Pharmaceutical Analytical Chemistry: Open Access

OPEN ACCESS Freely available online

Short Communication

Synthesized Metal Oxide Nanoparticles in the Potentiometric Determination of Metformin: A Scientific Overview

Rongjn Xie*

Department of Pharmaceutics, University of Zhejiang, Hangzhou, China

DESCRIPTION

In the field of pharmaceuticals, the precise determination of drug concentrations is important for ensuring efficacy and safety. Metformin, a widely prescribed antidiabetic agent, exemplifies this need due to its importance in managing diabetes mellitus. Traditional analytical techniques like spectrophotometry and chromatography have been fundamental in metformin analysis. However, recent advancements in nanotechnology, particularly the utilization of Metal Oxide Nanoparticles (MONPs), offer promising avenues for enhancing the accuracy and sensitivity of metformin determination through potentiometric methods [1,2].

Metal oxide nanoparticles: Synthesis and properties

Metal oxide nanoparticles encompass a diverse class of nanomaterials with unique physicochemical properties. These nanoparticles typically range in size from 1 to 100 nanometers and exhibit high surface area-to-volume ratios, which can significantly influence their reactivity and interaction capabilities with analytes like metformin. Synthesis methods for MONPs vary and include techniques such as sol-gel, precipitation, and hydrothermal methods, each yielding nanoparticles with distinct morphologies and surface characteristics. For instance, Zinc Oxide (ZnO) nanoparticles synthesized via sol-gel methods often exhibit high crystallinity and well-defined surface structures, which are advantageous for sensor applications due to their enhanced electron transfer properties [3,4].

Potentiometric determination techniques

Potentiometry relies on measuring the potential difference between an indicator electrode and a reference electrode in a chemical system at equilibrium. In the context of metformin determination, Ion-Selective Electrodes (ISEs) play a pivotal role. These electrodes are typically coated with ionophores that selectively bind metformin ions, generating a measurable potential difference corresponding to the analyte concentration in the sample solution. The integration of metal oxide nanoparticles into ISEs enhances their performance by improving ion selectivity, response time, and stability. For example, incorporating Titanium Dioxide (TiO_2) nanoparticles into the sensing membrane of an ISE can enhance the electrode's sensitivity to metformin ions while maintaining robustness against interference from other ions present in biological samples [5].

Role of metal oxide nanoparticles in enhancing sensitivity and selectivity

The unique physicochemical properties of MONPs contribute significantly to the effectiveness of potentiometric sensors for metformin detection:

Surface modification: Functionalizing MONPs with specific ligands or coatings enhances their affinity for metformin ions, thereby improving sensor selectivity [6].

Enhanced electron transfer: MONPs facilitate rapid electron transfer at the electrode-solution interface, leading to faster response times and increased sensor sensitivity.

Reduced interference: MONPs can act as barriers against interference from other ions present in complex biological matrices, thereby improving the accuracy and reliability of metformin measurements [7].

Recent advances and applications

Recent research has focused on optimizing MONP-based potentiometric sensors for metformin determination in clinical and environmental samples. Studies have demonstrated the feasibility of using MONPs such as iron oxide (Fe_2O_3) nanoparticles to fabricate sensitive and selective metformin sensors capable of detecting trace levels of the drug in biological fluids with high precision. Moreover, the integration of MONPs with advanced nanomaterials like carbon nanotubes or graphene has shown promising results in further enhancing sensor performance through synergistic effects in electron transfer kinetics and surface area enhancement [8].

Correspondence to: Rongjn Xie, Department of Pharmaceutics, University of Zhejiang, Hangzhou, China, E-mail: rongju@xieu.edu.cn

Received: 28-Jun-2024, Manuscript No. PACO-24-32690; **Editor assigned:** 01-Jul-2024, PreQC No. PACO-24-32690 (PQ); **Reviewed:** 15-Jul-2024, QC No. PACO-24-32690; **Revised:** 22-Jul-2024, Manuscript No. PACO-24-32690 (R); **Published:** 29-Jul-2024, DOI: 10.35841/2471-2698.24.9.249.

Citation: Xie R (2024). Synthesized Metal Oxide Nanoparticles in the Potentiometric Determination of Metformin: A Scientific Overview. Pharm Anal Chem. 9:249.

Challenges and future directions

Despite significant progress, challenges remain in the widespread adoption of MONP-based potentiometric sensors for metformin determination. Issues such as reproducibility of nanoparticle synthesis, long-term stability of sensing membranes, and standardization of calibration protocols need to be addressed [9].

Future research directions could explore

Multifunctional nanocomposites: Developing multifunctional nanocomposite materials that combine MONPs with polymers or biomolecules to enhance sensor performance and stability.

Miniaturization and integration: Miniaturizing potentiometric sensors for point-of-care applications and integrating them into wearable devices for real-time monitoring of metformin levels in diabetic patients [10].

Biocompatibility and safety: Evaluating the biocompatibility and long-term safety of MONP-based sensors for clinical use.

CONCLUSION

In conclusion, the integration of synthesized metal oxide nanoparticles into potentiometric sensors represents a promising approach for enhancing the accuracy, sensitivity, and selectivity of metformin determination. Continued advancements in nanoparticle synthesis, sensor fabrication techniques, and interdisciplinary collaborations will pave the way for the development of next-generation analytical tools capable of meeting the evolving demands of pharmaceutical analysis and personalized medicine.

REFERENCES

1. Sivaraj R, Rahman PK, Rajiv P, Narendhran S, Venckatesh R. Biosynthesis and characterization of *Acalypha indica* mediated copper oxide nanoparticles and evaluation of its antimicrobial and anticancer activity. Spectrochim Acta a Mol Biomol Spectrosc. 2014;129:255-258.
2. Sharma R, Garg R, Kumari A. A review on biogenic synthesis, applications and toxicity aspects of zinc oxide nanoparticles. EXCLI J. 2020;19:1325.
3. Hamidon TS, Garba ZN, Zango ZU, Hussin MH. Biopolymer-based beads for the adsorptive removal of organic pollutants from wastewater: Current state and future perspectives. Int J Biol Macromol. 2024:131759.
4. Lan Y, Coetsier C, Causserand C, Serrano KG. An experimental and modelling study of the electrochemical oxidation of pharmaceuticals using a boron-doped diamond anode. J Chem Eng. 2018;333:486-494.
5. Li M, Cushing SK, Wu N. Plasmon-enhanced optical sensors: A review. Analyst. 2015;140(2):386-406.
6. Rosi NL, Mirkin CA. Nanostructures in biodiagnostics. Chem Rev. 2005;105(4):1547-1562.
7. Bharathi D, Ranjithkumar R, Chandarshekar B, Bhuvaneshwari V. Preparation of chitosan coated zinc oxide nanocomposite for enhanced antibacterial and photocatalytic activity: As a bionanocomposite. Int J Biol Macromol. 2019; 129:989-996.
8. Divya M, Govindarajan M, Karthikeyan S, Preetham E, Alharbi NS, Kadaikunnan S, et al. Antibiofilm and anticancer potential of β-glucan-binding protein-encrusted zinc oxide nanoparticles. Microb Pathog. 2020; 141:103992.
9. Thatoi P, Kerry RG, Gouda S, Das G, Pramanik K, Thatoi H, et al. Photo-mediated green synthesis of silver and zinc oxide nanoparticles using aqueous extracts of two mangrove plant species, Heritiera fomes and Sonneratia apetala and investigation of their biomedical applications. J Photochem Photobiol B Bioo. 2016;163:311-318.
10. Manasa DJ, Chandrashekar KR, Kumar MP, Suresh D, Kumar DM, Ravikumar CR, et al. Proficient synthesis of zinc oxide nanoparticles from Tabernaemontana heyneana Wall. *via* green combustion method: Antioxidant, anti-inflammatory, antidiabetic, anticancer and photocatalytic activities. Results in Chemistry. 2021;3:100178.