Materials Today Chemistry 37 (2024) 102003

Contents lists available at ScienceDirect

Materials Today Chemistry

journal homepage: www.journals.elsevier.com/materials-today-chemistry/

Recent advances in functionalization of copper and tin oxide nanomaterials for application in sensing: A comparative review

Md Ashraful Kader [a], Nina Suhaity Azmi [a], A.K.M. Kafi [b,*], Samiul Alim [c]

[a] Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuhraya Tun Razak, Gambang, 26300, Kuantan, Pahang, Malaysia
[b] Department of Chemistry and Biochemistry, Kent State University, Kent, OH, 44242, USA
[c] Ian Potter Nano Biosensing Facility, Nanobiotechnology Research Laboratory (NBRL), School of Science, RMIT University, Melbourne, 3001, Victoria, Australia

ARTICLE INFO

Keywords:
Nanomaterials
Cupric Oxide
Cuprous Oxide
Tin (II) oxide
Tin(IV) oxide
Chemical Sensor
Gas Sensor
Immunosensor
Non enzymatic Sensor

ABSTRACT

Sensors can detect various environmental parameters such as air quality, water quality, soil conditions, and more. They enable continuous monitoring, and early detection of pollutants, and help in assessing environmental health. With advancements, sensors could become more portable, cost-effective, and capable of detecting a wider range of pollutants with higher sensitivity. Copper and tin-based oxide nanomaterials are the most dynamic of such metal oxide nanomaterials that have been widely exploited in the development of chemical and gas sensors. Indeed, metal oxides, while catalytically active, can suffer from drawbacks such as limited selectivity and unstable reactivity, which can hamper sensor performance. Functionalization techniques involving various nanomaterials and conducting polymers are commonly employed by researchers to address the limitations associated with metal oxide-based sensors. This review covers the recent developments of functionalization of the most commonly used metal oxide nanomaterials derived from Cupric oxide (CuO), Cuprous oxide (Cu_2O), Tin(II) oxide (SnO) and Tin(IV) oxide (SnO_2) and their applications in the field of chemical and gas sensing. Cabbalistic data are displayed in the tables, and the review concludes with possibilities and difficulties related to metal oxide-based sensors are discussed.

1. Introduction

Sensors are an applied device-based technology that helps improve the quality of life on earth by monitoring various physical, chemical and biological phenomena around us. Chemical sensors are one form of sensor that is becoming increasingly used in a variety of applications, including industrial, domestic clinical diagnostics, security surveillance, food safety, and environmental monitoring [1,2]. It is constructed by attaching a chemically sensitive layer to a transducer platform, where the sensing layer interacts with the analyte and convert the signal into an analytically quantifiable signal. It is very selective, sensitive, and capable of detecting solid, liquid, and gaseous components with minimal fuss. Recently, nanomaterials have gained wide popularity in different applications due to their large surface to volume ratio, size, mechanical, electrical, biodegradable and thermal properties. Nanoscience and nanotechnology have shown exciting prospects in this sensing technology by introducing novel metal and metal oxide-based nanomaterials, including nanoparticles, nanotubes, nanoflower, nanorods, nanofibers, nanoplates, nanomembranes, and quantum dots, and many others [3,4].

Metal oxides (MOX) are great prospects for next-generation sensing due to their fast-sensing response, non-toxicity, and long-term response stability under demanding conditions. It has a high surface-to-volume ratio, which allows for increased sensitivity, selectivity, and catalytic activity during detection [5]. It exhibits enhanced signal and higher temperature stability compared to their bulk counterparts. Metal oxide-based detection sensors are classified into two types: chemical and biological compound detection sensors and gas detection sensors. Metal oxide nanomaterials are the current focus of researchers for constructing chemical detection sensors because they possess desirable features such as large surface-to-volume ratio, rapid electron transport behavior, and wide band gap energy [6]. Metal oxide nanostructure contributes to tremendous development in the sensor arena. Metal oxide decorated novel electro-analytical devices displayed higher sensitivity, cost-effectiveness, and improved selectivity [7,8]. Those metal oxide-based detection system can mimic natural enzymes as well as lessen these above drawbacks of natural enzyme [9].

To safeguard ecosystems against gas-related toxicity and ensure healthy lifestyle, gas sensors are currently required to detect the

* Corresponding author.
E-mail address: akafi@kent.edu (A.K.M. Kafi).

https://doi.org/10.1016/j.mtchem.2024.102003
Received 13 December 2023; Received in revised form 23 February 2024; Accepted 8 March 2024
Available online 4 April 2024
2468-5194/