SAND2018-8260C

Direct Electrical Detection of Target Gases by a Novel Metal−Organic-Framework-Based Sensor

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ABSTRACT: High-fidelity detection of iodine species is of utmost importance to the safety of the population in cases of nuclear accidents or advanced nuclear fuel reprocessing. Herein, we describe the success at using impedance spectroscopy to directly detect the real-time adsorption of individual iodine species (eg., I_2, org-I, I^-) by tuned metal organic framework - based sensors. One example is the detection of I_2; Methanolic suspensions of ZIF-8 were dropcast onto platinum interdigitated electrodes, dried, and exposed to gaseous I_2 at 25, 40, or 70 °C. Using an unoptimized sensor geometry, I_2 was readily detected at 25 °C in air within 720 s of exposure. The specific response is attributed to the chemical selectivity of the ZIF-8 toward I_2. Furthermore, equivalent circuit modeling of the impedance data indicates a $>10^5$ decrease in ZIF-8 resistance when 116 wt % I_2 is adsorbed by ZIF-8 at 70 °C in air. This irreversible decrease in resistance is accompanied by an irreversible loss in the long-range crystallinity, as evidenced by X-ray diffraction and infrared spectroscopy. Air, argon, methanol, and water were found to produce minimal changes in ZIF-8 impedance. This report demonstrates how selective I_2 adsorption by ZIF-8 can be leveraged to create a highly selective sensor using $>10^5$ changes in impedance response to enable the direct electrical detection of environmentally relevant gaseous toxins.

Acknowledgements: Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.