2020

Solid State Chemi-Resistors: A Promising Solution of Heavy Metals in Africa

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Abstract

The presence of heavy metals in water sources have increased in recent times due to the raising number of anthropogenic activities. These metals exhibit harmful effects on both animal and human health even in parts per billion levels as they tend to bioaccumulate in the body. Of all these metals, mercury, lead, and cadmium are classified as the most toxic due to their carcinogenic effects on humans. According to Environmental Protection Agency (EPA), the permissible limit for most metals is 1part per million (ppm) for surface water. Detecting heavy metals is crucial for both industrial and environmental monitoring activities which have resulted to the high demands of sensing devices that are cheap, highly efficient, sensitive, and have a low power utilization. To develop a sensor with these properties, there is the need to explore materials that exhibit these features hence the use of 2D materials. Nanostructures of 2D materials have properties like large surface area, high surface to volume ratio that favours adsorption process of heavy metals onto surfaces of these materials.

Over the last decade, nanomaterials are extensively studied to address environmental effects of heavy metals in both water bodies and the atmosphere. Specifically, two-dimensional 2D materials are being explored as excellent nanomaterials that offers remedy to various environmental problems due to their specific properties at the nano level. Most studied of these materials is graphene and graphene-based nanomaterials but of recent, other emerging 2D materials such as molybdenum disulfide (MoS_2) are being explored. MoS_2 thin nanosheet is utilized for detecting heavy metals due to its distinctive properties such as high accuracy, large surface area, excellent mechanical and electrical abilities. There are several sensing detection techniques ranging from electrochemical techniques, optical techniques to electro-transduction sensing techniques via chemi-resistors. Of all these techniques, the use of electro-transduction devices is highly favoured due to their advantages like low cost of maintenance and reduced device complexity. Electro-transduction chemi-resistors made from molybdenum disulfide are emerging devices useful for detecting metals at these extremely low concentrations. These chemi-resistors sense contaminants through changes in electrical conductivity by acting as dopants even at extremely low concentrations unlike electrochemical techniques that utilize redox reactions on electrode surface.

Hence, properties like thickness, electrical conductivity and surface area of thin film lead to excellent performance of chemi-resistors. In this research, a solid state chemi-resistive device using molybdenum disulfide nanosheets is proposed to detect the presence of heavy metals and determine the concentration of these metals present in water. This device can be incorporated to existing systems for in-line measurements where sensing of heavy metals is required.

Keyword: Lead, chemi-resistors, molybdenum disulfide