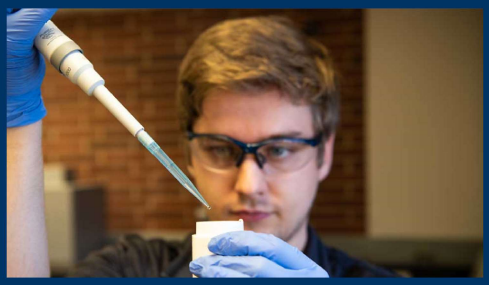


Novel Breath Acetone Sensor Based on 1D/2D Nanocomposite for Diabetes Prevention and Monitoring

Danling Wang, Department of Electrical and Computer Engineering, Fargo, ND 58102

ABSTRACT

The acetone content in the exhaled breath of individuals as a biomarker of diabetes, has become widely studied as a non-invasive means of quantifying blood glucose levels. This calls for development of sensors for the quantitative analysis of trace concentration of acetone, which is presents in the human exhaled breath. Traditional gas detection systems such as the GC/MS and several types of chemiresistive sensors are currently being used for this purpose. However, these systems are known to have limitations of size, cost, response time, operating conditions, and consistent accuracy. An ideal breath acetone sensor should provide solutions to overcome the above limitations and provide good stability and reliability. This should be a simple and portable detection system of good sensitivity, selectivity that is low in terms of both cost and power consumption. In this poster, we will present a novel sensor using a newly synthesized nanocomposite, 1D KWO ($K_2W_7O_{22}$) nanorods /2D $Ti_3C_2T_x$ nanosheets, to detect exhaled acetone from human. The result reveals that this new sensor has excellent sensing response to acetone with much better tolerance of humidity interference, and enhanced stability. By comparing with other nanomaterials: Ti_3C_2, KWO, KWO/$Ti_3C_2T_x$ nanocomposite can be an excellent sensing material for application in sensitive and selective detection of breath acetone for diabetics health care and prevention.

Danling Wang
Assistant Professor
Email: danling.wang@ndsu.edu

Diabetes statistics in U.S.

- In the United States, diabetes is the seventh leading cause of death in the nation, accounting for more than 80,000 deaths every year.
- These statistics are serious, and it is alarming to know that in 2017, up to 30.3 million Americans had diabetes with 7.2 million being undiagnosed.
- Estimated cost of diabetes in the U.S in 2017 is about $327B ($237 billion in direct medical cost ,$90 billion in non medical costs.

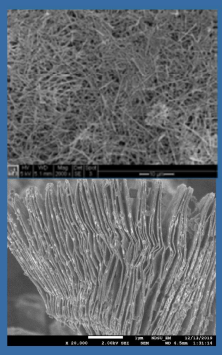
Current Techniques for Diabetes Diagnosis and Monitoring

Invasive, Inconvenient, Expensive

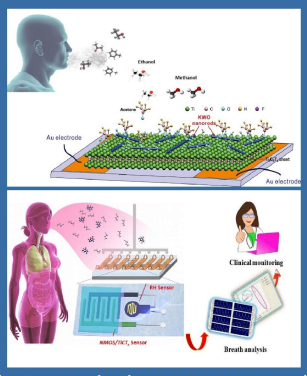
Sensing Materials

1D NANOWIRES $K_2W_7O_{22}$

2D Nanosheets Ti_3C_2 MXene



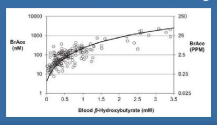
Device Sketch



Breath acetone sensor based on KWO/$Ti_3C_2T_x$ nanocomposite

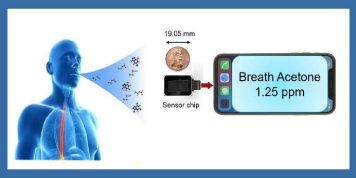
Working Principles

- Some breath volatile organic compounds (VOCs) directly link to metabolic activity in the body, and some of these VOCs can directly provide information on health conditions such as infections or metabolic diseases. Breath acetone is a biomarker for diagnose diabetes.
- Study shows that the concentration of acetone in the breath is closely related to the concentration of blood glucose.

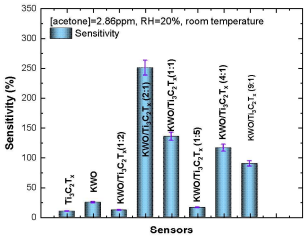


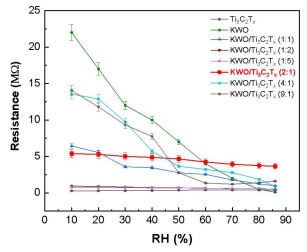
Sensor Features

- Low-power
- Non-toxic
- Low-cost
- Accurate
- Non-invasive
- IoT enabled



Results





Advantages

- **Low power device** which can operate at room temperature
- **High accurate device** with high sensitivity to acetone and less humidity interference for early stage diabetes diagnosis
- **Low cost and self-stabilized device** for long-term glucose monitoring.
- **IoT enabled device** for real-time glucose classification and in-time treatment guidance.

Publications & Patent

1. "Highly Sensitive Room-Temperature Sensor Based on Nanostructured $K_2W_7O_{22}$ for Application in the Non-Invasive Diagnosis of Diabetes", Md Razuan Hossain, Qifeng Zhang, Michael Johnson and Danling Wang, Sensors 2018.
2. "High Sensitive Breath Sensor Based on $K_2W_7O_{22}$ Nanorods for Diabetes", Danling Wang, Qifeng Zhang, Md. Razuan Hossain, and Michael Johnson (2017) , IEEE Sensor Journal.
3. "KWO is a novel ferroelectric nanomaterial for application as a room temperature acetone sensor", M.E.Johnson, Q. Zhang, and D. Wang, Nanomaterials, 2020.
4. "Novel 1D/2D KWO/Ti_3C_2 nanocomposite-based acetone sensor for diabetes prevention and monitoring", Chemosensors, 2020.
5. "Room-temperature ferroelectric $K_2W_7O_{22}$ (KWO) nanorods as a sensor material for the detection of acetone", Michael Johnson, Qifeng Zhang, and Danling Wang, Medical Devices and Sensors, 2019.
6. D. Wang and Q. Zhang, "Low Cost Diabetes Breath Analyzer Based on Nanostructured $K_2W_7O_{22}$ Material," US Patent Number: US 2020/0077923 A1

Acknowledgement

North Dakota NASA EPSCoR
ND EPSCoR
Sanford
NDSU FOUNDATION AND ALUMNI ASSOCIATION