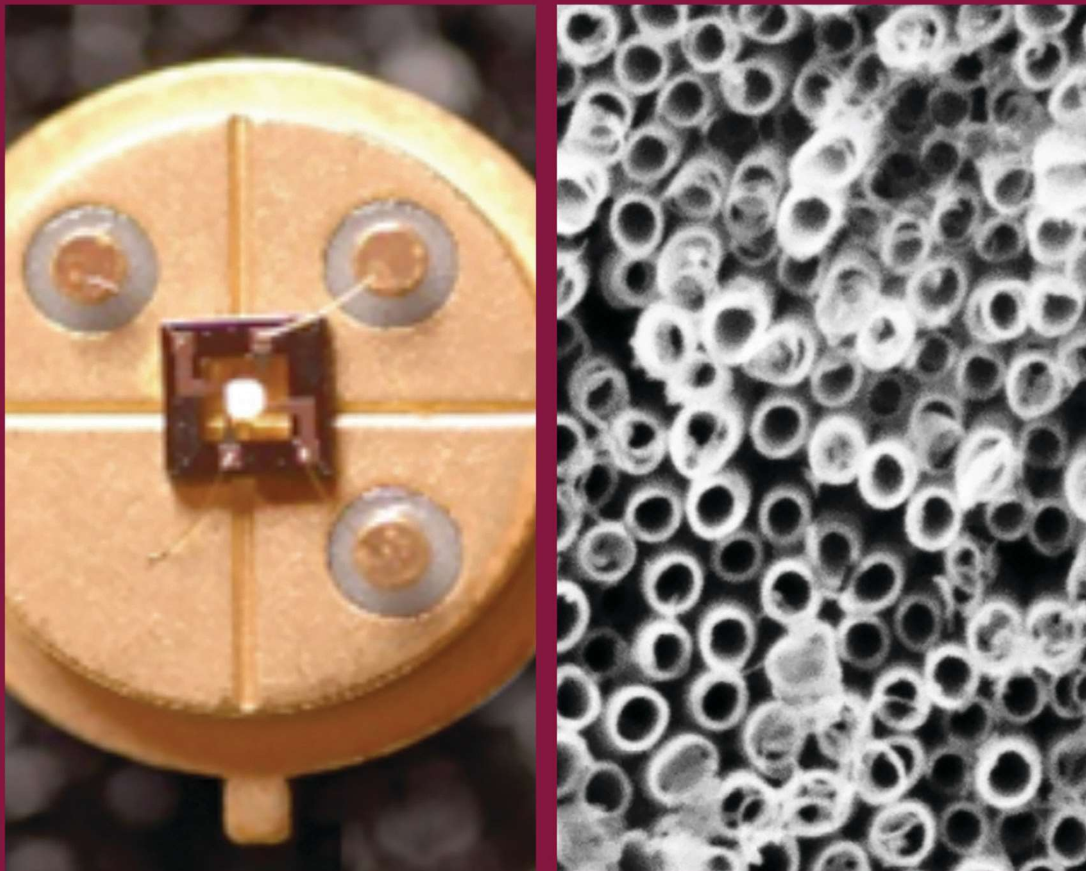

EMERGING MATERIALS AND TECHNOLOGIES

NANOMATERIAL-BASED SENSORS FOR HEALTHCARE APPLICATION

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3 Nanotechnology Tools for Diagnosis and Therapy

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3.1 INTRODUCTION

Nanotechnology is now regarded as the most promising technology of the twenty-first century based on the exploitation of the unique properties of quasi-atomic particles at a size scale ranging from 1 to 100 nm.[1] The concept of nanotechnology was first introduced in 1959 by Richard Feynman, an American physicist. Nanotechnology has been widely used in the field of drug delivery systems, tissue-engineered constructs, implants, and pharmaceutical therapeutics. Nanocarriers can be used for targeted drug delivery, which can improve the dosage and accuracy of drug release, thereby reducing the toxic and side effects of drugs on normal tissues. Additionally, nanoparticles (NPs) can be functionalized based on the surface chemistry of the particles and conjugation of ligands (small molecules, antibodies, and peptides) to precisely target the expressed receptors.[2,3]

Managing and treating a disease requires an understanding of its underlying causes, which includes information about the patient's medical background and physical examination, as well as applying diagnostic methods to identify and characterize symptoms.[4] Nanodiagnostics has emerged as a modality that utilizes nanoscale properties, such as unique physiochemical and optical properties to meet the demand for early detection, high sensitivity, and point of-care testing, particularly for community clinics in developing countries.[5,6]

Recent advancements in nanotechnology have enabled an opportunity to combine diagnosis and therapy in a single platform or carrier.[7] Theranostic nanosystems have been recognized as a potential breakthrough to revolutionize future disease management. The term 'theranostics' integrates the technology with concurrent and complementary diagnostic and therapeutic capabilities to achieve more specific and personalized disease management.[8,9] Some common nanotechnology tools employed in the development of theranostic formulations are shown in Figure 3.1.

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Liu, J ., Wang, X ., Wang, T ., Li, D ., Xi, F ., Wang, J ., & Wang, E . (2014). Functionalization of monolithic and porous three-dimensional graphene by one-step chitosan electrodeposition for enzymatic biosensor. ACS Applied Materials & Interfaces, *6* (22), 19997–20002. https://doi.org/10.1021/am505547f

Ran, X ., Du, Y ., Wang, Z ., Wang, H ., Pu, F ., Ren, J ., & Qu, X . (2017). Hyaluronic acid-templated Ag Nanoparticles/Graphene Oxide composites for synergistic therapy of bacteria infection. ACS Applied Materials & Interfaces, *9* (23), 19717–19724. https://doi.org/10.1021/acsami.7b05584

Wu, M. C. , Deokar, A. R. , Liao, J. H. , Shih, P. Y. , & Ling, Y. C. (2013). Graphene-based photothermal agent for rapid and effective killing of bacteria. ACS Nano, *7* (2), 1281–1290. https://doi.org/10.1021/nn304782d

Cheon, Y. A. , Bae, J. H. , & Chung, B. G. (2016). Reduced Graphene Oxide Nanosheet for Chemo-photothermal Therapy. Langmuir: The ACS Journal of Surfaces and Colloids, *32* (11), 2731–2736. https://doi.org/10.1021/acs.langmuir.6b00315

Hao, L ., Song, H ., Zhan, Z ., & Lv, Y . (2020). Multifunctional reduced Graphene Oxide-Based nanoplatform for synergistic targeted Chemo-Photothermal Therapy. ACS Applied Bio Materials, *3* (8), 5213–5222. https://doi.org/10.1021/acsabm.0c00614

Prasad, R ., Yadav, A. S. , Gorain, M ., Chauhan, D. S. , Kundu, G. C. , Srivastava, R ., & Selvaraj, K . (2019). Graphene Oxide supported Liposomes as Red Emissive Theranostics for Phototriggeredtissue visualization and tumor regression. ACS Applied Bio Materials, *2* (8), 3312–3320. https://doi.org/10.1021/acsabm.9b00335

Pan, J ., Yang, Y ., Fang, W ., Liu, W ., Le, K ., Xu, D ., & Li, X . (2018). Fluorescent phthalocyanine–graphene conjugate with enhanced NIR absorbance for imaging and multi-modality therapy. ACS Applied Nano Materials, *1* (6), 2785–2795.

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Nasiri N ., & Clarke C . (2019). Nanostructured gas sensors for medical and health applications: Low to high dimensional materials. Biosensors, 9(1), 43. https://doi.org/10.3390/bios9010043

Drmosh Q. A. , Olanrewaju Alade I ., Qamar M ., & Akbar S . (2021). Zinc oxide-based acetone gas sensors for breath analysis: A review. Chemistry–An Asian Journal, 16(12), 1519–1538. https://doi.org/10.1002/asia.202100303

Horne J ., McLoughlin L ., Bridgers B ., & Wujcik E. K. (2020). Recent developments in nanofiber-based sensors for disease detection, immunosensing, and monitoring. Sensors and Actuators Reports, 2(1), 100005. https://doi.org/10.1016/j.snr.2020.100005

Kim S. J. , Choi S. J. , Jang J. S. , Cho H. J. , & Kim I. D. (2017). Innovative nanosensor for disease diagnosis. Accounts of Chemical Research, 50(7), 1587–1596. https://doi.org/10.1021/acs.accounts.7b00047

Yoon J. W. , & Lee J. H. (2017). Toward breath analysis on a chip for disease diagnosis using semiconductor-based chemiresistors: Recent progress and future perspectives. Lab on a Chip, 17(21), 3537–3557. https://doi.org/10.1039/C7LC00810D

Mout R ., Moyano D. F. , Rana S ., & Rotello V. M. (2012). Surface functionalization of nanoparticles for nanomedicine. Chemical Society Reviews, 41(7), 2539–2544. https://doi.org/10.1039/C2CS15294K

Zhang C ., Luo Y ., Xu J ., & Debliquy M . (2019). Room temperature conductive type metal oxide semiconductor gas sensors for NO2 detection. Sensors and Actuators A: Physical, 289, 118–133. https://doi.org/10.1016/j.sna.2019.02.027

Su P. G. , & Yang L. Y. (2016). NH3 gas sensor based on Pd/SnO2/RGO ternary composite operated at room-temperature. Sensors and Actuators B: Chemical, 223, 202–208. https://doi.org/10.1016/j.snb.2015.09.091

Zhang L ., Guo Y. Y. H. , Liu G ., & Tan Q . (2020). Na-doped zno and rgo composite-based flexible acetone gas sensor operated in room temperature. IEEE Access, 8, 171568–171574. https://doi.org/10.1109/ACCESS.2020.3023028

Zhou Q ., Chen W ., Xu L ., Kumar R ., Gui Y ., Zhao Z ., ... & Zhu S . (2018). Highly sensitive carbon monoxide (CO) gas sensors based on Ni and Zn doped SnO2 nanomaterials. Ceramics International, 44(4), 4392–4399. https://doi.org/10.1016/j.ceramint.2017.12.038