

TO: Texas Air Research Center (or Texas Hazardous Waste Research Center)

FROM: **Investigators:** Sidney Lin
Institution: Lamar University
Contact Information: 409-880-2314

SUBJECT: Annual Progress Report

PROJECT NUMBER: 513LUB00208

PROJECT TITLE: Detection of Nitrogen Oxides in Automobile Exhaust by Nanoceramic Sensor

PROJECT PERIOD: 9/1/2013 – 7/15/2014

DATE: 9/15/2014

Project Description

This two-year project is to manufacture a fast-response high-accuracy sensor for nitrogen oxides (NO_x) detection using chemically stable high-surface-area ceramic nanowires. To achieve this goal, ceramic nanowires will be first formed from ceramic slurry via the electrospinning process followed by a high temperature sintering in a controlled atmosphere. The wires will then be integrated with an electrical circuit to be a portable sensor. Finite element analysis will be employed to modify the electrospinning process to control the dimension and porosity of the spun nanowires in order to increase the surface area of the spun nanowires and thus maximize the detection sensitivity of the sensor. The sintering process will be modified to maximize the surface area and control the nanostructure of the synthesized wires in order to improve the sensor performance. The first year deliverables will be a custom made electrospinning

system for ceramic nanowires preparation. The second year deliverables will include a one dimensional mathematic model to analyze the electrospinning process, and nanowires of three different compositions. In addition to the PI, one graduate student and two undergraduate students will work on this project.

Objectives

The overall goal of this project is to produce a NO_x sensor that is portable, fast response, with high selectivity and high accuracy. We will assemble a prototype sensor using nanoceramic wires which will not only reduce the size and weight of the sensor but also will have very low detection limit and fast response time due to its very high specific surface area. With the fast detection capability, NO_x can be detected and then treated/reduced quickly. The success of this project will benefit the air pollution control/reduction and improve the air quality and living environment in Texas.

Methodology

Recent progress in solid state sensors provides a new opportunity to improve the detection of trace gases (e.g. NO_x, carbon dioxide, methane, and ethanol) at very low concentrations (**in ppb range**). We propose to use the nanoceramic wire concept to design and assemble a sensor to detect NO_x of low concentrations.

The success of this project objective will be achieved/evaluated by the following steps:

1. Selection of sensor materials (detailed literature search).
2. Production of nanoceramic wires of the desired compositions by electrospinning process.

3. Sintering the spun wires to form high surface solid nanowires.
4. Improvement the sintering process and electrospinning process by mathematical modeling (finite element analysis).
5. Assembly and test a sensor device to detect NO_x.

There are three tasks in this project.

Task 1. Preparation of NanoCeramic Wires via Electrospinning Process

Task 2. Sintering of Spun Nanowires and Assembly of Sensor

Task 3. Development of a mathematical model to simulate the electrospinning process

Accomplishments/Problems

Equipment

The most important equipment for this project, a high voltage power supply (Figure 1) to provide necessary electric field for the electrospinning process has been purchased and installed. The integration of this power supply and syringe pump (Figure 2) that will deliver the reactant solution has been set up as proposed in the proposal.



(a)



(b)

Figure 1. (a) The front view of the high voltage power supply, (b) The back panel of the high voltage power supply.



(a)



(b)

Figure 2. (a) The syringe pump that will be used to control the delivery rate of reactant solutions, (b) Various sizes of syringes that will be used to deliver the reactant solutions.

Personnel

One Ph.D. student and two undergraduate students were recruited to conduct this project. The PI used one full summer month in year 2014 to conduct experiments, train students to operate the experimental setup, and teach them using the COMSOL MultiPhysics program to build a mathematic model. The PI attended the 3rd International Conference on Electrospinning in San Francisco to collect information and build up network with researchers in the electrospinning research for future collaboration.

Future Work

We will use the second year to produce nanoceramic wires via electrospinning process and sinter the spun nanowires and develop the mathematical model to study the electrospinning process.