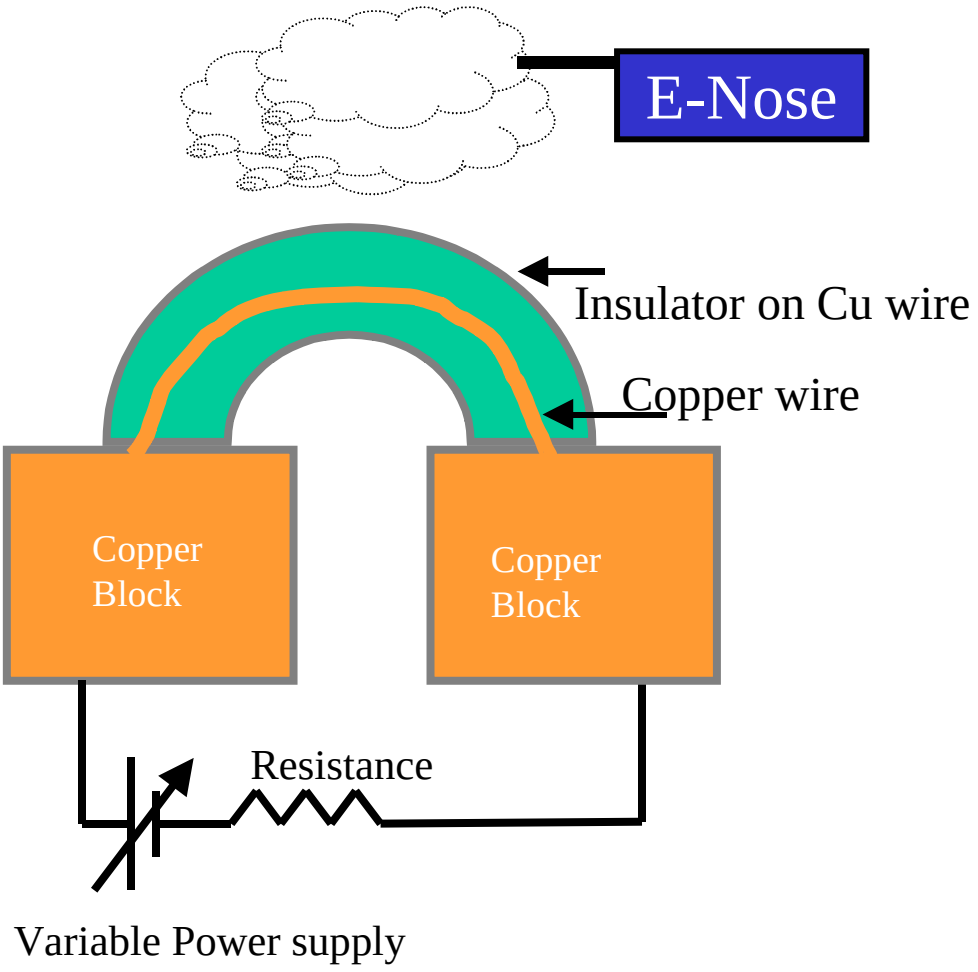

Figure 1: Schematic of the test set-up to detect the outgassing species using an electronic nose (E-Nose)

Figure 2: Optical photograph of the green lab wire after the electrical test.

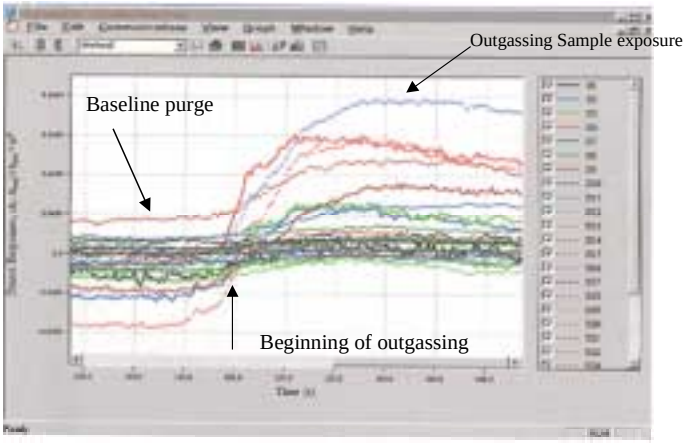

Figure 3: Cyranose E-Nose response through the baseline purge, outgassing species exposure.