Nanomaterials as Sensor : For Water and Air Pollutants

Kulsum Hashmi, Satya*, Sakshi Gupta, Nidhi Singh, Seema Joshi
Department of chemistry, Isabella Thoburn college, Lucknow, U.P., India
*Email-sasatya7745@gmail.com

Abstract

Environmental restoration is one of the global concerns today. The degradation of environment is impacting it's biodiversity and also is showing an adverse effect on human health. Hydrocarbons, CO, chlorofluorocarbons, volatile organic compounds, and nitrogen oxides are the principal contributors to air pollution. Water that has been contaminated with both organic and inorganic substances. The main sources of water contamination are sewage water, industrial effluents and inadequate use of pesticides and fertilisers. The need of better technological advancements are required to reduce pollution levels. There is a lot of interest in the potential applications of nanomaterials in better systems for monitoring and cleaning up water and air contaminants. Nanomaterials, such as zeolites, carbon nanotubes, and nano-adsorbents, are a few examples that can be employed for the removal of metallic contaminants from water and wastewater. Various nanomaterials have also been produced for the detection and removal of gaseous pollutants from air, such as carbon, graphene, metal and metal oxide nanomaterias etc. Due to their significant specific surface areas and high reactivities, nanomaterials are ideal adsorbents, catalysts, and sensors. It can help in designing new methods for sensing and detection of pollutants. The present review gives an insight of the major applications of nanomaterials for removing contaminants from air and water.

Introduction

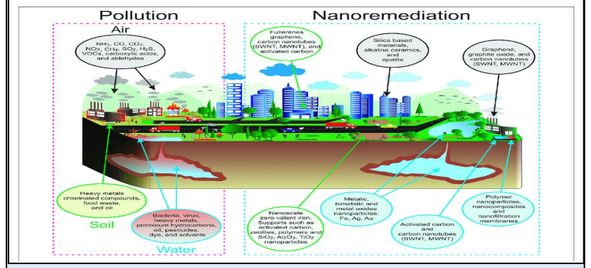
Nanotechnology offers the capacity to control matter at the nanoscale and generates materials with specialized traits and capabilities. The nanomaterial can be utilized to detect highly sensitive pollutants due to its small size and high surface area to volume ratio, composition, electrical properties, magnetic properties, mechanical properties and optical properties. Applications of nanotechnology can help to protect the environment by lowering the consumption of natural resources and manufactured materials, reducing or eliminating the production of wastes and effluents, and reducing toxics.

A wide variety of nanostructured systems, such as metal nanotubes, nanowires, nanofibers, nanocomposites, nanorods, nanoparticles, nanostructured polymers, and various allotropes of carbon, such as carbon nanotubes, graphene, or fullerenes, are among the nanomaterials currently used in sensor development.

There is a lot of expectation that environmental cleanup and health improvements will result from nanotechnology. The current study focuses on how nanomaterials is used for the detection and removal of pollutants from water and air.

Methodology

The data was collected from several databases such as Scopus, PubMed, Google Scholar and ScienceDirect. The literature of the last 5 years was reviewed to find the applications of nanomaterials for the detection and removal of different types of pollutants from air and water.



Discussions

Nanomaterials for water pollutants:

1. Detection of heavy metal ions (Cu^{2+} and Pb^{2+}) by polyDOPA-AgNPs(3,4-dihdroxy-L-phenylalanine AgNPs):

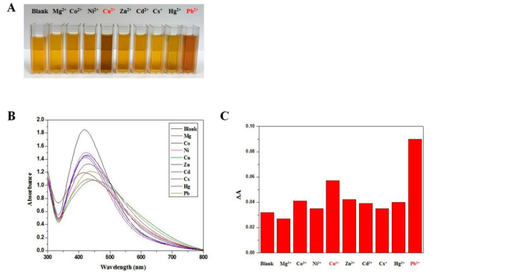


Fig.: (A) polyDOPA-AgNPs in the presence of various metal ions, (B) UV-Vis absorption spectra, (C) absorption ratio with various metal ions.

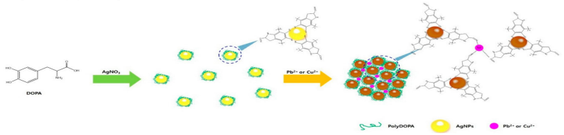
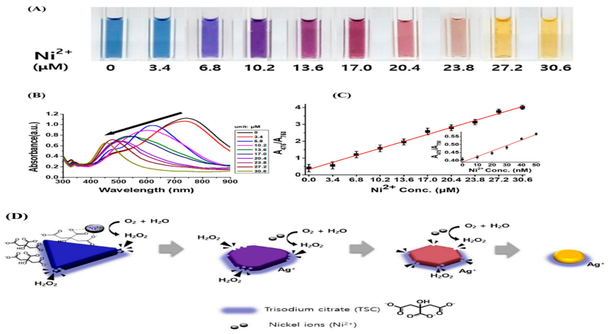


Fig.: Mechanism of detection of Pb^{2+} and Cu^{2+} ions

2. Citrate capped triangular AgNPs for the detection of Ni^{2+} ions:



UV spectra of Ni2+ on different conc. (C) absorption ratios, (D) the sensing mechanism of Ni^{2+} ions.

Nanomaterials for air pollutants:

1. Graphene/TiO_2 NPs for sensing of NO_2 :

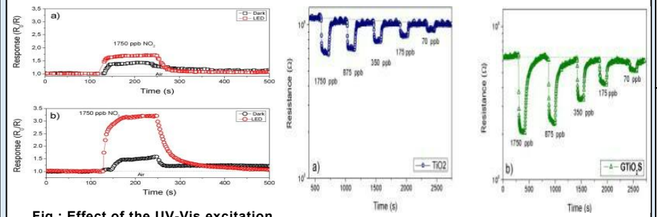


Fig.: Effect of the UV-Vis excitation on the response behaviour of the a) TiO_2 and b) $GTiO_2$ sensor towords NO_2.

Fig.: Resistance variation under UV excitation for a) TiO_2 and b) $GTiO_2$ at different conc. of NO_2.

2. Pd-doped SnO_2 nanosenor for CO gas:

Real time testing of the sensor:

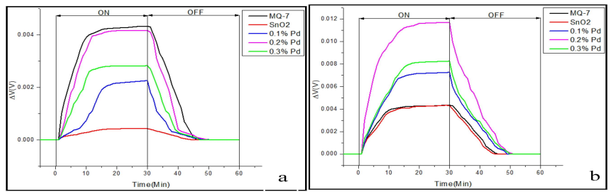


Fig.: Comparison of change in voltage for SnO_2, Pd-SnO_2 and commercial CO sensor MQ-7, tested for 60min @100rpm, connected as a) 3-sensor array and b) 8-sensor array.

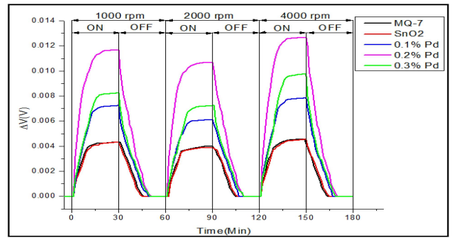


Fig.: Change in voltage for 8-sensor array of pure SnO_2 , Pd-SnO_2 and commercial CO sensor MQ-7, @1000 , 2000 and 4000 rpm.

• By functioning as an adsorbent or photocatalyst, a number of nanocomposites, including Fe_3O_4/MnO_2, CO Fe_2O_4-reduced graphene oxide, nano-Fe/Ca/CaO, etc., have made it easier to release pollutants into the environment under controlled conditions.

Conclusion

Although the applications of nanomaterials have a great potential in sensing, prevention and treatment of pollution in water and air with low cost, it needs to be studied further to assess its risk. This is in accordance with the principle that the more sophisticated the technologies, the greater the risks they pose.

References

1. Panahi, Y., Mellatyar, H., Farshbaf, M., Sabet, Z., Fattahi, T., & Akbarzadehe, A. (2018). Biotechnological applications of nanomaterials for air pollution and water/wastewater treatment. Materials Today: Proceedings, 5(7), 15550-15558.
2. Rastogi, S., Sharma, G., & Kandasubramanian, B. (2020). Nanomaterials and the environment. The ELSI Handbook of Nanotechnology: Risk, Safety, ELSI and Commercialization, 1-23.
3. Cheon, J. Y., & Park, W. H. (2016). International Journal of Molecular Sciences, Green synthesis of silver nanoparticles stabilized with mussel-inspired protein and colorimetric sensing of lead (II) and copper (II) ions. Int. J. Mol. Sci., 17, 1-10.
4. Prosposito, P., Burratti, L., & Venditti, I. (2020). Silver nanoparticles as colorimetric sensors for water pollutants. Chemosensors, 8(2), 26.
5. Giampiccolo, A., Tobaldi, D. M., Leonardi, S. G., Murdoch, B. J., Seabra, M. P., Ansell, M. P., ... & Ball, R. J. (2019). Sol gel graphene/TiO2 nanoparticles for the photocatalytic-assisted sensing and abatement of NO2. Applied Catalysis B: Environmental, 243, 183-194.
6. Sam Jebakumar, J., & Juliet, A. V. (2020). Palladium-doped tin oxide nanosensor for the detection of the air pollutant carbon monoxide gas. Sensors, 20(20), 5889.