Grant: AFC820-22

Title: Miniaturized and Low Cost Electrochemical Particulate Matter (PM) Sensor for Mine Dust Exposure Assessment

Organization: Oakland University

Principal Investigators: Xiangqun Zeng

Topic: Health and Safety Interventions, Monitoring Systems and Integrated Control Technologies

SYNOPSIS

Problem Statement: Mining, maintenance or processing activities release dust particles (coal, quartz, and other finely divided or powdered materials) into the air. Breathing in these particles damages the lungs and airways. Exposure of miners to particulate matter (PM) in their work environments is a leading cause of respiratory symptoms and diseases including silicosis, coal workers' pneumoconiosis (CWP), chronic obstructive pulmonary disease (COPD) and lung cancer. Currently, the lack of monitoring tools capable of individual, real-time assessment of PM emission greatly impede the thorough study of exposure and its health impacts. Such tools would enable successful realization of well-informed interventions to reduce PM exposures and improve health of vulnerable and disproportionately-impacted individuals, through effective policy and regulation.

PM monitoring in mines is very challenging due to heterogeneity of PM. PM can vary in size, concentration and composition depending on emission sources and processes undergone. Further, particulate size and the number and type of chemical elements and compounds present in PM vary from one location to another. Current PM monitoring technologies mostly rely on collection of samples from fixed-site, which are then transported off-site and analyzed in laboratories using sophisticated instruments. Consequently, these technologies cannot measure spatial and temporal variations of PM emission *in situ*. Although Thermo Scientific’s continuous personal dust monitor (PDM3700) currently used in underground mining has significantly improved respirable coal dust monitoring capabilities and complies with MSHA coal mine dust exposure regulations, it cannot properly characterize and quantify the size and chemical type of PMs to estimate population-wide exposure. Monitoring PM emission in mines requires new monitoring tools that can continuously quantify PM size distribution and composition. This detailed PM information will be critical for understanding of the mechanisms of PM biological toxicity needed to provide effective prevention and treatment for miners’ health and safety. Currently, no device exists that can provide this kind of detailed information.

Research Approach: We will develop an inexpensive miniaturized electrochemical PM sensor that can monitor the concentration of the respirable fine dust PM exposure and perform *in situ* analyses of the size and type of PM (coal, quartz, and other minerals). This sensor will use an innovative funnel microelectrode array capable of electrochemically detecting PM sizes and types continuously and in real-time through impact electrochemistry (i.e. single particle collision events). Although we intend to prototype this device for PM monitoring in coal mines, the sensor can easily be modified for use in other types of mines and under varying mine conditions. There are three specific research Aims.

- Aim 1. Develop impact electrochemistry based electroanalytical methods for continuous detection and classification of PM in concentration, size and type
- Aim 2. Develop and characterize novel funnel microelectrode arrays for highly sensitive and selective PM detection and classification
- Aim 3. Develop, characterize, and validate a miniaturized PM electrochemical sensor prototype for coal and crystalline silica dust monitoring in coal mines

Impact of the Research: This work will produce an electrochemical PM sensor prototype that is convenient and safe for use for accurately measuring miners’ exposure to PM over time in underground coal mines. Assessment of the size and chemical composition of PM to which individual miners are exposed throughout their work environments will generate quantitative data that will be invaluable in understanding the behavior of PM in mining environments; differences in the prevalence, type, and concentration of PM in different parts of miners’ work space; and thereby improving our understanding of the effects of PM on miners' health and the mechanisms leading to those effects. In addition to its benefits to mine health and miners' health research, the proposed PM sensor will also provide real-time monitoring and reporting of individual's personal PM exposure. That information can be used to set thresholds for generation of personalized alerts to individual miners when they enter an area where high levels of PM are present, allowing them to take immediate steps to avoid specific health risks.