micromachines

MDPI

Review

Stimuli-Responsive Nanomaterial-Based Biosensor Structures for Wound Care: pH, ROS, and Temperature Sensing Strategies

Anita Ioana Visan [1], Adrian Birnaz [2] and Irina Negut [1,*]

[1] National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor 409, 077125 Magurele, Romania; anita.visan@inflpr.ro
[2] Center for Nanotechnology and Nanosensors, Department of Microelectronics and Biomedical Engineering, Technical University of Moldova, 168 Ștefan cel Mare Avenue, MD-2004 Chisinau, Moldova; adrian.birnaz@mib.utm.md
* Correspondence: negut.irina@inflpr.ro

Abstract

Chronic and infected wounds remain a major clinical challenge due to their dynamic microenvironments and the lack of real-time diagnostic feedback in conventional dressings. Recent advances in stimuli-responsive nanomaterial-based biosensors have enabled the development of smart wound-care systems capable of continuous monitoring and on-demand therapeutic intervention. This review systematically summarizes progress in nanomaterial-enabled wound biosensing strategies, with a focus on pH, reactive oxygen species, and temperature nanosensors, which serve as key indicators of infection, inflammation, and healing status. We discuss the sensing mechanisms and functional roles of diverse nanomaterials. A particular focus is placed on emerging multimodal and theranostic platforms which integrate biochemical and physical sensing with controlled drug release, photothermal or photodynamic therapy, and redox regulation. These systems represent a shift from passive wound monitoring toward closed-loop, adaptive wound management. Also, future perspectives are outlined, highlighting the convergence of nanomaterials, self-powered electronics, and intelligent data processing as a pathway toward personalized and precision wound care.

Keywords: smart wound biosensors; stimuli-responsive nanomaterials; theranostic wound care

Check for updates

Academic Editors: Stella Girousi and Cheng-Hsin Chuang

Received: 4 February 2026
Revised: 24 February 2026
Accepted: 25 February 2026
Published: 28 February 2026

Author Contributions: Conceptualization, I.N. and A.I.V.; methodology, I.N. and A.I.V.; software, A.B.; validation, I.N.; formal analysis, I.N.; investigation, I.N. and A.I.V.; resources, I.N.; data curation, A.I.V.; writing—original draft preparation, I.N., A.B. and A.I.V.; writing—review and editing, I.N. and A.I.V.; visualization, I.N.; supervision, I.N.; project administration, I.N.; funding acquisition, I.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: I.N., A.B. and A.I.V. acknowledge the support from a grant of the Ministry of Education and Research, CCCDI-UEFISCDI, project number PN-IV-P8-8.3-ROMD-2023-0060, within PNCDI IV and by the Romanian Ministry of Research, Innovation and Digitalization under the Romanian National Nucleu Program LAPLAS VII—contract no. 30N/2023. I.N. also acknowledges the support by a grant of the Ministry of Education and Research, CCCDI–UEFISCDI, project number PN-IV-PCB-RO-MD-2024-0254, within PNCDI IV. Grammarly was used to improve spelling, grammar, and readability of the manuscript. The authors confirm that all scientific content, analysis, and conclusions were developed independently.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Eskilson, O.; Zattarin, E.; Berglund, L.; Oksman, K.; Hanna, K.; Rakar, J.; Sivlér, P.; Skog, M.; Rinklake, I.; Shamasha, R.; et al. Nanocellulose Composite Wound Dressings for Real-Time pH Wound Monitoring. *Mater. Today Bio* **2023**, *19*, 100574. [CrossRef]
2. Cherifi, K.; Toupchinejad, F.; Christodoulopoulos, K.; Kizilkaya, A.; Matoori, S. Colorimetric Detection Methods of pH-Sensing Wound Dressing for Point-of-Care Wound Diagnostics. *bioRxiv* **2024**. [CrossRef]
3. Hoveizavi, N.B.; Alihosseini, F.; Lehner, S.; Meier, P.; Gaan, S. Colorimetric pH-Responsive Nanofibrous Hydrogels for in Vitro Monitoring of Wound Infection. *J. Mater. Chem. B* **2025**, *13*, 11621–11639. [CrossRef]
4. Lokuge, N.D.; Casillas-Popova, S.N.; Singh, P.; Clermont-Paquette, A.; Skinner, C.D.; Findlay, B.L.; Naccache, R.; Oh, J.K. Luminescent Electro-Spun Nanofibers Crosslinked with Boronic Esters Exhibiting Controlled Release of Carbon Dots for Detection of Wound pHs and Enhanced Antimicrobial. *Macromol. Biosci.* **2025**, *25*, e00352. [CrossRef]
5. Yang, Z.; You, J.; Zhai, S.; Zhou, J.; Quni, S.; Liu, M.; Zhang, L.; Ma, R.; Qin, Q.; Huangfu, H.; et al. pH-Responsive Molybdenum Disulphide Composite Nanomaterials for Skin Wound Healing Using "ROS Leveraging" Synergistic Immunomodulation. *Mater. Today Bio* **2025**, *31*, 101481. [CrossRef]
6. Yang, Y.; Huang, Q.; Hu, Y.; Chen, Y.; Chen, J.; Chen, Z.; Jiang, X.; Zhang, Y. Thermochromic, Antibacterial, and Conductive Hydrogel Patch with Sandwich Structure for Visual Infectious Chronic Wound Care and Treatment. *Adv. Healthc. Mater.* **2026**, *15*, e03296. [CrossRef]
7. Wu, J.; Li, Y.; Duan, S.; Wang, Z.; Jing, X.; Lin, Y.; Zhu, D.; Lei, W.; Shi, Q.; Tao, L. Bioinspired Stretchable MXene Deformation-Insensitive Hydrogel Temperature Sensors for Plant and Skin Electronics. *Research* **2023**, *6*, 0106. [CrossRef] [PubMed]
8. Sun, B.; Xu, G.; Yang, Z.; Guan, C.; Ji, X.; Chen, S.; Chen, X.; Ma, Y.; Feng, J. Dual-Mode Temperature Monitoring Using High-Performance Flexible Thermocouple Sensors Based on PEDOT:PSS/CNTs and MXene/Bi2Se3. *Microsyst. Nanoeng.* **2025**, *11*, 31. [CrossRef] [PubMed]
9. Barik, S.; Keswani, K.; Ray, P.; Chakraborty, R.; Mohini, S.; Banoth, E.; Kumar, P. Emerging Smart Biomaterials/Devices to Accelerate Chronic Wound Healing by Modulating Wound Microenvironments. *Small* **2025**, *21*, e06791. [CrossRef] [PubMed]
10. Tang, N.; Zheng, Y.; Jiang, X.; Zhou, C.; Jin, H.; Jin, K.; Wu, W.; Haick, H. Wearable Sensors and Systems for Wound Healing-Related pH and Temperature Detection. *Micromachines* **2021**, *12*, 430. [CrossRef]
11. Youssef, K.; Ullah, A.; Rezai, P.; Hasan, A.; Amirfazli, A. Recent Advances in Biosensors for Real Time Monitoring of pH, Temperature, and Oxygen in Chronic Wounds. *Mater. Today Bio* **2023**, *22*, 100764. [CrossRef]
12. Yang, J.; He, Y.; Li, Z.; Yang, X.; Gao, Y.; Chen, M.; Zheng, Y.; Mao, S.; Shi, X. Intelligent Wound Dressing for Simultaneous *in Situ* Detection and Elimination of Pathogenic Bacteria. *Acta Biomater.* **2024**, *174*, 177–190. [CrossRef]
13. Jiang, L.; Loo, S.C.J. Intelligent Nanoparticle-Based Dressings for Bacterial Wound Infections. *ACS Appl. Bio Mater.* **2021**, *4*, 3849–3862. [CrossRef] [PubMed]
14. Song, Z.; Zhou, S.; Qin, Y.; Xia, X.; Sun, Y.; Han, G.; Shu, T.; Hu, L.; Zhang, Q. Flexible and Wearable Biosensors for Monitoring Health Conditions. *Biosensors* **2023**, *13*, 630. [CrossRef]

15. Antony, A. Flexible and Wearable Biosensors: Revolutionizing Health Monitoring. In *Biosensors: Developments, Challenges and Perspectives*; Mathew, R., Ajayan, J., Eds.; Springer Nature: Singapore, 2024; pp. 237–258.
16. Wallace, H.A.; Basehore, B.M.; Zito, P.M. Wound Healing Phases. In *StatPearls*; StatPearls Publishing: Treasure Island, FL, USA, 2025.
17. Jing, S.L.; Suh, E.J.; Huang, K.X.; Griffin, M.F.; Wan, D.C.; Longaker, M.T. Understanding and Advancing Wound Healing in the Era of Multi-Omic Technology. *Bioengineering* **2026**, *13*, 51. [CrossRef] [PubMed]
18. Negut, I.; Grumezescu, V.; Grumezescu, A.M. Treatment Strategies for Infected Wounds. *Molecules* **2018**, *23*, 2392. [CrossRef]
19. El Ayadi, A.; Jay, J.W.; Prasai, A. Current Approaches Targeting the Wound Healing Phases to Attenuate Fibrosis and Scarring. *Int. J. Mol. Sci.* **2020**, *21*, 1105. [CrossRef] [PubMed]
20. Kumar, M.; Sethi, P.; Shiekmydeen, J.; Rastogi, S.; Mahmood, S.; Chopra, S.; Thomas, S.; Kumar, D.; Bhatia, A. A Recent Review on Smart Sensor-Integrated Wound Dressings: Real-Time Monitoring and on-Demand Therapeutic Delivery. *Int. J. Biol. Macromol.* **2025**, *313*, 144251. [CrossRef]
21. Ma, C.; Gao, Y.; Cao, Y.; Yang, Y.; Wang, W.; Wang, J. Hierarchically Core-Shell Nanofiber Textiles for Personal Cooling in Hot and Humid Conditions. *Nano Energy* **2024**, *123*, 109400. [CrossRef]
22. Gao, W.; Wang, Q.; Gong, W.; Zheng, L.; Liu, Q.; Zhang, L.; Ma, Y. Recent Advances in Biosensors: Structure, Principles, Classification, and Application in Bio-Manufacturing. *Methods* **2025**, *242*, 123–142. [CrossRef]
23. Vo, D.-K.; Trinh, K.T.L. Advances in Wearable Biosensors for Wound Healing and Infection Monitoring. *Biosensors* **2025**, *15*, 139. [CrossRef]
24. Hunt, M.; Torres, M.; Bachar-Wikstrom, E.; Wikstrom, J.D. Cellular and Molecular Roles of Reactive Oxygen Species in Wound Healing. *Commun. Biol.* **2024**, *7*, 1534. [CrossRef]
25. Ukaegbu, K.; Allen, E.; Svoboda, K.K.H. Reactive Oxygen Species and Antioxidants in Wound Healing: Mechanisms and Therapeutic Potential. *Int. Wound J.* **2025**, *22*, e70330. [CrossRef]
26. Barrientos, S.; Brem, H.; Stojadinovic, O.; Tomic-Canic, M. Clinical Application of Growth Factors and Cytokines in Wound Healing. *Wound Repair Regen.* **2014**, *22*, 569–578. [CrossRef]
27. Burian, E.A.; Sabah, L.; Karlsmark, T.; Kirketerp-Møller, K.; Moffatt, C.J.; Thyssen, J.P.; Ågren, M.S. Cytokines and Venous Leg Ulcer Healing—A Systematic Review. *Int. J. Mol. Sci.* **2022**, *23*, 6526. [CrossRef]
28. Firmansyah, Y.; Sidharta, V.M.; Wijaya, L.; Tan, S.T. Unraveling the Significance of Growth Factors (TGF-β, PDGF, KGF, FGF, Pro Collagen, VEGF) in the Dynamic of Wound Healing. *Asian J. Med. Health* **2024**, *22*, 49–61. [CrossRef]
29. Rembe, J.-D.; Garabet, W.; Augustin, M.; Dissemond, J.; Ibing, W.; Schelzig, H.; Stuermer, E.K. Immunomarker Profiling in Human Chronic Wound Swabs Reveals IL-1 Beta/IL-1RA and CXCL8/CXCL10 Ratios as Potential Biomarkers for Wound Healing, Infection Status and Regenerative Stage. *J. Transl. Med.* **2025**, *23*, 407. [CrossRef] [PubMed]
30. Azimzadeh, M.; Khashayar, P.; Mousazadeh, M.; Daneshpour, M.; Rostami, M.; Goodlett, D.R.; Manji, K.; Fardindoost, S.; Akbari, M.; Hoorfar, M. Volatile Organic Compounds (VOCs) Detection for the Identification of Bacterial Infections in Clinical Wound Samples. *Talanta* **2025**, *292*, 127991. [CrossRef]
31. Haller, H.L.; Sander, F.; Popp, D.; Rapp, M.; Hartmann, B.; Demircan, M.; Nischwitz, S.P.; Kamolz, L.P. Oxygen, pH, Lactate, and Metabolism—How Old Knowledge and New Insights Might Be Combined for New Wound Treatment. *Medicina* **2021**, *57*, 1190. [CrossRef] [PubMed]
32. Sørensen, M.A.; Petersen, L.J.; Bundgaard, L.; Toft, N.; Jacobsen, S. Regional Disturbances in Blood Flow and Metabolism in Equine Limb Wound Healing with Formation of Exuberant Granulation Tissue. *Wound Repair Regen.* **2014**, *22*, 647–653. [CrossRef] [PubMed]
33. Slade, E.A.; Thorn, R.M.S.; Young, A.E.; Reynolds, D.M. Real-time Detection of Volatile Metabolites Enabling Species-level Discrimination of Bacterial Biofilms Associated with Wound Infection. *J. Appl. Microbiol.* **2022**, *132*, 1558–1572. [CrossRef] [PubMed]
34. Mohammed, H.T.; Bartlett, R.L.; Babb, D.; Fraser, R.D.J.; Mannion, D. A Time Motion Study of Manual versus Artificial Intelligence Methods for Wound Assessment. *PLoS ONE* **2022**, *17*, e0271742. [CrossRef]
35. Clemett, V.J. Wound Assessment and Documentation: Rationale and Guidance. *Br. J. Nurs.* **2025**, *34*, S20–S26. [CrossRef]
36. Jørgensen, L.B.; Sørensen, J.A.; Jemec, G.B.; Yderstræde, K.B. Methods to Assess Area and Volume of Wounds – a Systematic Review. *Int. Wound J.* **2015**, *13*, 540–553. [CrossRef] [PubMed]
37. Mamone, V.; Fonzo, M.D.; Esposito, N.; Ferrari, M.; Ferrari, V. Monitoring Wound Healing With Contactless Measurements and Augmented Reality. *IEEE J. Transl. Eng. Health Med.* **2020**, *8*, 2700412. [CrossRef]
38. Smet, S.; Probst, S.; Holloway, S.; Fourie, A.; Beele, H.; Beeckman, D. The Measurement Properties of Assessment Tools for Chronic Wounds: A Systematic Review. *Int. J. Nurs. Stud.* **2021**, *121*, 103998. [CrossRef]
39. Pearson, J.E.; Gill, A.; Vadgama, P. Analytical Aspects of Biosensors. *Ann. Clin. Biochem.* **2000**, *37*, 119–145. [CrossRef]
40. Niu, R. Biosensors and Research on Their Applications. *Highlights Sci. Eng. Technol.* **2025**, *129*, 97–102. [CrossRef]
41. Chen, S.; Cheng, Y.F. Biosensors for Bacterial Detection. *Int. J. Biosens. Bioelectron.* **2017**, *2*. [CrossRef]
42. Naresh, V.; Lee, N. A Review on Biosensors and Recent Development of Nanostructured Materials-Enabled Biosensors. *Sensors* **2021**, *21*, 1109. [CrossRef] [PubMed]

43. Zhou, Y.; Feng, T.; Li, Y.; Ao, X.; Liang, S.; Yang, X.; Wang, L.; Xu, X.; Zhang, W. Recent Advances in Enhancing the Sensitivity of Biosensors Based on Field Effect Transistors. *Adv. Electron. Mater.* **2025**, *11*, 2400712. [CrossRef]
44. Goumas, G.; Vlachothanasi, E.N.; Fradelos, E.C.; Mouliou, D.S. Biosensors, Artificial Intelligence Biosensors, False Results and Novel Future Perspectives. *Diagnostics* **2025**, *15*, 1037. [CrossRef] [PubMed]
45. Ford, R.; Quinn, S.J.; O'Neill, R.D. Characterization of Biosensors Based on Recombinant Glutamate Oxidase: Comparison of Crosslinking Agents in Terms of Enzyme Loading and Efficiency Parameters. *Sensors* **2016**, *16*, 1565. [CrossRef]
46. Chiavaioli, F.; Gouveia, C.A.J.; Jorge, P.A.S.; Baldini, F. Towards a Uniform Metrological Assessment of Grating-Based Optical Fiber Sensors: From Refractometers to Biosensors. *Biosensors* **2017**, *7*, 23. [CrossRef]
47. Thévenot, D.R.; Toth, K.; Durst, R.A.; Wilson, G.S. Electrochemical Biosensors: Recommended Definitions and Classification. *Anal. Lett.* **2001**, *34*, 635–659. [CrossRef]
48. Ravina; Kumar, D.; Prasad, M.; Mohan, H. Biological Recognition Elements. In *Electrochemical Sensors*; Woodhead Publishing: Delhi, India, 2022; pp. 213–239.
49. Gao, Y.; Nguyen, D.T.; Yeo, T.; Lim, S.B.; Tan, W.X.; Madden, L.E.; Jin, L.; Long, J.Y.K.; Aloweni, F.A.B.; Liew, Y.J.A.; et al. A Flexible Multiplexed Immunosensor for Point-of-Care in Situ Wound Monitoring. *Sci. Adv.* **2021**, *7*, eabg9614. [CrossRef]
50. Du, Y.; Dong, S. Nucleic Acid Biosensors: Recent Advances and Perspectives. *Anal. Chem.* **2017**, *89*, 189–215. [CrossRef]
51. Ahmed, A.; Rushworth, J.V.; Hirst, N.A.; Millner, P.A. Biosensors for Whole-Cell Bacterial Detection. *Clin. Microbiol. Rev.* **2014**, *27*, 631–646. [CrossRef]
52. Srivastava, B.B.L. Biosensor-Signal Transducers. In *Fundamentals of Biosensors in Healthcare*; Academic Press: Cambridge, MA, USA, 2025; pp. 71–85.
53. Fraden, J. Physical Principles of Sensing. In *Handbook of Modern Sensors: Physics, Designs, and Applications*; Fraden, J., Ed.; Springer: New York, NY, USA, 2004; pp. 37–121, ISBN 978-0-387-21604-1.
54. Bengtsson, L. Sensors. In *Electrical Measurement Techniques: For the Physics Laboratory*; Bengtsson, L., Ed.; Springer Nature: Singapore, 2024; pp. 33–76, ISBN 978-981-99-8187-8.
55. Currie, E.H. Sensors and Sensing. In *Mixed-Signal Embedded Systems Design: A Hands-on Guide to the Cypress PSoC*; Currie, E.H., Ed.; Springer International Publishing: Cham, Switzerland, 2021; pp. 99–120, ISBN 978-3-030-70312-7.
56. Chircov, C.; Grumezescu, A.M. Microelectromechanical Systems (MEMS) for Biomedical Applications. *Micromachines* **2022**, *13*, 164. [CrossRef]
57. Inobeme, A.; Natarajan, A.; Pradhan, S.; Adetunji, C.O.; Ajai, A.I.; Inobeme, J.; Tsado, M.J.; Jacob, J.O.; Pandey, S.S.; Singh, K.R.; et al. Chemical Sensor Technologies for Sustainable Development: Recent Advances, Classification, and Environmental Monitoring. *Adv. Sens. Res.* **2024**, *3*, 2400066. [CrossRef]
58. Abu-Mahfouz, I. Temperature Measurements. In *Instrumentation:Theory and Practice Part II: Sensors and Transducers*; Abu-Mahfouz, I., Ed.; Springer International Publishing: Cham, Switzerland, 2022; pp. 103–128, ISBN 978-3-031-79211-3.
59. Simon, E. Biological and Medical Sensors. In *Sensors in Science and Technology: Functionality and Application Areas*; Hering, E., Schönfelder, G., Eds.; Springer Fachmedien: Wiesbaden, Germany, 2022; pp. 651–689, ISBN 978-3-658-34920-2.
60. Katey, B.; Voiculescu, I.; Penkova, A.N.; Untaroiu, A. A Review of Biosensors and Their Applications. *ASME Open J. Eng.* **2023**, *2*, 020201. [CrossRef]
61. Javaid, Z.; Iqbal, M.A.; Javeed, S.; Maidin, S.S.; Morsy, K.; Shati, A.A.; Choi, J.R. Reviewing Advances in Nanophotonic Biosensors. *Front. Chem.* **2024**, *12*, 1449161. [CrossRef]
62. Wang, J. Research of Flexible Sensor Based on Nanomaterial. *Appl. Comput. Eng.* **2024**, *60*, 148–153. [CrossRef]
63. Feng, Z.; Liu, Z.; Shao, T.; Zhang, Y. Application of Nanomaterials in Flexible Sensors. *Appl. Comput. Eng.* **2023**, *23*, 162–169. [CrossRef]
64. Chen, S. Carbon Nanomaterials in Flexible Wearable Sensors. *Appl. Comput. Eng.* **2024**, *85*, 120–126. [CrossRef]
65. Han, X.; Lin, X.; Sun, Y.; Huang, L.; Huo, F.; Xie, R. Advancements in Flexible Electronics Fabrication: Film Formation, Patterning, and Interface Optimization for Cutting-Edge Healthcare Monitoring Devices. *ACS Appl. Mater. Interfaces* **2024**, *16*, 54976–55010. [CrossRef]
66. Mahato, K.; Chandra, P. *Biosensors for Personalized Healthcare*; Springer Nature: Singapore, 2024; ISBN 978-981-97-5473-1.
67. Kim, J.; Kang, D.; Kwak, M.S.; Jung, G.; Kim, J.; Park, S.; Ko, H.; Tsukruk, V.V. Ultrathin Soft Wearable Sensor Materials and Structures: A Review of Current Trends and Prospectives. *ACS Appl. Mater. Interfaces* **2025**, *17*, 59994–60027. [CrossRef] [PubMed]
68. Ma, J.; Liu, X.; Wang, R.; Lu, C.; Wen, X.; Tu, G. Research Progress and Application of Polyimide-Based Nanocomposites. *Nanomaterials* **2023**, *13*, 656. [CrossRef] [PubMed]
69. Zhang, T.; Chai, Y.; Wang, S.; Yu, J.; Jiang, S.; Zhu, W.; Fang, Z.; Li, B. Recent Study Advances in Flexible Sensors Based on Polyimides. *Sensors* **2023**, *23*, 9743. [CrossRef] [PubMed]
70. Constantin, C.P.; Aflori, M.; Damian, R.F.; Rusu, R.D. Biocompatibility of Polyimides: A Mini-Review. *Materials* **2019**, *12*, 3166. [CrossRef]
71. Liu, Y.; Song, S.; Liu, S.; Zhu, X.; Wang, P. Application of Nanomaterial in Hydrogels Related to Wound Healing. *J. Nanomater.* **2022**, *2022*, 4656037. [CrossRef]

72. Lin, X.; Mao, Y.; Li, P.; Bai, Y.; Chen, T.; Wu, K.; Chen, D.; Yang, H.; Yang, L. Ultra-Conformable Ionic Skin with Multi-Modal Sensing, Broad-Spectrum Antimicrobial and Regenerative Capabilities for Smart and Expedited Wound Care. *Adv. Sci.* **2021**, *8*, 2004627. [CrossRef]
73. Zhu, L.; Zhang, W.; Luan, S.; Wei, J.; Yang, Y.; Miao, J. Nanomaterials for Smart Wearable Fibers and Textiles: A Critical Review. *iScience* **2025**, *28*, 113126. [CrossRef]
74. Mendes, C.; Thirupathi, A.; Corrêa, M.E.A.B.; Gu, Y.; Silveira, P.C.L.; Mendes, C.; Thirupathi, A.; Corrêa, M.E.A.B.; Gu, Y.; Silveira, P.C.L. The Use of Metallic Nanoparticles in Wound Healing: New Perspectives. *Int. J. Mol. Sci.* **2022**, *23*, 15376. [CrossRef]
75. Lu, T.; Chen, Y.; Sun, M.; Chen, Y.; Tu, W.; Zhou, Y.; Li, X.; Hu, T. Multifunctional Carbon-Based Nanocomposite Hydrogels for Wound Healing and Health Management. *Gels* **2025**, *11*, 345. [CrossRef] [PubMed]
76. Gaur, M.; Misra, C.; Yadav, A.B.; Swaroop, S.; Maolmhuaidh, F.Ó.; Bechelany, M.; Barhoum, A. Biomedical Applications of Carbon Nanomaterials: Fullerenes, Quantum Dots, Nanotubes, Nanofibers, and Graphene. *Materials* **2021**, *14*, 5978. [CrossRef]
77. Wang, M.; Deng, Z.; Guo, Y.; Xu, P. Engineering Functional Natural Polymer-Based Nanocomposite Hydrogels for Wound Healing. *Nanoscale Adv.* **2023**, *5*, 27–45. [CrossRef]
78. Singaravelu, S.; Motsoene, F.; Abrahamse, H.; Dhilip Kumar, S.S. Green-Synthesized Metal Nanoparticles: A Promising Approach for Accelerated Wound Healing. *Front. Bioeng. Biotechnol.* **2025**, *13*, 1637589. [CrossRef]
79. Sadat, Z.; Farrokhi-Hajiabad, F.; Lalebeigi, F.; Naderi, N.; Gorab, M.G.; Cohan, R.A.; Eivazzadeh-Keihan, R.; Maleki, A. A Comprehensive Review on the Applications of Carbon-Based Nanostructures in Wound Healing: From Antibacterial Aspects to Cell Growth Stimulation. *Biomater. Sci.* **2022**, *10*, 6911–6938. [CrossRef] [PubMed]
80. Chang, G.; Pan, X.; Hao, Y.; Du, W.; Wang, S.; Zhou, Y.; Yang, J.; He, Y. PVDF/ZnO Piezoelectric Nanofibers Designed for Monitoring of Internal Micro-Pressure. *RSC Adv.* **2024**, *14*, 11775–11783. [CrossRef] [PubMed]
81. Lu, P.; Liao, X.; Guo, X.; Cai, C.; Liu, Y.; Chi, M.; Du, G.; Wei, Z.; Meng, X.; Nie, S. Gel-Based Triboelectric Nanogenerators for Flexible Sensing: Principles, Properties, and Applications. *Nano-Micro Lett.* **2024**, *16*, 206. [CrossRef]
82. Alshangiti, D.M.; El-Damhougy, T.K.; Zaher, A.; Madani, M. Revolutionizing Biomedicine: Advancements, Applications, and Prospects of Nanocomposite Macromolecular Carbohydrate-Based Hydrogel Biomaterials: A Review. *RSC Adv.* **2023**, *13*, 35251–35291. [CrossRef]
83. Amornwairat, P.; Pissuwan, D. Colorimetric Sensing of Gram-Negative and Gram-Positive Bacteria Using 4-Mercaptophenylboronic Acid-Functionalized Gold Nanoparticles in the Presence of Polyethylene Glycol. *ACS Omega* **2023**, *8*, 13456–13464. [CrossRef]
84. Zhou, Y.; Yan, X. D-Shaped Fiber Surface Plasmon Resonance Refractive Index Sensor Enhanced By MXene (Ti_3C_2Tx). *IEEE Photonics J.* **2022**, *14*, 18477–18487. [CrossRef]
85. Sharifuzzaman, M.; Hasabnis, G.K.; Saleh, S.A.A.; Siebert, L.; Maschkowitz, G.; Altintas, Z. Hydrogel Microneedle Array-Based Transdermal Dressing System for Multiplexed Assessment and Combined Therapy of Chronic Wounds. *bioRxiv* **2023**. [CrossRef]
86. Houshyar, S.; Bhattacharyya, A.; Khalid, A.; Rifai, A.; Dekiwadia, C.; Kumar, G.S.; Tran, P.A.; Fox, K. Multifunctional Sutures with Temperature Sensing and Infection Control. *Macromol. Biosci.* **2021**, *21*, 2000364. [CrossRef] [PubMed]
87. Hu, Y.; Wang, F.; Ye, H.; Jiang, J.; Li, S.; Dai, B.; Li, J.; Yang, J.; Song, X.; Zhang, J.; et al. MXene-Based Flexible Electronic Materials for Wound Infection Detection and Treatment. *Npj Flex. Electron.* **2024**, *8*, 30. [CrossRef]
88. Mostufa, S.; Yari, P.; Rezaei, B.; Xu, K.; Wu, K. Flexible Magnetic Field Nanosensors for Wearable Electronics: A Review. *ACS Appl. Nano Mater.* **2023**, *6*, 13732–13765. [CrossRef]
89. Pathak, D.K.; Moon, H.C. Enzyme-Free, Metal Oxide-Based Amperometric-Colorimetric Dual-Mode Functional Glucose Sensor. *Mater. Des.* **2023**, *234*, 112309. [CrossRef]
90. Murugan, P.; Annamalai, J.; Atchudan, R.; Govindasamy, M.; Nallaswamy, D.; Ganapathy, D.; Reshetilov, A.; Sundramoorthy, A.K. Electrochemical Sensing of Glucose Using Glucose Oxidase/PEDOT:4-Sulfocalix [4]Arene/MXene Composite Modified Electrode. *Micromachines* **2022**, *13*, 304. [CrossRef] [PubMed]
91. Feng, J.; Liu, R.; Yuan, X.; Cao, C.; Xie, J.; Sun, Z.; Ma, S.; Nie, S. MXene-Enhanced ePatch with Antibacterial Activity for Wound Healing. *Front. Chem.* **2023**, *11*, 1280040. [CrossRef]
92. Lenar, N.; Paczosa-Bator, B. Nanosensors and Microsensors for Body Fluid Monitoring: Various Analyte Detection and Construction Solutions. *Int. J. Mol. Sci.* **2025**, *26*, 5001. [CrossRef]
93. Alavi, M.; Nokhodchi, A. An Overview on Antimicrobial and Wound Healing Properties of ZnO Nanobiofilms, Hydrogels, and Bionanocomposites Based on Cellulose, Chitosan, and Alginate Polymers. *Carbohydr. Polym.* **2020**, *227*, 115349. [CrossRef] [PubMed]
94. Bodla, S.; Jain, P.; Khanra, A.; Sharma, C.; Jyoti, A.; Purohit, S.D.; Singh, H.; Singh, A.; Saxena, J. Biomimetic Chitosan-Based Hydrogels for Sustainable Wound Healing with AI/ML Insights. *IEEE Open J. Eng. Med. Biol.* **2025**, *6*, 450–458. [CrossRef] [PubMed]
95. Bharathi, D.; Lee, J. Polysaccharide-Based Nanomaterials and Hydrogels for Antibiofilm and Wound Healing Applications. *Int. J. Biol. Macromol.* **2025**, *320*, 145899. [CrossRef] [PubMed]

96. Kumar, M.; Mahmood, S.; Chopra, S.; Bhatia, A. Biopolymer Based Nanoparticles and Their Therapeutic Potential in Wound Healing–A Review. *Int. J. Biol. Macromol.* **2024**, *267*, 131335. [CrossRef]
97. Kwiatkowska, A.; Drabik, M.; Lipko, A.; Grzeczkowicz, A.; Stachowiak, R.; Marszalik, A.; Granicka, L.H. Composite Membrane Dressings System with Metallic Nanoparticles as an Antibacterial Factor in Wound Healing. *Membranes* **2022**, *12*, 215. [CrossRef]
98. Singh, M.; Thakur, V.; Kumar, V.; Raj, M.; Gupta, S.; Devi, N.; Upadhyay, S.K.; Macho, M.; Banerjee, A.; Ewe, D. Silver Nanoparticles and Its Mechanistic Insight for Chronic Wound Healing: Review on Recent Progress. *Molecules* **2022**, *27*, 5587. [CrossRef]
99. Deng, Z.; Guo, Y.; Wang, X.; Song, J.; Yang, G.; Shen, L.; Wang, Y.; Zhao, X.; Guo, B.; Wang, W. Multiple Crosslinked, Self-Healing, and Shape-Adaptable Hydrogel Laden with Pain-Relieving Chitosan@ Borneol Nanoparticles for Infected Burn Wound Healing. *Theranostics* **2025**, *15*, 1439. [CrossRef]
100. Lee, Y.-H.; Hong, Y.-L.; Wu, T.-L. Novel Silver and Nanoparticle-Encapsulated Growth Factor Co-Loaded Chitosan Composite Hydrogel with Sustained Antimicrobility and Promoted Biological Properties for Diabetic Wound Healing. *Mater. Sci. Eng. C* **2021**, *118*, 111385. [CrossRef]
101. Wei, S.; Wang, Y.; Su, S.; Hao, M.; Wang, Y. Herbal-Based Hydrogel Fabricated by Self-Assembly of Mangiferin Loading with Rhein-Functionalized Silver Nanoparticles for Treating Infected Diabetic Wound. *Colloids Surf. B Biointerfaces* **2025**, *255*, 114890. [CrossRef]
102. Liu, A.; Li, J.; Qu, W.; Yang, B.; Li, X.; Li, L.; Liang, H.; Whittaker, A.K.; Wang, K.; Wang, Z. The Versatile Nanocomposite Wound Dressing with Zinc Replenishment, and Enhanced Photothermal and Fluorescent Performance for Accelerating Methicillin-Resistant Staphylococcus Aureus-Infected Diabetic Wound Repair and Indicating Dressing Replacement. *J. Colloid Interface Sci.* **2025**, *696*, 137867. [CrossRef]
103. Rahman, M.A.; Abul Barkat, H.; Harwansh, R.K.; Deshmukh, R. Carbon-Based Nanomaterials: Carbon Nanotubes, Graphene, and Fullerenes for the Control of Burn Infections and Wound Healing. *Curr. Pharm. Biotechnol.* **2022**, *23*, 1483–1496. [CrossRef]
104. Zaffar, S.; Saha, S.; Agrawal, T.; Gupta, S.K.; Gulati, P.; Paul, D.; Verma, A.; Pal, S.; Rakshit, T. Improved Diabetic Wound Healing via Flower Extracellular Vesicles and Carbon-Dot-Infused Alginate-Polyethylenimine Antibacterial Hydrogel. *ACS Biomater. Sci. Eng.* **2025**, *11*, 4219–4230. [CrossRef] [PubMed]
105. He, J.; Shi, M.; Liang, Y.; Guo, B. Conductive Adhesive Self-Healing Nanocomposite Hydrogel Wound Dressing for Photothermal Therapy of Infected Full-Thickness Skin Wounds. *Chem. Eng. J.* **2020**, *394*, 124888. [CrossRef]
106. Lai, S.; Shi, C.; Yuan, L.; Li, K.; Wang, X.; Yu, X.; Liu, P.; Wang, H.; Wang, L.; Yu, H. Five-In-One Hydrogel Integrating Bacteriostasis, Self-Healing Capability, Growth Factor Release, Electrical Stimulation, and Photothermal Stimulation Tailored for Complex Wound Repair. *ACS Biomater. Sci. Eng.* **2025**, *11*, 3709–3725. [CrossRef] [PubMed]
107. Alaa, A.L.; Yehia, S.; Sayed, H.A.; Hussein, M.A.M.; El-Sayed, E.-S.M.; El-Sherbiny, I.M. Multifunctional Bilayer Wound Dressing Based on 3D-Printed Sodium Alginate/Gelatin Hydrogel and Polycaprolactone Nanofibers for Accelerating Diabetic Wound Healing. *Int. J. Biol. Macromol.* **2025**, *318*, 144832.
108. Yun, L.; Fan, Q.; Wang, J.; Wu, A.; Liu, Z.; Sun, F.; Zhou, X.; Wang, Q.; Du, X.; Luo, N. A Thermosensitive Chitosan Hydrogel Loaded with Thonningianin A Nanoparticles Promotes Diabetic Wound Healing by Modulating Oxidative Stress and Angiogenesis. *Int. J. Biol. Macromol.* **2025**, *310*, 143136. [CrossRef]
109. Wang, Y.; Liu, K.; Wei, W.; Dai, H. A Multifunctional Hydrogel with Photothermal Antibacterial and AntiOxidant Activity for Smart Monitoring and Promotion of Diabetic Wound Healing. *Adv. Funct. Mater.* **2024**, *34*, 2402531. [CrossRef]
110. Ou, X.; Yu, Z.; Zheng, X.; Chen, L.; Pan, C.; Li, D.; Qiao, Z.; Zheng, X. An MXene Nanocomposite Hydrogel for Enhanced Diabetic Infected Wound Healing via Photothermal Antibacterial Properties and Bioactive Molecule Integration. *Mater. Today Bio* **2025**, *31*, 101538. [CrossRef] [PubMed]
111. Kurchin, R.C.; Gandhi, D.; Viswanathan, V. Nonequilibrium Electrochemical Phase Maps: Beyond Butler–Volmer Kinetics. *J. Phys. Chem. Lett.* **2023**, *14*, 7802–7807. [CrossRef]
112. Zuo, L.; Liu, Y.; Zhang, J.; Wang, L.; Zhu, J.-J. Wearable Electrochemical Biosensors for Monitoring and Management of Chronic Wounds. *Biosensors* **2025**, *15*, 785. [CrossRef]
113. Gupta, S.; Narajczyk, M.; Sawczak, M.; Bogdanowicz, R. Perspectives on Electron Transfer Kinetics across Graphene-Family Nanomaterials and Interplay of Electronic Structure with Defects and Quantum Capacitance. *Sci. Rep.* **2025**, *15*, 19722. [CrossRef] [PubMed]
114. Xie, X.; Holze, R. Electrode Kinetic Data: Geometric vs. Real Surface Area. *Batteries* **2022**, *8*, 146. [CrossRef]
115. Prabhu, P.; Lee, J.-M. Influencing Electrocatalytic Processes through Topographically Disordered Atomic Sites. *Chem Catal.* **2023**, *3*, 100621. [CrossRef]
116. Holloway, A.F.; Wildgoose, G.G.; Compton, R.G.; Shao, L.; Green, M.L.H. The Influence of Edge-Plane Defects and Oxygen-Containing Surface Groups on the Voltammetry of Acid-Treated, Annealed and "Super-Annealed" Multiwalled Carbon Nanotubes. *J. Solid State Electrochem.* **2008**, *12*, 1337–1348. [CrossRef]

117. Peng, Y.; Chen, Z.; Zhang, R.; Zhou, W.; Gao, P.; Wu, J.; Liu, H.; Liu, J.; Hu, A.; Chen, X. Oxygen-Containing Functional Groups Regulating the Carbon/Electrolyte Interfacial Properties Toward Enhanced K+ Storage. *Nano-Micro Lett.* **2021**, *13*, 192. [CrossRef]
118. Chusuei, C.C.; Nepal, R.C. Role of Defects and Exposed Graphene in Carbon Nanomaterial-Based Electrocatalysts. *New J. Chem.* **2023**, *48*, 260–267. [CrossRef]
119. Liu, L.; Raymundo-Piñero, E.; Sunny, S.; Taberna, P.-L.; Simon, P. Role of Surface Terminations for Charge Storage of Ti_3C_2Tx MXene Electrodes in Aqueous Acidic Electrolyte. *Angew. Chem. Int. Ed.* **2024**, *63*, e202319238. [CrossRef]
120. Bilibana, M.P. Electrochemical Properties of MXenes and Applications. *Adv. Sens. Energy Mater.* **2023**, *2*, 100080. [CrossRef]
121. Kaewpradub, K.; Veenuttranon, K.; Jantapaso, H.; Mittraparp-arthorn, P.; Jeerapan, I. A Fully-Printed Wearable Bandage-Based Electrochemical Sensor with pH Correction for Wound Infection Monitoring. *Nano-Micro Lett.* **2024**, *17*, 71. [CrossRef] [PubMed]
122. Cheng, T.-J.; Hsiao, H.-Y.; Tsai, P.-C.; Chen, R.L.C. Redoxless Electrochemical Capacitance Spectroscopy for Investigating Surfactant Adsorption on Screen-Printed Carbon Electrodes. *Chemosensors* **2023**, *11*, 343. [CrossRef]
123. Liljeström, T.; Kontturi, K.S.; Durairaj, V.; Wester, N.; Tammelin, T.; Laurila, T.; Koskinen, J. Protein Adsorption and Its Effects on Electroanalytical Performance of Nanocellulose/Carbon Nanotube Composite Electrodes. *Biomacromolecules* **2023**, *24*, 3806–3818. [CrossRef]
124. Dai, Y.; Guo, Y.; Tang, W.; Chen, D.; Xue, L.; Chen, Y.; Guo, Y.; Wei, S.; Wu, M.; Dai, J.; et al. Reactive Oxygen Species-Scavenging Nanomaterials for the Prevention and Treatment of Age-Related Diseases. *J. Nanobiotechnology* **2024**, *22*, 252. [CrossRef]
125. Kamal, A.; Hong, S.; Ju, H. Carbon Quantum Dots: Synthesis, Characteristics, and Quenching as Biocompatible Fluorescent Probes. *Biosensors* **2025**, *15*, 99. [CrossRef]
126. Liu, Y.; Feng, S.; Zhu, Q. The Effect of CQDs' Particle Size on Its Fluorescence Behavior and Cu^{2+} Detection. *Spectrochim. Acta. A. Mol. Biomol. Spectrosc.* **2025**, *341*, 126408. [CrossRef]
127. Chaturvedi, V.; Kumari, R.; Sharma, P.; Pati, A.K. Diverse Fluorescent Probe Concepts for Detection and Monitoring of Reactive Oxygen Species. *Chem. Asian J.* **2025**, *20*, e202401524. [CrossRef]
128. Nirmalkar, N.; Patel, D.; Shrivas, K.; Kumari, N.; Thakur, K.; Sharma, B.; Dewangan, K.; Thakur, S.S.; Patra, G.K. Understanding Carbon Quantum Dots through Computational Methods in Quantum Chemistry. *Discov. Chem.* **2025**, *2*, 306. [CrossRef]
129. Dhifaoui, H.; Colson, P.; Spronck, G.; Belkacem, W.; Bouazizi, A.; He, G.; Lang, F.; Cloots, R.; Dewalque, J. Reducing Non-Radiative Recombination Through Interfacial N-Bromosuccinimide Engineering for Multi-Cation Perovskite Solar Cells. *Coatings* **2025**, *15*, 1195. [CrossRef]
130. Alzoubi, F.Y.; Ahmad, A.A.; Aljarrah, I.A.; Migdadi, A.B.; Al-Bataineh, Q.M. Localize Surface Plasmon Resonance of Silver Nanoparticles Using Mie Theory. *J. Mater. Sci. Mater. Electron.* **2023**, *34*, 2128. [CrossRef]
131. Ou, W.; Zhou, B.; Shen, J.; Zhao, C.; Li, Y.Y.; Lu, J. Plasmonic Metal Nanostructures: Concepts, Challenges and Opportunities in Photo-Mediated Chemical Transformations. *iScience* **2021**, *24*, 101982. [CrossRef]
132. Mcoyi, M.P.; Mpofu, K.T.; Sekhwama, M.; Mthunzi-Kufa, P. Developments in Localized Surface Plasmon Resonance. *Plasmonics* **2025**, *20*, 5481–5520. [CrossRef]
133. Vörös, J. The Density and Refractive Index of Adsorbing Protein Layers. *Biophys. J.* **2004**, *87*, 553–561. [CrossRef]
134. Salleh, N.A.b.M.; Tanaka, Y.; Sutarlie, L.; Su, X. Detecting Bacterial Infections in Wounds: A Review of Biosensors and Wearable Sensors in Comparison with Conventional Laboratory Methods. *Analyst* **2022**, *147*, 1756–1776. [CrossRef] [PubMed]
135. Campuzano, S.; Pedrero, M.; Yáñez-Sedeño, P.; Pingarrón, J.M. Antifouling (Bio)Materials for Electrochemical (Bio)Sensing. *Int. J. Mol. Sci.* **2019**, *20*, 423. [CrossRef]
136. Zhao, C.; Deng, H.; Chen, X. Harnessing Immune Response Using Reactive Oxygen Species-Generating/Eliminating Inorganic Biomaterials for Disease Treatment. *Adv. Drug Deliv. Rev.* **2022**, *188*, 114456. [CrossRef]
137. Pirmohamed, T.; Dowding, J.M.; Singh, S.; Wasserman, B.; Heckert, E.; Karakoti, A.S.; King, J.E.S.; Seal, S.; Self, W.T. Nanoceria Exhibit Redox State-Dependent Catalase Mimetic Activity. *Chem. Commun.* **2010**, *46*, 2736–2738. [CrossRef]
138. Mahapatra, C. Redox Nanotherapeutics: Fundamentals and Applications. In *Nanomedicine in Translational Research*; Academic Press: Cambridge, MA, USA, 2025; pp. 229–268.
139. Bolaños-Cardet, J.; Pepió-Tárrega, B.; Saiz-Poseu, J.; López-Moral, A.; Ullah, F.; Yuste, V.J.; Ruiz-Molina, D.; Suárez-García, S. The Redox Properties of Polyphenols and Their Role in ROS Generation for Biomedical Applications. *Angew. Chem.* **2026**, *65*, e13698. [CrossRef] [PubMed]
140. Sharma, H.; Kalita, D.; Panda, R.; Kumar, P.; Mirza, K.B. Effect of Biofouling on Electrochemical Impedance Parameters and Sensitivity of Polyvinyl Alcohol-Coated Iridium Oxide-Based pH Biosensors. *IEEE Trans. Instrum. Meas.* **2025**, *74*, 1–11. [CrossRef]
141. Meng, H.; Zhong, W.; Ma, K.; Su, J.; Ma, L.; Hao, Y.; Jiang, Y.; Liu, X.; Fu, X.; Zhang, C. Flexible Wearable Sensors: An Emerging Platform for Monitoring of Bacterial Infection in Skin Wounds. *Eng. Regen.* **2024**, *5*, 186–198. [CrossRef]
142. Prakashan, D.; Kaushik, A.; Gandhi, S. Smart Sensors and Wound Dressings: Artificial Intelligence-Supported Chronic Skin Monitoring–A Review. *Chem. Eng. J.* **2024**, *497*, 154371. [CrossRef]
143. Szunerits, S.; Boukherroub, R.; Kleber, C.; Knoll, W.; Yunda, J.; Rumipamba, J.; Torres, G.; Melinte, S. Biosensors Integrated within Wearable Devices for Monitoring Chronic Wound Status. *APL Bioeng.* **2025**, *9*, 010901. [CrossRef] [PubMed]

144. Cheng, S.; Gu, Z.; Zhou, L.; Hao, M.; An, H.; Song, K.; Wu, X.; Zhang, K.; Zhao, Z.; Dong, Y. Recent Progress in Intelligent Wearable Sensors for Health Monitoring and Wound Healing Based on Biofluids. *Front. Bioeng. Biotechnol.* **2021**, *9*, 765987. [CrossRef] [PubMed]
145. Pang, Q.; Lou, D.; Li, S.; Wang, G.; Qiao, B.; Dong, S.; Ma, L.; Gao, C.; Wu, Z. Smart Flexible Electronics-Integrated Wound Dressing for Real-Time Monitoring and On-Demand Treatment of Infected Wounds. *Adv. Sci.* **2020**, *7*, 1902673. [CrossRef]
146. Zheng, X.T.; Yang, Z.; Sutarlie, L.; Thangaveloo, M.; Yu, Y.; Salleh, N.A.B.M.; Chin, J.S.; Xiong, Z.; Becker, D.L.; Loh, X.J.; et al. Battery-Free and AI-Enabled Multiplexed Sensor Patches for Wound Monitoring. *Sci. Adv.* **2023**, *9*, eadg6670. [CrossRef] [PubMed]
147. Wu, P.; Jin, L.; Jiang, W.; Zhou, Y.; Lin, L.; Lin, H.; Chen, H. Smart Bandages for Wound Monitoring and Treatment. *Biosens. Bioelectron.* **2025**, *283*, 117522. [CrossRef]
148. Lou, D.; Pang, Q.; Pei, X.; Dong, S.; Li, S.; Tan, W.; Ma, L. Flexible Wound Healing System for Pro-Regeneration, Temperature Monitoring and Infection Early Warning. *Biosens. Bioelectron.* **2020**, *162*, 112275. [CrossRef]
149. Xu, J.; Huang, H.; Sun, C.; Yu, J.; Wang, M.; Dong, T.; Wang, S.; Chen, X.; Cui, T.; Li, J. Flexible Accelerated-Wound-Healing Antibacterial Hydrogel-Nanofiber Scaffold for Intelligent Wearable Health Monitoring. *ACS Appl. Mater. Interfaces* **2024**, *16*, 5438–5450. [CrossRef]
150. Sun, X.; Zhang, Y.; Ma, C.; Yuan, Q.; Wang, X.; Wan, H.; Wang, P. A Review of Recent Advances in Flexible Wearable Sensors for Wound Detection Based on Optical and Electrical Sensing. *Biosensors* **2021**, *12*, 10. [CrossRef]
151. Lee, T.; Kim, C.; Kim, J.; Seong, J.B.; Lee, Y.; Roh, S.; Cheong, D.Y.; Lee, W.; Park, J.; Hong, Y.; et al. Colorimetric Nanoparticle-Embedded Hydrogels for a Biosensing Platform. *Nanomaterials* **2022**, *12*, 1150. [CrossRef]
152. Zubova, G.; Melnyk, H.; Zaets, I.; Sergeyeva, T.; Havryliuk, O.; Rogalsky, S.; Khirunenko, L.; Zaika, L.; Ruban, T.; Antonenko, S.; et al. Halochromic Bacterial Cellulose/Anthocyanins Hybrid Polymer Film with Wound-Healing Potential. *Polymers* **2024**, *16*, 2327. [CrossRef]
153. Hou, X.; Zhao, H.; Zhang, K.-Q.; Meng, K. Preparation of Wide-Domain pH Color-Changing Nanocapsules and Application in Hydrogel Fibers. *Materials* **2022**, *15*, 8787. [CrossRef]
154. Yang, X.; Chai, L.; Huang, Z.; Zhu, B.; Liu, H.; Shi, Z.; Wu, Y.; Guo, L.; Xue, L.; Lei, Y. Smart Photonic Crystal Hydrogels for Visual Glucose Monitoring in Diabetic Wound Healing. *J. Nanobiotechnology* **2024**, *22*, 618. [CrossRef] [PubMed]
155. Yang, P.; Zhu, Z.; Zhang, T.; Zhang, W.; Chen, W.; Cao, Y.; Chen, M.; Zhou, X. Orange-Emissive Carbon Quantum Dots: Toward Application in Wound pH Monitoring Based on Colorimetric and Fluorescent Changing. *Small* **2019**, *15*, 1902823. [CrossRef]
156. Kromer, C.; Schwibbert, K.; Gadicherla, A.K.; Thiele, D.; Nirmalananthan-Budau, N.; Laux, P.; Resch-Genger, U.; Luch, A.; Tschiche, H.R. Monitoring and Imaging pH in Biofilms Utilizing a Fluorescent Polymeric Nanosensor. *Sci. Rep.* **2022**, *12*, 9823. [CrossRef] [PubMed]
157. Terrones, Y.T.; Leskow, F.C.; Bordoni, A.V.; Acebedo, S.L.; Spagnuolo, C.C.; Wolosiuk, A. A Silica Supported Tricarbocyanine Based pH Nanosensor with a Large Stokes Shift and a near Infrared Fluorescence Response: Performance in Vitro and in Live Cells. *J. Mater. Chem. B* **2017**, *5*, 4031–4034. [CrossRef] [PubMed]
158. He, X.; Wei, Y.; Xu, K. Hydrogel-Based Treatment of Diabetic Wounds: From Smart Responsive to Smart Monitoring. *Gels* **2025**, *11*, 647. [CrossRef]
159. Li, B.; Li, M.; Wang, Y. Smart Hydrogels in Wearable Electronics for Wound Treatments. *Small* **2025**, *21*, e07368. [CrossRef]
160. Liu, J.; Chen, Z.; Liu, H.; Qin, S.; Li, M.; Shi, L.; Zhou, C.; Liao, T.; Li, C.; Lv, Q.; et al. Nickel-Based Metal-Organic Frameworks Promote Diabetic Wound Healing via Scavenging Reactive Oxygen Species and Enhancing Angiogenesis. *Small* **2024**, *20*, 2305076. [CrossRef]
161. Ghazaryan, G.; Zanginyan, H.; Hovsepyan, L.; Azatyan, A.; Ghazaryan, M.; Mardanyan, L. Cronassial Ameliorates Autoimmune Encephalomyelitis by Inhibiting Lipid Oxidation and Carbonyl Stress in the Brain and Spinal Cord of Rats. *Biochem. Res. Int.* **2023**, *2023*, 5552740. [CrossRef]
162. Zhang, L.; Wang, X.; Lu, X.; Ma, Y.; Xin, X.; Xu, X.; Wang, S.; Hou, Y. Tetramethylpyrazine Enhanced the Therapeutic Effects of Human Umbilical Cord Mesenchymal Stem Cells in Experimental Autoimmune Encephalomyelitis Mice through Nrf2/HO-1 Signaling Pathway. *Stem Cell Res. Ther.* **2020**, *11*, 186. [CrossRef]
163. Guo, X.; Li, H.; Chen, Y.; Li, Z.; Zhang, M.; Zheng, J.; Li, J.; Jiang, X.; Tang, J. Light-Activatable Nanotherapeutic Platform Synchronizing ROS-Mediated Antibacterial Action with Macrophage Polarization for Refractory Wound Infections. *Small* **2025**, *21*, e07586. [CrossRef]
164. Zhou, X.; Zhou, Q.; He, Z.; Xiao, Y.; Liu, Y.; Huang, Z.; Sun, Y.; Wang, J.; Zhao, Z.; Liu, X.; et al. ROS Balance Autoregulating Core–Shell CeO2@ZIF-8/Au Nanoplatform for Wound Repair. *Nano-Micro Lett.* **2024**, *16*, 156. [CrossRef]
165. Padaga, S.G.; Paul, M.; Banerjee, T.; Goswami, S.; Ghosh, B.; Biswas, S. Hybrid Metallic Nanozyme with Nitric Oxide-Releasing Photothermal Coating for Accelerated Infected Diabetic Wound Healing. *J. Nanobiotechnology* **2025**, *23*, 630. [CrossRef]
166. Dong, D.-L.; Jin, G.-Z. Exploring the Antioxidant Mechanisms of Nanoceria in Protecting HT22 Cells from Oxidative Stress. *Int. J. Mol. Sci.* **2024**, *25*, 13281. [CrossRef]

167. Guo, J.; Wei, W.; Zhao, Y.; Dai, H. Iron Oxide Nanoparticles with Photothermal Performance and Enhanced Nanozyme Activity for Bacteria-Infected Wound Therapy. *Regen. Biomater.* **2022**, *9*, rbac041. [CrossRef] [PubMed]
168. Yang, W.; Yuan, H.; Sun, H.; Hu, J.; Xu, Y.; Li, Y.; Qiu, Y. Microenvironment Self-Adaptive Ce-Ag-Doped Mesoporous Silica Nanomaterials (CA@MSNs) for Multidrug-Resistant Bacteria-Infected Diabetic Wound Treatment. *Molecules* **2025**, *30*, 1848. [CrossRef]
169. Liu, Y.; Tang, L.; Ma, Q.; Shen, Y.; Zhao, H.; Liu, X.; Lin, D.; Zhou, G. Skin-Adaptable, Highly Stretchable, and Self-Debonding Hydrogel Dressings for Accelerating Infected Wound Healing without Secondary Damage. *J. Colloid Interface Sci.* **2025**, *691*, 137473. [CrossRef] [PubMed]
170. Hu, J.-J.; Yu, X.-Z.; Zhang, S.-Q.; Zhang, Y.-X.; Chen, X.-L.; Long, Z.-J.; Hu, H.-Z.; Xie, D.-H.; Zhang, W.-H.; Chen, J.-X.; et al. Hydrogel with ROS Scavenging Effect Encapsulates BR@Zn-BTB Nanoparticles for Accelerating Diabetic Mice Wound Healing via Multimodal Therapy. *iScience* **2023**, *26*, 106775. [CrossRef]
171. Miao, L.; Xu, Z.; Sui, J.; Meng, X.; Huo, S.; Liu, S.; Chen, M.; Zheng, Z.; Cai, X.; Zhang, H. A New Nanoplatform Under NIR Released ROS Enhanced Photodynamic Therapy and Low Temperature Photothermal Therapy for Antibacterial and Wound Repair. *Int. J. Nanomedicine* **2024**, *19*, 7509–7527. [CrossRef] [PubMed]
172. Cui, F.; Fu, W.; Chang, Q.; Wang, J.; Xie, Y.; Deng, X. ROS-Modulating Bio-Heterojunction Nanosheets for Infected Wound Healing via Nanozyme Activity. *Small* **2025**, *21*, 2412441. [CrossRef]
173. Sun, Z.; Chen, X.; Miao, F.; Meng, N.; Hu, K.; Xiong, S.; Peng, X.; Ma, L.; Zhou, C.; Yang, Y. Engineering Ag-Decorated Graphene Oxide Nano-Photothermal Platforms with Enhanced Antibacterial Properties for Promoting Infectious Wound Healing. *Int. J. Nanomedicine* **2024**, *19*, 8901–8927. [CrossRef]
174. Huang, Y.; Ni, Z.; Yu, H.; Wang, L.; Zhang, Z.; Wang, H.; Shen, D. Preparation of ROS-Responsive Drug-Loaded Particles and Microneedles for Diabetic Wounds Healing. *J. Appl. Polym. Sci.* **2025**, *142*, e57181. [CrossRef]
175. Luan, Q.; Qiao, R.; Wu, X.; Shan, J.; Song, C.; Zhao, X.; Zhao, Y. Plant-Derived Chinese Herbal Hydrogel Microneedle Patches for Wound Healing. *Small* **2024**, *20*, e2404850. [CrossRef]
176. Liang, X.; Xian, C.; Du, J.; Huang, X.; Yang, Y.; Bi, G.; Li, X.; Gao, M.; Wu, M.; Wu, J.; et al. Sprayable Self-Assembled Curcumin-Metal-Polyphenol Nanomedicine with Anti-Inflammatory, ROS-Scavenging and pro-Angiogenesis Effects for Promoting Diabetic Wound Healing. *Nano Res.* **2025**, *18*, 94908001. [CrossRef]
177. Hajialyani, M.; Tewari, D.; Sobarzo-Sánchez, E.; Nabavi, S.M.; Farzaei, M.H.; Abdollahi, M. Natural Product-Based Nanomedicines for Wound Healing Purposes: Therapeutic Targets and Drug Delivery Systems. *Int. J. Nanomedicine* **2018**, *13*, 5023–5043. [CrossRef]
178. Lv, H.; Zhao, M.; Li, Y.; Li, K.; Chen, S.; Zhao, W.; Wu, S.; Han, Y. Electrospun Chitosan–Polyvinyl Alcohol Nanofiber Dressings Loaded with Bioactive Ursolic Acid Promoting Diabetic Wound Healing. *Nanomaterials* **2022**, *12*, 2933. [CrossRef] [PubMed]
179. Tiwari, R.; Pathak, K. Local Drug Delivery Strategies towards Wound Healing. *Pharmaceutics* **2023**, *15*, 634. [CrossRef]
180. Xu, S.; Chang, L.; Hu, Y.; Zhao, X.; Huang, S.; Chen, Z.; Ren, X.; Mei, X. Tea Polyphenol Modified, Photothermal Responsive and ROS Generative Black Phosphorus Quantum Dots as Nanoplatforms for Promoting MRSA Infected Wounds Healing in Diabetic Rats. *J. Nanobiotechnology* **2021**, *19*, 362. [CrossRef] [PubMed]
181. Pang, Q.; Jiang, Z.; Wu, K.; Hou, R.; Zhu, Y. Nanomaterials-Based Wound Dressing for Advanced Management of Infected Wound. *Antibiotics* **2023**, *12*, 351. [CrossRef]
182. Mei, L.; Zhang, Y.; Wang, K.; Chen, S.; Song, T. Nanomaterials at the Forefront of Antimicrobial Therapy by Photodynamic and Photothermal Strategies. *Mater. Today Bio* **2024**, *29*, 101354. [CrossRef]
183. Qin, Y.; Xu, Y.; Lin, F.; Qiu, Y.; Luo, Y.; Lv, X.; Liu, T.; Li, Y.; Liu, Z.; Yang, S. Reactive Oxygen Species-Responsive Nano Gel as a Carrier, Combined with Photothermal Therapy and Photodynamic Therapy for the Treatment of Brucellosis. *J. Biomater. Appl.* **2025**, *39*, 748–761. [CrossRef] [PubMed]
184. Joorabloo, A.; Liu, T. Recent Advances in Reactive Oxygen Species Scavenging Nanomaterials for Wound Healing. *Exploration* **2024**, *4*, 20230066. [CrossRef]
185. Deng, L.; Cheng, Y.; Liu, J.; Yuan, Y.; Zhou, C.; Yao, C.; Sun, J.; Zhou, Z.; Chen, Z.; Wang, Z.; et al. Intelligent ROS Therapy Driven by Iron-Based Nanozyme with Controllable Catalytic Activity for Infected Wound Healing. *J. Nanobiotechnology* **2025**, *23*, 456. [CrossRef] [PubMed]
186. Wang, S.; Zhang, Y.; Zhong, Y.; Xue, Y.; Liu, Z.; Wang, C.; Kang, D.D.; Li, H.; Hou, X.; Tian, M.; et al. Accelerating Diabetic Wound Healing by ROS-Scavenging Lipid Nanoparticle–mRNA Formulation. *Proc. Natl. Acad. Sci. USA* **2024**, *121*, e2322935121. [CrossRef]
187. Duan, Y.; Li, L.; Hu, J.; Zheng, B.; He, K. Engineering Gas-Releasing Nanomaterials for Efficient Wound Healing. *ChemBioChem* **2025**, *26*, e202400790. [CrossRef]
188. Saeidi-Javash, M.; Du, Y.; Zeng, M.; Wyatt, B.C.; Zhang, B.; Kempf, N.; Anasori, B.; Zhang, Y. All-Printed MXene–Graphene Nanosheet-Based Bimodal Sensors for Simultaneous Strain and Temperature Sensing. *ACS Appl. Electron. Mater.* **2021**, *3*, 2341–2348. [CrossRef]

189. Li, R.; Chang, S.; Bi, J.; Guo, H.; Yi, J.; Chu, C. Flexible, Stretchable, and Self-Healing MXene-Based Conductive Hydrogels for Human Health Monitoring. *Polymers* **2025**, *17*, 2683. [CrossRef] [PubMed]
190. Chen, K.; Lai, W.; Xiao, W.; Li, L.; Huang, S.; Xiao, X. Low-Temperature Adaptive Dual-Network MXene Nanocomposite Hydrogel as Flexible Wearable Strain Sensors. *Micromachines* **2023**, *14*, 1563. [CrossRef]
191. Zhu, H.; Dai, W.; Wang, L.; Yao, C.; Wang, C.; Gu, B.; Li, D.; He, J. Electroactive Oxidized Alginate/Gelatin/MXene ($Ti_3C_2T_x$) Composite Hydrogel with Improved Biocompatibility and Self-Healing Property. *Polymers* **2022**, *14*, 3908. [CrossRef]
192. Guo, Q.; Zhang, M.; Zheng, J.; Li, Z.; Zhang, Y.; Chen, Y.; Chen, Y.; Jiang, X.; Tang, J. A Multifunctional MXene@CeO2-Enhanced Hydrogel Dressing for Synergistic Photothermal Antibacterial and Antioxidative Therapy in Wound Healing. *Adv. Healthc. Mater.* **2025**, *14*, 2500656. [CrossRef] [PubMed]
193. Ding, Y.; Wang, X.; Liu, J.; Shen, H.; Wang, Z.; Xie, M.; Chen, Y.; Barcenas, A.R.; Zhao, Z.; Li, G. A Reduced Graphene Oxide-Coated Conductive Surgical Silk Suture Targeting Microresistance Sensing Changes for Wound Healing. *Sci. China Technol. Sci.* **2024**, *67*, 3499–3512. [CrossRef]
194. Dou, Y.; Zhang, Y.; Zhang, S.; Ma, S.; Zhang, H. Multi-Functional Conductive Hydrogels Based on Heparin–Polydopamine Complex Reduced Graphene Oxide for Epidermal Sensing and Chronic Wound Healing. *J. Nanobiotechnology* **2023**, *21*, 343. [CrossRef]
195. Yang, L.; Chen, X.; Dutta, A.; Zhang, H.; Wang, Z.; Xin, M.; Du, S.; Xu, G.; Cheng, H. Thermoelectric Porous Laser-Induced Graphene-Based Strain-Temperature Decoupling and Self-Powered Sensing. *Nat. Commun.* **2025**, *16*, 792. [CrossRef]
196. Yu, Z.; Wan, Y.; Zhou, M.; Mia, M.H.; Huo, S.; Huang, L.; Xu, J.; Jiang, Q.; Zheng, Z.; Hu, X.; et al. Muscle-Inspired Anisotropic Aramid Nanofibers Aerogel Exhibiting High-Efficiency Thermoelectric Conversion and Precise Temperature Monitoring for Firefighting Clothing. *Nano-Micro Lett.* **2025**, *17*, 214. [CrossRef]
197. Khoso, N.A.; Jiao, X.; GuangYu, X.; Tian, S.; Wang, J. Enhanced Thermoelectric Performance of Graphene Based Nanocomposite Coated Self-Powered Wearable e-Textiles for Energy Harvesting from Human Body Heat. *RSC Adv.* **2021**, *11*, 16675–16687. [CrossRef]
198. Li, J.; Xu, T.; Ma, Z.; Li, W.; Qian, Y.; Tao, Y.; Wei, Y.; Jiang, Q.; Luo, Y.; Yang, J. Self-Healable and Stretchable PAAc/XG/$Bi_2Se_{0.3}Te_{2.7}$ Hybrid Hydrogel Thermoelectric Materials. *ENERGY Environ. Mater.* **2024**, *7*, e12547. [CrossRef]
199. Zhang, C.; Shi, X.-L.; Liu, Q.; Chen, Z.-G. Hydrogel-Based Functional Materials for Thermoelectric Applications: Progress and Perspectives. *Adv. Funct. Mater.* **2024**, *34*, 2410127. [CrossRef]
200. Geng, Y.; Chen, G.; Cao, R.; Dai, H.; Hu, Z.; Yu, S.; Wang, L.; Zhu, L.; Xiang, H.; Zhu, M. A Skin-Inspired Self-Adaptive System for Temperature Control During Dynamic Wound Healing. *Nano-Micro Lett.* **2024**, *16*, 152. [CrossRef] [PubMed]
201. Zhang, L.; Shi, X.-L.; Shang, H.; Gu, H.; Chen, W.; Li, M.; Huang, D.; Dong, H.; Wang, X.; Ding, F.; et al. High-Performance Ag2Se-Based Thermoelectrics for Wearable Electronics. *Nat. Commun.* **2025**, *16*, 5002. [CrossRef]
202. Miskovic, V.; Malafronte, E.; Minetti, C.; Machrafi, H.; Varon, C.; Iorio, C.S. Thermotropic Liquid Crystals for Temperature Mapping. *Front. Bioeng. Biotechnol.* **2022**, *10*, 806362. [CrossRef] [PubMed]
203. Li, C.; Zhou, S.; Chen, J.; Jiang, X. Fluorescence Imaging of Inflammation with Optical Probes. *Chem. Biomed. Imaging* **2023**, *1*, 495–508. [CrossRef]
204. Petrushenko, S.I.; Fijalkowski, M.; Adach, K.; Lebedev, V.; Lebedeva, K.; Cherkashina, A.; Rudnieva, K.I.; Klochko, N.P. Autofluorescent Activity of Thermosensitive, Hemostatic, and Wound Healing Biopolymer Hydrogels. *Gels* **2025**, *11*, 301. [CrossRef]
205. Wang, H.; Yang, M.; Li, K.; Li, N.; Song, L.; Wang, M.; Wei, M.; Yang, X.; Liu, Y. Fluorescent Carbon Dot-Functionalized Injectable Self-Healing Hydrogels With Antibacterial Activity for Skin Wound Repair. *J. Polym. Sci.* **2025**, *63*, 3900–3912. [CrossRef]
206. Ma, L.; Zhou, Y.; Zhang, Z.; Liu, Y.; Zhai, D.; Zhuang, H.; Li, Q.; Yuye, J.; Wu, C.; Chang, J. Multifunctional Bioactive Nd-Ca-Si Glasses for Fluorescence Thermometry, Photothermal Therapy, and Burn Tissue Repair. *Sci. Adv.* **2020**, *6*, eabb1311. [CrossRef]
207. He, C.; Korposh, S.; Correia, R.; Liu, L.; Hayes-Gill, B.R.; Morgan, S.P. Optical Fibre Sensor for Simultaneous Temperature and Relative Humidity Measurement: Towards Absolute Humidity Evaluation. *Sens. Actuators B Chem.* **2021**, *344*, 130154. [CrossRef]
208. Chen, H.; Liu, Y.; Gao, Z.; Gao, Y.; Chen, T.; Ye, H.; Wu, D. Dynamic and Thermostable Supramolecular Hydrogels via Peptide Nanoparticle Crosslinking for Enhanced Wound Healing. *Adv. Funct. Mater.* **2025**, *36*, e21667. [CrossRef]
209. Geraskevich, A.V.; Solomonenko, A.N.; Dorozhko, E.V.; Korotkova, E.I.; Barek, J. Electrochemical Sensors for the Detection of Reactive Oxygen Species in Biological Systems: A Critical Review. *Crit. Rev. Anal. Chem.* **2024**, *54*, 742–774. [CrossRef]
210. Feng, K.; Wang, G.; Wang, S.; Ma, J.; Wu, H.; Ma, M.; Zhang, Y. Breaking the pH Limitation of Nanozymes: Mechanisms, Methods, and Applications. *Adv. Mater.* **2024**, *36*, 2401619. [CrossRef] [PubMed]
211. Landén, N.X.; Li, D.; Ståhle, M. Transition from Inflammation to Proliferation: A Critical Step during Wound Healing. *Cell. Mol. Life Sci. CMLS* **2016**, *73*, 3861–3885. [CrossRef]
212. Ghoneim, M.T.; Nguyen, A.; Dereje, N.; Huang, J.; Moore, G.C.; Murzynowski, P.J.; Dagdeviren, C. Recent Progress in Electrochemical pH-Sensing Materials and Configurations for Biomedical Applications. *Chem. Rev.* **2019**, *119*, 5248–5297. [CrossRef]

213. Buehler, H.W.; Bucher, R. Applications of Electrochemical Sensors. In *Sensors in Bioprocess Control*; CRC Press: Boca Raton, FL, USA, 1990.
214. Fan, B.; Wang, S.; Huang, S.; Ma, S.; Zuo, H.; Li, S.; Chen, Z. Real-Time Monitoring of Wound Infection Based on Multi-Channel Biomedical Sensors. *J. Anal. Test.* **2025**. [CrossRef]
215. Buck, R.P.; Rondinini, S.; Covington, A.K.; Baucke, F.G.K.; Brett, C.M.A.; Camoes, M.F.; Milton, M.J.T.; Mussini, T.; Naumann, R.; Pratt, K.W.; et al. Measurement of pH. Definition, Standards, and Procedures (IUPAC Recommendations 2002). *Pure Appl. Chem.* **2002**, *74*, 2169–2200. [CrossRef]
216. Ameer, Q.; Adeloju, S.B. Development of a Potentiometric Catechol Biosensor by Entrapment of Tyrosinase within Polypyrrole Film. *Sens. Actuators B Chem.* **2009**, *140*, 5–11. [CrossRef]
217. Mariello, M. Microfabricated Neural Biosensors for Detection of Neurotransmitters, Biomarkers, and Small Molecules: Emerging Trends on Self-Sustained Systems and Energy Harvesting. *Adv. Sens. Res.* **2026**, *5*, e00111. [CrossRef]
218. Wu, S.-H.; Huang, X.-B.; Tang, Y.; Ma, L.-M.; Liu, Y.; Sun, J.-J. Temperature Controllable Electrochemical Sensors Based on Horseradish Peroxidase as Electrocatalyst at Heated Au Disk Electrode and Its Preliminary Application for H2O2 Detection. *Anal. Chim. Acta* **2020**, *1096*, 44–52. [CrossRef] [PubMed]
219. Zeng, G.-C.; Wang, Y.-L. Development and Validation of a Thermally Stable Aptamer-Based BioFET Sensor for Sensitive Mercury Ion Detection. In *Proceedings of the 2025 23rd International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers), Orlando, FL, USA, 29 June–3 July 2025*; IEEE: New York, NY, USA, 2025; pp. 2036–2039.
220. Dewhirst, M.W.; Jones, E.; Samulski, T.; Vujaskovic, Z.; Li, C.; Prosnitz, L. The Biology of Hyperthermia. In *Holland-Frei Cancer Medicine*, 6th ed.; BC Decker: Hamilton, ON, USA, 2003.
221. Pellitero, M.A.; Sfragano, P.S.; de-los-Santos-Álvarez, N.; Lobo-Castañón, M.J. Revealing the Impact of Temperature on Electrochemical, DNA-Based Sensors to Correct Signaling Fluctuations. *Sens. Actuators B Chem.* **2025**, *443*, 138279. [CrossRef]
222. Deshpande, A.S.; Muraoka, W.; Andreescu, S. Electrochemical Sensors for Oxidative Stress Monitoring. *Curr. Opin. Electrochem.* **2021**, *29*, 100809. [CrossRef]
223. Jamieson, L.E.; Jaworska, A.; Jiang, J.; Baranska, M.; Harrison, D.J.; Campbell, C.J. Simultaneous Intracellular Redox Potential and pH Measurements in Live Cells Using SERS Nanosensors. *Analyst* **2015**, *140*, 2330–2335. [CrossRef]
224. Wesley, T.S.; Hülsey, M.J.; Westendorff, K.S.; Lewis, N.B.; Crumlin, E.J.; Román-Leshkov, Y.; Surendranath, Y. Metal Nanoparticles Supported on a Nonconductive Oxide Undergo pH-Dependent Spontaneous Polarization. *Chem. Sci.* **2023**, *14*, 7154–7160. [CrossRef]
225. Mervis, J.S. The Impact of Chronic Wound Exudate on the Patient, Clinician and Payer: Addressing the Challenges With Foam Dressings. *Int. Wound J.* **2025**, *22*, e70369. [CrossRef]
226. Saberianpour, S.; Melotto, G.; Redhead, L.; Terrazzini, N.; Forss, J.R.; Santin, M. Harnessing the Interactions of Wound Exudate Cells with Dressings Biomaterials for the Control and Prognosis of Healing Pathways. *Pharmaceuticals* **2024**, *17*, 1111. [CrossRef]
227. Seaton, B.T.; Hill, D.F.; Cowen, S.L.; Heien, M.L. Mitigating the Effects of Electrode Biofouling-Induced Impedance for Improved Long-Term Electrochemical Measurements In Vivo. *Anal. Chem.* **2020**, *92*, 6334–6340. [CrossRef]
228. Liu, Y.; Ge, L. Smart Biomaterials in Wound Healing: Advances, Challenges, and Future Directions in Intelligent Dressing Design. *Bioengineering* **2025**, *12*, 1178. [CrossRef]
229. Lv, M.; Wang, L.; Hou, Y.; Qiao, X.; Luo, X. A Wearable Antifouling Electrochemical Sensor Integrated with an Antimicrobial Microneedle Array for Uric Acid Detection in Interstitial Fluid. *Anal. Chim. Acta* **2025**, *1339*, 343610. [CrossRef]
230. Ma, Y.; Zhang, Y.; Li, X.; Yang, P.; Yue, J.-Y.; Jiang, Y.; Tang, B. Linker-Eliminated Nano Metal–Organic Framework Fluorescent Probe for Highly Selective and Sensitive Phosphate Ratiometric Detection in Water and Body Fluids. *Anal. Chem.* **2020**, *92*, 3722–3727. [CrossRef] [PubMed]
231. Ding, M.; Zhang, S.; Wang, J.; Ding, Y.; Ding, C. Ultrasensitive Ratiometric Electrochemiluminescence Sensor with an Efficient Antifouling and Antibacterial Interface of PSBMA@SiO2-MXene for Oxytetracycline Trace Detection in the Marine Environment. *Anal. Chem.* **2023**, *95*, 16327–16334. [CrossRef]
232. Salvo, P.; Calisi, N.; Melai, B.; Dini, V.; Paoletti, C.; Lomonaco, T.; Pucci, A.; Di Francesco, F.; Piaggesi, A.; Romanelli, M. Temperature- and pH-Sensitive Wearable Materials for Monitoring Foot Ulcers. *Int. J. Nanomedicine* **2017**, *12*, 949–954. [CrossRef] [PubMed]
233. Yang, T.; Sun, X.; Yang, H.; Liu, Y.; Zhao, H.; Dong, Z.; Mu, S. Integrated Thermal Error Modeling and Compensation of Machine Tool Feed System Using Subtraction-Average-Based Optimizer-Based CNN-GRU Neural Network. *Int. J. Adv. Manuf. Technol.* **2024**, *131*, 6075–6089. [CrossRef]
234. Joorabloo, A.; Liu, T. Smart Theranostics for Wound Monitoring and Therapy. *Adv. Colloid Interface Sci.* **2024**, *330*. [CrossRef] [PubMed]
235. Elango, P.F.M.; Perera, G.; Yang, M.; Low, M.X.; Cheong, Y.Z.; Manjunath, B.B.; Rahman, M.A.; Ramanathan, R.; Sriram, S.; Dhanabalan, S.S.; et al. Multiplexed Cutaneous Wound Monitor for Point-of-Care Applications. *Adv. NanoBiomed Res.* **2025**, *5*, 2500142. [CrossRef]

236. Ramirez-GarciaLuna, J.L.; Martinez-Jimenez, M.A.; Fraser, R.D.J.; Bartlett, R.; Lorincz, A.; Liu, Z.; Saiko, G.; Berry, G.K. Is My Wound Infected? A Study on the Use of Hyperspectral Imaging to Assess Wound Infection. *Front. Med.* **2023**, *10*, 1165281. [CrossRef]
237. Rajčić, A.; Ristić, Z.; Periša, J.; Milićević, B.; Aldawood, S.; Alodhayb, A.N.; Antić, Ž.; Dramićanin, M.D. Using Principal Component Analysis for Temperature Readings from YF3:Pr3+ Luminescence. *Technologies* **2024**, *12*, 131. [CrossRef]
238. Wang, C.; Sani, E.S.; Gao, W. Wearable Bioelectronics for Chronic Wound Management. *Adv. Funct. Mater.* **2022**, *32*, 2111022. [CrossRef] [PubMed]
239. Jarosińska, E.; Zambrowska, Z.; Witkowska Nery, E. Methods of Protection of Electrochemical Sensors against Biofouling in Cell Culture Applications. *ChemRxiv* **2023**. [CrossRef] [PubMed]
240. Zhao, Z.; Fu, H.; Tang, R.; Zhang, B.; Chen, Y.; Jiang, J. Failure Mechanisms in Flexible Electronics. *Int. J. Smart Nano Mater.* **2023**, *14*, 510–565. [CrossRef]
241. Zhao, Y.; Ruan, Q.; Li, T.; Qiu, H.; Zhang, R.; Wen, S.; Chi, L.; Ji, S. A Universal Method for Constructing Stretchable and Conductive Connections in Flexible Electronics. *Npj Flex. Electron.* **2025**, *9*, 63. [CrossRef]
242. Ullah, A.; Kim, D.Y.; Lim, S.I.; Lim, H.-R. Hydrogel-Based Biointerfaces: Recent Advances, Challenges, and Future Directions in Human–Machine Integration. *Gels* **2025**, *11*, 232. [CrossRef]
243. Ling, S.; Xu, C.; Jiang, Y.; Xu, F.; Jin, H.; Chen, H.; Chen, S.; Ding, Z.; Sun, D. Toward Continuous Monitoring Systems: Emerging Trends of on-Chip Sensors in Organ-on-a-Chip. *Microsyst. Nanoeng.* **2026**, *12*, 61. [CrossRef]
244. Seaton, B.T.; Heien, M.L. Biocompatible Reference Electrodes to Enhance Chronic Electrochemical Signal Fidelity in Vivo. *Anal. Bioanal. Chem.* **2021**, *413*, 6689–6701. [CrossRef]
245. Biswas, N.B.; Read, T.; Levey, K.J.; Macpherson, J.V. Choosing the Correct Internal Reference Redox Species for Overcoming Reference Electrode Drift in Voltammetric pH Measurements. *ACS Electrochem.* **2025**, *1*, 1532–1539. [CrossRef]
246. Sun, S.; Yang, B.; Zhang, Q.; Wüchner, R.; Pan, L.; Zhu, H. Long-Term Continuous Automatic Modal Tracking Algorithm Based on Bayesian Inference. *Struct. Health Monit.* **2024**, *23*, 1530–1546. [CrossRef]
247. Song, Y.; Mukasa, D.; Zhang, H.; Gao, W. Self-Powered Wearable Biosensors. *Acc. Mater. Res.* **2021**, *2*, 184–197. [CrossRef]
248. Boumaiz, M.; Ghazi, M.E.; Bouayad, A.; Balboul, Y.; El Bekkali, M. Energy-Efficient Strategies in Wireless Body Area Networks: A Comprehensive Survey. *IoT* **2025**, *6*, 49. [CrossRef]
249. Rayegani, A.; Saberian, M.; Delshad, Z.; Liang, J.; Sadiq, M.; Nazar, A.M.; Mohsan, S.A.H.; Khan, M.A. Recent Advances in Self-Powered Wearable Sensors Based on Piezoelectric and Triboelectric Nanogenerators. *Biosensors* **2022**, *13*, 37. [CrossRef]
250. Chen, J.; Li, Z.; Kar-Narayan, S.; Luo, D.; Wang, X.; Wu, W.; Liu, C. Nanogenerators for Self-Powered Wearable Devices. *Cell Rep. Phys. Sci.* **2025**, *6*, 102656. [CrossRef]
251. Khadeeja Thanha, K.P.; Ayisha Sana, P.; Ajesh, J.S.; Naseef, P.P.; Tharayil, H.; Lubaib, P.; Pramod, K. Advanced Smart Bioelectronics for Wound Healing: Biosensing, Drug Delivery, and Artificial Intelligence. *Int. J. Pharm.* **2025**, *684*, 126098. [CrossRef] [PubMed]
252. AI-Driven Predictive Models For Wound Deterioration: A Pilot Study—Wounds Canada. Available online: https://www.woundscanada.ca/news/744-ai-driven-predictive-models-for-wound-deterioration-a-pilot-study (accessed on 20 February 2026).
253. Peng, M.; Ning, Y.; Zhang, J.; He, Y.; Xu, Z.; Li, D.; Yang, Y.; Ren, T.-L. Wearable Sensing Systems for Multi-Modal Body Fluid Monitoring: Sensing-Combination Strategy, Platform-Integration Mechanism, and Data-Processing Pattern. *Biosensors* **2026**, *16*, 46. [CrossRef]
254. Kalasin, S.; Sangnuang, P.; Surareungchai, W. Intelligent Wearable Sensors Interconnected with Advanced Wound Dressing Bandages for Contactless Chronic Skin Monitoring: Artificial Intelligence for Predicting Tissue Regeneration. *Anal. Chem.* **2022**, *94*, 6842–6852. [CrossRef] [PubMed]
255. Hughes, C.M.L.; Jeffers, A.; Sethuraman, A.; Klum, M.; Tan, M.; Tan, V. The Detection and Prediction of Surgical Site Infections Using Multi-Modal Sensors and Machine Learning: Results in an Animal Model. *Front. Med. Technol.* **2023**, *5*, 1111859. [CrossRef]
256. Chen, M.-Y.; Cao, M.-Q.; Xu, T.-Y. Progress in the Application of Artificial Intelligence in Skin Wound Assessment and Prediction of Healing Time. *Am. J. Transl. Res.* **2024**, *16*, 2765–2776. [CrossRef]
257. Liu, Y.; Liu, Z.; Duan, X.; Wang, Z.; Li, Y.; Shi, T.; Xu, Y.; Peng, Q.; Hsieh, D.-J.; Chang, K.-C. Wound Monitoring Based on Machine Learning Using a Pro-Healing Acellular Dermal Matrix. *Device* **2025**, *3*, 100808. [CrossRef]
258. Cristea, A.-G.; Lisă, E.-L.; Iacob, S.; Dragostin, I.; Ștefan, C.S.; Fulga, I.; Anghel, A.M.; Dragan, M.; Morariu, I.D.; Dragostin, O.-M. Antimicrobial Smart Dressings for Combating Antibiotic Resistance in Wound Care. *Pharmaceuticals* **2025**, *18*, 825. [CrossRef] [PubMed]
259. Zhao, H.; Liang, G.; Xiong, J.; Wang, X.; Hu, X.; Wei, Z. A Closed-Loop Smart Dressing Based on Microneedle and Electrochemical Micropump for Early Diagnosis and in-Time Therapy of Chronic Wound. *Sens. Actuators B Chem.* **2024**, *417*, 136092. [CrossRef]
260. Mohr, G.J.; Kassal, P.; Žuvić, I.; Krawczyk, K.K.; Steinberg, M.D.; Steinberg, I.M. Design of Halochromic Cellulosic Materials and Smart Textiles for Continuous Wearable Optical Monitoring of Epidermal pH. *Microchim. Acta* **2025**, *192*, 405. [CrossRef]

261. Mariani, F.; Serafini, M.; Gualandi, I.; Arcangeli, D.; Decataldo, F.; Possanzini, L.; Tessarolo, M.; Tonelli, D.; Fraboni, B.; Scavetta, E. Advanced Wound Dressing for Real-Time pH Monitoring. *ACS Sens.* **2021**, *6*, 2366–2377. [CrossRef] [PubMed]
262. Pakolpakçıl, A.; Karaca, E.; Becerir, B. Investigation of a Natural pH-Indicator Dye for Nanofibrous Wound Dressings. *IOP Conf. Ser. Mater. Sci. Eng.* **2018**, *460*, 012020. [CrossRef]
263. Wang, X.; Cheng, J.; Wang, H. Chronic Wound Management: A Liquid Diode-Based Smart Bandage with Ultrasensitive pH Sensing Ability. *Microsyst. Nanoeng.* **2024**, *10*, 193. [CrossRef]
264. Liu, L.; Li, X.; Nagao, M.; Elias, A.L.; Narain, R.; Chung, H.-J. A pH-Indicating Colorimetric Tough Hydrogel Patch towards Applications in a Substrate for Smart Wound Dressings. *Polymers* **2017**, *9*, 558. [CrossRef]
265. El-Sedik, M.S.; Hemdan, B.A.; Hashem, M.M.; Aysha, T.S.; Mousa, A.A.; Youssef, Y.A.; El-Naggar, M.E. Bactericidal Action of Cost-Effective Colorimetric Acid-Base Sensor of Dyed Cotton-Based Fabrics as a Promising Wound Dressing Mat. *J. Photochem. Photobiol. Chem.* **2024**, *456*, 115837. [CrossRef]
266. Mirani, B.; Hadisi, Z.; Pagan, E.; Dabiri, S.M.H.; Van Rijt, A.; Almutairi, L.; Noshadi, I.; Armstrong, D.G.; Akbari, M. Smart Dual-Sensor Wound Dressing for Monitoring Cutaneous Wounds. *Adv. Healthc. Mater.* **2023**, *12*, 2203233. [CrossRef]
267. Lin, P.; He, K.; Luo, J.; Wang, J.; Liu, Y.; Zhang, J.; Fan, H.; Huang, S.; Lan, W.; Wang, W. Multifunctional Nanofiber System with Photothermal-Controlled Drug Delivery and Motion Monitoring Capabilities as Intelligent Wound Dressing. *Chem. Eng. J.* **2025**, *503*, 158544. [CrossRef]
268. Ge, Z.; Guo, W.; Tao, Y.; Sun, H.; Meng, X.; Cao, L.; Zhang, S.; Liu, W.; Akhtar, M.L.; Li, Y.; et al. Wireless and Closed-Loop Smart Dressing for Exudate Management and On-Demand Treatment of Chronic Wounds. *Adv. Mater.* **2023**, *35*, 2304005. [CrossRef]
269. Jiang, Y.; Trotsyuk, A.A.; Niu, S.; Henn, D.; Chen, K.; Shih, C.-C.; Larson, M.R.; Mermin-Bunnell, A.M.; Mittal, S.; Lai, J.-C. Wireless, Closed-Loop, Smart Bandage with Integrated Sensors and Stimulators for Advanced Wound Care and Accelerated Healing. *Nat. Biotechnol.* **2023**, *41*, 652–662. [CrossRef]
270. Kim, D.H.; Shin, H.J.; Lee, H.; Jeong, C.K.; Park, H.; Hwang, G.; Lee, H.; Joe, D.J.; Han, J.H.; Lee, S.H.; et al. In Vivo Self-Powered Wireless Transmission Using Biocompatible Flexible Energy Harvesters. *Adv. Funct. Mater.* **2017**, *27*, 1700341. [CrossRef]
271. Gupta, B.K.; Ghosal, S.; Ganesan, S.; Sudhakar, T.; Mishra, A.; Pandey, N. Energy Harvesting Techniques for Self-Powered Body-Worn Sensors in Wireless Body Area Networks. In *Proceedings of the 2025 International Conference on Automation and Computation (AUTOCOM), Dehradun, India, 4–6 March 2025*; IEEE: New York, NY, USA, 2025; pp. 577–582.
272. Guida, R.; Melodia, T. Powering Smart Wireless Implantable Medical Devices: Toward an Internet of Self-Powered Intra-Body Things. *Ad Hoc Netw.* **2025**, *169*, 103748. [CrossRef]
273. Vital, D.; Bhushan, P.; Gaire, P.; Islam, M.K.; Lahade, S.; Pozdin, V.; Volakis, J.L.; Bhansali, S.; Bhardwaj, S. SkinAid: A Wirelessly Powered Smart Dressing Solution for Continuous Wound-Tracking Using Textile-Based Frequency Modulation. *IEEE Trans. Biomed. Circuits Syst.* **2023**, *17*, 985–998. [CrossRef] [PubMed]
274. Xu, G.; Lu, Y.; Cheng, C.; Li, X.; Xu, J.; Liu, Z.; Liu, J.; Liu, G.; Shi, Z.; Chen, Z.; et al. Battery-Free and Wireless Smart Wound Dressing for Wound Infection Monitoring and Electrically Controlled On-Demand Drug Delivery. *Adv. Funct. Mater.* **2021**, *31*, 2100852. [CrossRef]
275. Zou, H.; Zhou, Z.; Huang, M.; Li, W.; Yang, B.; Zhao, X.; Li, T.; Xu, L.; Wang, T.; Wang, L. NFC/RFID-Enabled Wearables and Implants for Biomedical Applications. *Microsyst. Nanoeng.* **2025**, *11*, 191. [CrossRef]
276. *ISO 10993-1:2025*; Biological Evaluation of Medical Devices. Part 1: Requirements and General Principles for the Evaluation of Biological Safety Within a Risk Management Process. ISO: Geneva, Switzerland, 2025. Available online: https://www.iso.org/standard/10993-1 (accessed on 19 February 2026).
277. Center for Devices and Radiological Health Use of International Standard ISO 10993-1, "Biological Evaluation of Medical Devices—Part 1: Evaluation and Testing Within a Risk Management Process". Available online: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/use-international-standard-iso-10993-1-biological-evaluation-medical-devices-part-1-evaluation-and (accessed on 19 February 2026).
278. Vasyukova, I.A.; Zakharova, O.V.; Kuznetsov, D.V.; Gusev, A.A. Synthesis, Toxicity Assessment, Environmental and Biomedical Applications of MXenes: A Review. *Nanomaterials* **2022**, *12*, 1797. [CrossRef]
279. Wang, X.; Song, X.; Feng, W.; Chang, M.; Yang, J.; Chen, Y. Advanced Nanomedicines for Treating Refractory Inflammation-Related Diseases. *Nano-Micro Lett.* **2025**, *17*, 323. [CrossRef]
280. Center for Devices and Radiological Health Classify Your Medical Device. Available online: https://www.fda.gov/medical-devices/overview-device-regulation/classify-your-medical-device (accessed on 19 February 2026).
281. European Medicines Agency (EMA). Medical Devices | European Medicines Agency (EMA). Available online: https://www.ema.europa.eu/en/human-regulatory-overview/medical-devices (accessed on 19 February 2026).
282. *Commissioner, O. of the Combination Product Definition Combination Product Types*; FDA: Silver Spring, MD, USA, 2019.
283. Pawnikar, V.; Patel, M. Biosensors in Wearable Medical Devices: Regulatory Framework and Compliance across US, EU, and Indian Markets. *Ann. Pharm. Françaises* **2025**, *83*, 637–648. [CrossRef] [PubMed]

284. Shafik, W. Data Privacy Challenges in Artificial Intelligence-Driven Healthcare. In *The Convergence of Federated Learning and Healthcare 5.0 and Beyond: A New Era of Intelligent Health Systems*; Shafik, W., Dutta, P.K., Pattanaik, P., Eds.; Springer Nature: Cham, Switzerland, 2026; pp. 67–98, ISBN 978-3-032-03985-9.
285. Agarwal, G.; Bhargava, S.; Dumoga, S. Nanomaterial Interventions for Wound Healing: Current Status of Preclinical and Clinical Studies. *Wound Repair Regen.* **2025**, *33*, e70031. [CrossRef]
286. Wang, M.; Li, H.; Luo, Y.; Chen, J.; Tang, Z.; Wei, Y.; Yang, Q.; Xiao, W.; You, W.; Feng, M.; et al. Biomimetic Nano Dressing in Wound Healing: Design Strategies and Application. *Burns Trauma* **2025**, *13*, tkaf038. [CrossRef]
287. Center for Drug Evaluation and Research. Drug Products, Including Biological Products, That Contain Nanomaterials—Guidance for Industry. Available online: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/drug-products-including-biological-products-contain-nanomaterials-guidance-industry (accessed on 19 February 2026).
288. de Souza Cardoso Delfino, C.; de Paula Pereira, M.C.; dos Santos Oliveira, M.; de Carvalho Favareto, I.; Valladão, V.S.; de Oliveira Mota, M.; Costa, M.V.B.; Sousa-Batista, A.J.; Balbino, T.A. Scaling Nanopharmaceutical Production for Personalized Medicine: Challenges and Strategies. *J. Nanoparticle Res.* **2025**, *27*, 108. [CrossRef]
289. Tessarolo, M.; Possanzini, L.; Gualandi, I.; Mariani, F.; Torchia, L.D.; Arcangeli, D.; Melandri, F.; Scavetta, E.; Fraboni, B. Wireless Textile Moisture Sensor for Wound Care. *Front. Phys.* **2021**, *9*. [CrossRef]
290. *ISO 11137-1:2025*; Sterilization of Health Care Products—Radiation. ISO: Geneva, Switzerland, 2025. Available online: https://www.iso.org/standard/81721.html (accessed on 19 February 2026).
291. *ISO 11135:2014*; Sterilization of Health-Care Products—Ethylene Oxide—Requirements for the Development, Validation and Routine Control of a Sterilization Process for Medical Devices. ISO: Geneva, Switzerland, 2014. Available online: https://www.iso.org/standard/56137.html (accessed on 19 February 2026).
292. Thakor, P.; Shah, S.; Shah, A.; Singh, O.V. Medical Device Shelf-Life and Recalls: Navigating Healthcare Challenges. *Expert Rev. Med. Devices* **2025**, *22*, 1391–1401. [CrossRef]
293. Gianino, E.; Miller, C.; Gilmore, J. Smart Wound Dressings for Diabetic Chronic Wounds. *Bioengineering* **2018**, *5*, 51. [CrossRef]
294. Derakhshandeh, H.; Kashaf, S.S.; Aghabaglou, F.; Ghanavati, I.O.; Tamayol, A. Smart Bandages: The Future of Wound Care. *Trends Biotechnol.* **2018**, *36*, 1259–1274. [CrossRef] [PubMed]
295. Lee, J.-C.; Kim, S.Y.; Song, J.; Jang, H.; Kim, M.; Kim, H.; Choi, S.Q.; Kim, S.; Jolly, P.; Kang, T.; et al. Micrometer-Thick and Porous Nanocomposite Coating for Electrochemical Sensors with Exceptional Antifouling and Electroconducting Properties. *Nat. Commun.* **2024**, *15*, 711. [CrossRef] [PubMed]
296. Kumar, R.; Yang, B.; Barton, J.; Stejfova, M.; Schäfer, A.; Koenig, M.; Knittel, P.; Cigler, P.; Hirtz, M. Diamond Surfaces with Clickable Antifouling Polymer Coating for Microarray-Based Biosensing. *Adv. Mater. Interfaces* **2022**, *9*, 2201453. [CrossRef]
297. Bitolas, R.; Brown, D.A. Preclinical Models for Wound Healing and Repair Studies. In *Management and Strategies for Wound Healing*; De Francesco, F., Turksen, K., Eds.; Springer Nature: Cham, Switzerland, 2026; pp. 259–286, ISBN 978-3-032-12442-5.
298. Li, H.; Yang, H.; Lu, F.; Hee, W.S.; Asefifeyzabadi, N.; Baniya, P.; Gallegos, A.; Schorger, K.; Zhu, K.; Recendez, C.; et al. Real-Time Diagnostics and Personalized Wound Therapy Powered by AI and Bioelectronics. *MedRxiv* **2025**. [CrossRef]
299. Szunerits, S.; Boukherroub, R. State-of-the-Art and Future Challenges of Smart Wound Dressings for Diabetic Foot Ulcer Treatment. *Adv. NanoBiomed Res.* **2024**, *4*, 2400040. [CrossRef]
300. Gao, Z.; Zhou, Y.; Zhang, J.; Foroughi, J.; Peng, S.; Baughman, R.H.; Wang, Z.L.; Wang, C.H. Advanced Energy Harvesters and Energy Storage for Powering Wearable and Implantable Medical Devices. *Adv. Mater.* **2024**, *36*, 2404492. [CrossRef]
301. Rong, G.; Zheng, Y.; Sawan, M. Energy Solutions for Wearable Sensors: A Review. *Sensors* **2021**, *21*, 3806. [CrossRef]
302. Al-Akayleh, F.; Abdel-Rahem, R.A.; Al-Remawi, M.; Aburub, F.; Al-Adham, I.S.I.; Ali Agha, A.S.A. AI-Driven Tools and Methods for Wound Healing: Towards Precision Wound Care and Optimized Outcomes. In *Proceedings of the 2025 1st International Conference on Computational Intelligence Approaches and Applications (ICCIAA), Amman, Jordan, 28–30 April 2025*; IEEE: New York, NY, USA, 2025; pp. 01–05.
303. Reddy, S. Global Harmonization of Artificial Intelligence-Enabled Software as a Medical Device Regulation: Addressing Challenges and Unifying Standards. *Mayo Clin. Proc. Digit. Health* **2025**, *3*, 100191. [CrossRef] [PubMed]
304. Rahi, S.; Lather, V.; Rana, A.; Pandit, J. Comprehensive Framework for the Global Regulation and Approval of AI-Integrated Medical Devices. *Appl. Drug Res. Clin. Trials Regul. Aff.* **2025**, *11*, E26673371347630. [CrossRef]
305. She, Y.; Liu, H.; Yuan, H.; Li, Y.; Liu, X.; Liu, R.; Wang, M.; Wang, T.; Wang, L.; Liu, M.; et al. Artificial Intelligence-Assisted Conductive Hydrogel Dressings for Refractory Wounds Monitoring. *Nano-Micro Lett.* **2025**, *17*, 319. [CrossRef]
306. Sattar, H.; Bajwa, I.S.; Shafi, U.F. An IoT Assisted Clinical Decision Support System for Wound Healthcare Monitoring. *Comput. Intell.* **2022**, *38*, 269–306. [CrossRef]