IJMPR, 2026, 10(3), 10-14 ISSN: 2319-5878

INTERNATIONAL JOURNAL OF MODERN PHARMACEUTICAL RESEARCH

www.ijmpronline.com

Review Article

Impact Factor: 7.533

Coden USA: IJMPR3

DEVELOPMENT OF MOLECULARLY IMPRINTED POLYMER FOR ENTRAPMENT OF GLUCOSE

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Article Received on: 02/02/2026 **Article Revised on: 23/02/2026** **Article Published on: 01/03/2026**

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https://doi.org/10.5281/zenodo.18812447

How to cite this Article: Swapnali Pankaj Mahajan*, Jatin Anil Sachdev, Sachin Sanjay Patil, Mr. Satish Bhagwan Bramhne (2026). Development Of Molecularly Imprinted Polymer For Entrapment Of Glucose. International Journal of Modern Pharmaceutical Research, 10(3), 10–14.

ABSTRACT

Development of Molecularly Imprinted Polymer For Entrapment Of Glucose (MIP) Molecularly Imprinted Polymer is an attractive technique for the synthesis of highly selective polymeric receptors having artificial generated recognition sites. These materials were sinthesized with polymerizable functional monomers and crosslinker that were surrounded around the template molecule Afler polymerization, a template molecule Was removed leaving in the polymer elective recognition sites with shape, size and Functionalities complementary to the template. This study presents a synthesis of MIP selectively for glucose binding. The main princiele of MIP is the entrapt the excess amount of glucose molecule and excrete out through the body. It cause maintain sugar level.

KEYWORDS: Production Methods of MIPs for Glucose Detection Readout Technologies Employed for MIP- Based Glucose Detection.

INTRODUCTION

Glucose plays a crucial part in multitudinous natural processes, similar as cellular respiration and glycosylation.[1,2] Once its metabolism is disturbed, it may lead to a variety of conditions, similar as hyperinsulinism and diabetes.[3,4] The ultimate is characterized by a high attention of glucose in the blood and other physiological fluids(hyperglycemia). Classical diabetes individual tests, thus, aim at directly assessing glucose situations in the blood of cases. More specifically, when the sugar attention is advanced than 7 mmol L −1 after no sweet input for a minimum of 8h or advanced than 11.1 mmol L −1 two hours after an oral glucose forbearance test(OGTT), the existent is considered to be affected by diabetes.[5] General Background on MIPs Molecularly ingrained polymers(MIPs) have attracted wide interest over the last many decades, as these accoutrements can mimic the natural antibody – antigen and enzyme – substrate systems, but overcome utmost of the issues that are generally encountered when using natural receptors innon-physiological conditions.[6] The general principle behind MIP conflation is the commerce between a target patch, a functional monomer, and across-linking agent. First, the functional monomer(s) and the target motes form a complex by relations between their functional groups[7], also thecross-linker stabilizes the complex and is responsible for the severity of the polymer. After birth of the template patch, nanocavities that are reciprocal to the uprooted patch are formed(Figure2).[8] This complementarity is both morphological and structural, icing that the target can widely rebind to the receptor, which isanalogous to the crucial- and- cinch medium that antibodies and enzymes use to descry their target.[9]

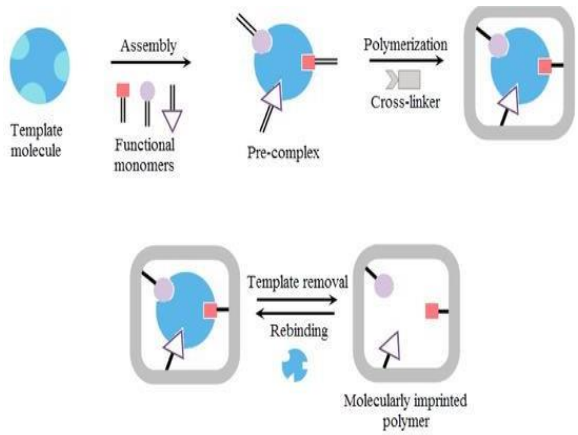

Fig:-1. Schematic representation of generic synthesis and rebinding of molecularly imprinted polymers.

Production Methods of MIPs for Glucose Detection

- In order to synthesize molecularly imprinted polymers, different reagents are required, including a functional monomer(s), template, cross-linker, and a polymerization initiator.[10,11]
- Their ratio with respect to one another greatly influences the specific interaction between the polymer and the template, and subsequently the binding capacity and imprinting factor of the resulting MIP.[12,13]
- Depending on the type of polymerization, initiators and solvents also play a vital role in the whole process.[14]
- Numerous polymerization techniques used to synthesize molecularly imprinted polymers have been explored in the last few decades (Table 1).[15,16]
- including bulk polymerization, electropolymerization, and photopolymerization.[17,18,19,20]
- More recently, MIPs have been used in combination with other materials such as gold nanoparticles to boost the sensitivity of the resulting sensor or nylon to open up the possibility of creating wearable glucose sensors.[21]
- Inevitably, a slightly different synthetic pathway needs to be employed for such sensors, often leading to additional steps in the fabrication process.

Readout Technologies Employed for MIP-Based Glucose Detection

Readout Technologies for MIP-Based Glucose Sensors MIPs act as synthetic receptors that bind glucose selectively. The readout system converts this binding event into a measurable signal using various transduction techniques.

1. Electrochemical Readouts

Most commonly used for glucose-MIP biosensors.

- a) Amperometric Detection

Measures: Current from oxidation/reduction of glucose or redox probe. Mechanism: Glucose binding alters electron transfer.

- Advantages
  - High sensitivity
  - Compatible with portable devices (e.g., glucose meters)
  - Common materials: Carbon electrodes, gold, graphene, redox-tagged MIPs

- b) Potentiometric Sensors

Measures: Voltage difference (potential) between electrodes.

Mechanism: Binding of glucose changes ion distribution or pH near MIP surface.

- c) Electrochemical Impedance Spectroscopy (EIS) Measures: Impedance changes at the electrode interface.

Mechanism: Glucose binding alters electrical resistance and capacitance of MIP layer.[22]

2. Optical Readouts

- a) Colorimetric Detection

Measures: Visible color change (by eye or camera).

Mechanism: MIP binding induces color shift, often via nanoparticles (e.g., AuNPs). Used for: Point-of-care, paper-based biosensors

- b) Fluorescence

Measures: Change in fluorescence intensity or wavelength. Mechanism: Glucose binding affects fluorophore–MIP interaction.

Can be label-free (intrinsic fluorophores) or label-based (dyes, quantum dots). Highly sensitive, but requires optics.

- c) Surface Plasmon Resonance (SPR)

Measures: Change in light reflection at sensor surface.

Mechanism: Binding changes refractive index near MIP-coated metal surface.

High-resolution, real-time detection.[23]

3. Thermal Readouts (e.g., Heat Transfer Method)

Measures: Thermal resistance or conductivity at sensor interface.

Mechanism: Glucose binding alters heat flow in MIP layer.[24]

4. Piezoelectric & Mass-Sensitive Sensors

- Quartz Crystal Microbalance (QCM)

Measures: Frequency change of vibrating quartz crystal.

Mechanism: Glucose binding increases mass on MIP-coated sensor. Highly sensitive to small mass changes.

Best Choices for Glucose Detection in Body Fluids.

- Application:
  - Recommended Readout
  - Wearable sensor (sweat/tear glucose)
  - Electrochemical (EIS, amperometric) or colorimetric Implantable sensor
  - EIS or thermal readout (biocompatibility matters)
  - Paper strip testing colorimetric or electrochemical.[25]

Promising MIP-Based Technologies for Glucose Sensing

1. Electrochemical NanoMIP Sensors

- Leading edge for real-time glucose monitoring
- NanoMIPs (nanoparticle-sized MIPs) offer high surface area and fast kinetics.
- Integrated with electrodes for amperometric or impedance-based detection.
- Example: Redox-tagged nanoMIPs that release signals upon glucose binding.
- Applications: Sweat-based wearables, microneedle patches, continuous monitoring devices.[26]

2. Optical MIP Sensors Using Plasmonic or Fluorescent Platforms

- Highly sensitive, enzyme-free alternatives
- Gold nanoparticles (AuNPs) or quantum dots embedded in MIPs enable colorimetric or fluorescence response upon glucose binding.

- Advantages:
- Visual/photonic detection (no wires or electricity needed)
- Non-invasive, ideal for point-of-care
- Use case: Paper-based or smartphone-compatible glucose testing.[27]

3. MIP-Coated Quartz Crystal Microbalance (QCM) Sensors

- Mass-based detection for ultra-sensitive quantification
- QCM sensors detect frequency shifts due to glucose binding on MIP surface.
- Highly precise and label-free.
- Suitable for clinical diagnostics, though mostly in lab settings.[28]

4. Heat-Transfer-Based MIP Sensors

- Smart thermal readout without labeling
- Uses thermal conductivity changes across MIP layer as a function of glucose binding.
- Advantage: Operates in turbid biological samples like whole blood or serum.
- Integrated into implantable or microfluidic platforms.
- Reference: Peeters et al., Analytical Chemistry (2017).[29]

5. Boronate-Modified MIPs for Aqueous Glucose Recognition

- Selective binding through reversible covalent interaction
- Boronic acid-functionalized MIPs form specific complexes with glucose diols.
- Enable better imprinting and stability in aqueous media.
- Applied in both electrochemical and optical sensors.
- Challenge: pH sensitivity, but being improved with new monomers.[30]

6. Paper-Based & Wearable MIP Devices

- Future of portable diabetes care
- Combining MIPs with paper microfluidics or flexible electronics.
- Example: MIP-coated electrodes on tattoos or patches detecting glucose in sweat.
- Goal: Non-invasive, continuous monitoring without enzymatic systems.[31]

7. Stimuli-Responsive MIPs (Smart MIPs)

- Dynamic sensing and drug-release systems.
- MIPs that change conformation or release glucose in response to pH, temperature, or glucose itself.
- Emerging in drug delivery (e.g., insulin release based on glucose levels).
- Cutting-edge direction toward artificial pancreas-like systems.
- Summary Table: MIP Technologies for Glucose Detection.
- Technology Detection Mode Highlights Suitability.
- NanoMIP Electrochemical Sensors Amperometric/EIS High sensitivity, wearable integration Sweat/tear glucose monitoring.
- Optical MIP Sensors Colorimetric/Fluorescence Enzyme-free, visual detection\ Paper strips, smartphones.
- QCM MIP Sensors Mass-sensitive Ultra-precise, lab-grade Lab diagnostics.
- Thermal MIP Sensors Heat transfer Turbid sample compatibility In-body detection.
- Boronic Acid-Modified MIPs Covalent glucose binding Aqueous-friendly, high selectivity Electrochemical/optical sensors.
- Wearable/Paper Devices Flexible formats Non-invasive, low-cost Point-of-care testing.
- Smart MIPs Stimuli-responsive Drug release or self-regulated detection Closed- loop insulin systems.[32]

CONCLUSIONS AND FUTURE OUTLOOK

Recent advances in MIP-based sensor technology published in academic studies demonstrate that these devices are rapidly approaching real-life applications. Their long shelf-life, chemical stability, and low cost make them advantageous over enzymes. In addition, these devices have proven to work in challenging environments such as urine and sweat that contain lower concentrations of glucose. This illustrates their potential application in non-invasive and continuous monitoring tools. However, the main bottleneck that must be addressed remains in the synthesis of large batches of homogenous MIPs. This facet of MIP technology has long been neglected, while enzymatic biosensors, as well as immunosensors, have benefited from decades to even centuries of research on the function, synthesis, and immobilization of these natural receptors.Slowly, MIP technology is trying to close this gap, with scholars devoting attention to MIP synthesis procedures that not only lead to highly performant MIPs from an academic perspective, but also take the potential scalability and possibility for mass production into account. Technologies such as solid-phase synthesis that takes place in automated reactors or fully automated electrospinning or electropolymerization approaches are rapidly evolving in this direction and multiple research groups are investigating ways to improve the more traditional approaches in this respect. Thus, we believe that MIP-based technologies may be a strong alternative to traditional enzymatic devices in the future and, by addressing the aforementioned obstacles to their commercialization, may finally reach the market. In combination with the continuously growing need for personalized medicine and non-invasive sampling, MIP-based glucose sensors could profit from the momentum and academic know-how in the coming decade or two, to achieve the next step towards commercialization, and therefore real-life application.

REFERENCE

1. Gerich, J.E.; Meyer, C.; Woerle, H.J.; Stumvoll, M. Renal Gluconeogenesis. Diabetes Care, 2001; 24:

382–391. [Google Scholar] [CrossRef] [PubMed].
2. Andrali, S.S.; Qian, Q.; Özcan, S. Glucose Mediates the Translocation of NeuroD1 by O- Linked Glycosylation. J. Biol. Chem, 2007; 282: 15589–15596. [Google Scholar] [CrossRef].
3. Deshpande, A.D.; Harris-Hayes, M.; Schootman, M. Epidemiology of Diabetes and Diabetes- Related Complications. Phys. Ther, 2008; 88: 1254–1264. [Google Scholar] [CrossRef] [PubMed].
4. Arnoux, J.-B.; de Lonlay, P.; Ribeiro, M.-J.; Hussain, K.; Blankenstein, O.; Mohnike, K.; Valayannopoulos, V.; Robert, J.-J.; Rahier, J.; Sempoux, C.; et al. Congenital Hyperinsulinism. Early Hum. Dev, 2010; 86: 287–294. [Google Scholar] [CrossRef].
5. Egan, A.M.; Dinneen, S.F. What Is Diabetes? Medicine, 2019; 47: 1–4. [Google Scholar] [CrossRef].
6. Parisi, O.I.; Francomano, F.; Dattilo, M.; Patitucci, F.; Prete, S.; Amone, F.; Puoci, F. The Evolution of Molecular Recognition: From Antibodies to Molecularly Imprinted Polymers (MIPs) as Artificial Counterpart. J. Funct. Biomater. 2022; 13: 12. [Google Scholar] [CrossRef].
7. Spivak, D. Optimization, Evaluation, and Characterization of Molecularly Imprinted Polymers. Adv. Drug. Deliv. Rev, 2005; 57: 1779–1794. [Google Scholar] [CrossRef].
8. Saylan, Y.; Akgönüllü, S.; Yavuz, H.; Ünal, S.; Denizli, A. Molecularly Imprinted Polymer Based Sensors for Medical Applications. Sensors, 2019; 19: 1279. [Google Scholar] [CrossRef].
9. Yan, H.; Row, K. Characteristic and Synthetic Approach of Molecularly Imprinted Polymer. Int. J. Mol. Sci, 2006; 7: 155–178. [Google Scholar] [CrossRef].
10. Refaat, D.; Aggour, M.G.; Farghali, A.A.; Mahajan, R.; Wiklander, J.G.; Nicholls, I.A.; Piletsky, S.A. Strategies for Molecular Imprinting and the Evolution of MIP Nanoparticles as Plastic Antibodies—Synthesis and Applications. Int. J. Mol. Sci, 2019; 20: 6304. [Google Scholar] [CrossRef] [PubMed]
11. He, S.; Zhang, L.; Bai, S.; Yang, H.; Cui, Z.; Zhang, X.; Li, Y. Advances of Molecularly Imprinted Polymers (MIP) and the Application in Drug Delivery. Eur. Polym. J., 2021; 143: 110179. [Google Scholar] [CrossRef]
12. Yilmaz, E.; Mosbach, K.; Haupt, K. Influence of Functional and Cross-Linking Monomers and the Amount of Template on the Performance of Molecularly Imprinted Polymers in Binding Assays. Anal. Commun, 1999; 36: 167–170. [Google Scholar] [CrossRef]
13. Lowdon, J.W.; Ishikura, H.; Kvernenes, M.K.; Caldara, M.; Cleij, T.J.; van Grinsven, B.; Eersels, K.; Diliën, H. Identifying Potential Machine Learning Algorithms for the Simulation of Binding Affinities to Molecularly Imprinted Polymers. Computation, 2021; 9: 103. [Google Scholar] [CrossRef]
14. Dong, W.; Yan, M.; Zhang, M.; Liu, Z.; Li, Y. A Computational and Experimental Investigation of the Interaction between the Template Molecule and the Functional Monomer Used in the Molecularly Imprinted Polymer. Anal. Chim. Acta, 2005; 542: 186–192. [Google Scholar] [CrossRef]
15. Boysen, R.I.; Schwarz, L.J.; Nicolau, D.V.; Hearn, M.T.W. Molecularly Imprinted Polymer Membranes and Thin Films for the Separation and Sensing of Biomacromolecules. J. Sep. Sci, 2017; 40: 314–335. [Google Scholar] [CrossRef]
16. Pichon, V.; Delaunay, N.; Combès, A. Sample Preparation Using Molecularly Imprinted Polymers. Anal. Chem, 2020; 92: 16–33. [Google Scholar] [CrossRef] [PubMed]
17. Moreira Gonçalves, L. Electropolymerized Molecularly Imprinted Polymers: Perceptions Based on Recent Literature for Soon-to-Be World-Class Scientists. Curr. Opin. Electrochem, 2021; 25: 100640. [Google Scholar] [CrossRef]
18. Paruli, E.I.; Soppera, O.; Haupt, K.; Gonzato, C. Photopolymerization and Photostructuring of Molecularly Imprinted Polymers. ACS Appl. Polym. Mater, 2021; 3: 4769–4790. [Google Scholar] [CrossRef]
19. A. Ramanavicius, S.; Samukaite-Bubniene, U.; Ratautaite, V.; Bechelany, M.; Ramanavicius, A Electrochemical Molecularly Imprinted Polymer Based Sensors for Pharmaceutical and Biomedical Applications (Review). J. Pharm. Biomed. Anal, 2022; 215: 114739. [Google Scholar] [CrossRef] [PubMed]
20. Crapnell, R.D.; Street, R.J.; Ferreira-Silva, V.; Down, M.P.; Peeters, M.; Banks, C.E. Electrospun Nylon Fibers with Integrated Polypyrrole Molecularly Imprinted Polymers for the Detection of Glucose. Anal. Chem, 2021; 93: 13235–13241. [Google Scholar] [CrossRef]
21. Sehit, E.; Drzazgowska, J.; Buchenau, D.; Yesildag, C.; Lensen, M.; Altintas, Z. Ultrasensitive Nonenzymatic Electrochemical Glucose Sensor Based on Gold Nanoparticles and Molecularly Imprinted Polymers. Biosens. Bioelectron, 2020; 165: 112432. [Google Scholar] [CrossRef] [PubMed]
22. Jose, S., & Beula, C. (2020). Molecularly imprinted polymers and copper nano-particles for electrochemical detection of glucose: A review. *AIP Conference Proceedings*, *2263*(1): 060003.
23. Caldara, M., Kulpa, J., Lowdon, J. W., Cleij, T. J., Diliën, H., Eersels, K., & Grinsven, B. V. (2023). Recent advances in molecularly imprinted polymers for glucose monitoring: From fundamental research to commercial application. *Chemosensors*, *11*(1): 32.
24. Wagner, P., Bakhshi Sichani, S., Khorshid, M., Lieberzeit, P., Losada-Pérez, P., & Yongabi, D. (2023). Bioanalytical sensors using the heat-transfer method HTM and related techniques. *Tm Technisches Messen*, *90*(12): 761–785.

25. Assalve, G., Lunetti, P., Di Cagno, A., De Luca, E. W., Aldegheri, S., Zara, V., & Ferramosca, A. (2024). Advanced wearable devices for monitoring sweat biochemical markers in athletic performance: A comprehensive review. *Biosensors*, *14*(12): 574.
26. Gagliani, F., Di Giulio, T., Asif, M. I., Malitesta, C., & Mazzotta, E. (2024). Boosting electrochemical sensing performances using molecularly imprinted nanoparticles. *Biosensors*, *14*(7): 358.
27. Jose, S., & Beula, C. (2020). Molecularly imprinted polymers and copper nano-particles for electrochemical detection of glucose: A review. *AIP Conference Proceedings*, *2263*(1): 060003.
28. Ayankojo, A. G., Reut, J., & Syritski, V. (2024). Electrochemically synthesized MIP sensors: Applications in healthcare diagnostics. *Biosensors*, *14*(2): 71.
- Wagner, P., Bakhshi Sichani, S., Khorshid, M., Lieberzeit, P., Losada-Pérez, P., & Yongabi, D. (2023). Bioanalytical sensors using the heat-transfer method HTM and related techniques. *Tm Technisches Messen*, *90*(12): 761–785.
29. Zhao, T., et al. (2024). Boronate-affinity surface molecular imprinting for sensitive detection of sugars in complex biological samples. *Analytica Chimica Acta*, *1285:* 341992.
30. Alvarez-Serna, B. E., et al. (2023). Molecular imprinted polymer paper-based biosensor for wireless measurement of sweat glucose. *IFMBE Proceedings*, *86*: 611–618.
31. Sullivan, M. V., Lasserre, P., Blackburn, C., Turner, N. W., & Sellergren, B. (2025). Stimuli-responsive molecularly imprinted materials: Fundamentals and applications. *Responsive Materials*, *1*.