Int. J. Sci. R. Tech., 2026 3(5)
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

Original Article

Bioelectronic Drug Delivery System:The Future Of Medicine

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ABSTRACT

Bioelectronic drug delivery systems combine electronic technologies with advanced drug delivery methods to achieve precise, targeted, and responsive therapeutic interventions. These systems can be activated by physiological signals or external stimuli, allowing for controlled regulation of when, where, and how much medication is released. This technology enhances treatment efficacy, reduces adverse side effects, and supports personalized medical approaches, making it especially beneficial for the management of chronic illnesses, neurological disorders, and pain.

Keywords: drug delivery systems, management, chronic illnesses, neurological disorders, Monitoring, Bioelectronic.

INTRODUCTION

Bioelectronic Drug Delivery Systems Represent An Emerging Field At The Intersection Of Biology, Electronics, And Pharmacology. These Systems Are Designed To Deliver Drugs With High Precision And Control By Integrating Electronic Components That Respond To Physiological Signals Or External Stimuli. Unlike Conventional Drug Delivery Methods, Which Often Rely On Passive Diffusion Or Bulk Administration Bioelectronic Systems Aim To Optimize Therapeutic Outcomes Through Real-Time Monitoring And Controlled Release Of Medication.

Applications Of Bioelectronic Drug Delivery Span Across Neurology, Endocrinology, And Oncology, With Growing Interest In Chronic Disease Management. For Instance, Implantable Devices For Pain Management, Insulin Delivery Systems Responsive To Glucose Levels, And Smart Patches For Transdermal Drug Delivery Are Notable Examples.

As The Field Evolves, Advances In Materials Science, Nanotechnology, And Wireless Communication Are Expected To Further Enhance The Functionality, Biocompatibility, And Miniaturization Of These Systems—Paving The Way For For Next-Generation Therapeutic Strategies That Are Smarter, Safer, And More Responsive To Individual.

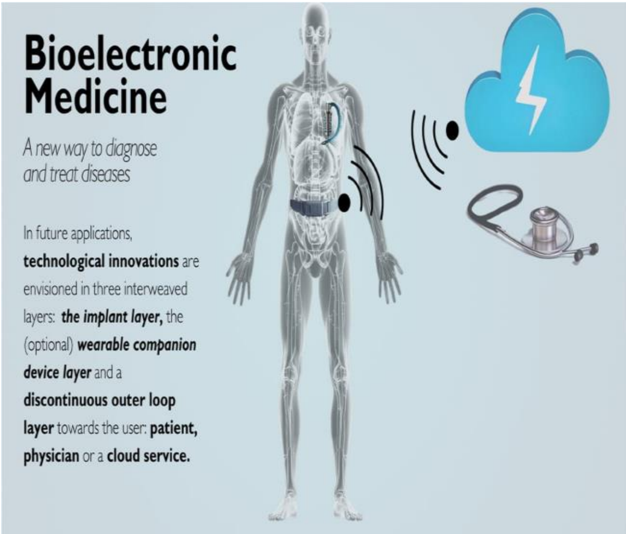


Fig.Bioelectronic Medicine

Introduction To Bioelectronic Drug Delivery Systems: Bioelectronic Drug Delivery Systems Represent A Cutting-Edge And Rapidly Evolving Field That Merges Principles From Biology, Electronics, And Pharmacology. These Innovative Systems Are Engineered To Administer Therapeutic Agents With Exceptional Precision And Control By

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Incorporating Electronic Components Capable Of Responding To Physiological Signals Or External Stimuli. Unlike Traditional Drug Delivery Methods—Which Often Depend On Passive Diffusion Or Large, Non-Specific Doses—Bioelectronic Systems Are Designed To Optimize Therapeutic Effectiveness Through Real-Time Monitoring And Intelligent, Controlled Drug Release.

At The Heart Of These Systems Lie Bioelectronic Interfaces Such As Microelectrodes, Biosensors, And Actuators, Which Are Capable Of Interacting Directly With Biological Tissues. These Components Can Detect Various Biological Signals, Including Specific Biomarkers, Fluctuations In Ph Levels, Changes In Temperature, Or Electrical Activity Within The Body. Based On These Inputs, The System Can Regulate The Timing, Dosage, And Location Of Drug Release. This Responsive And Highly Targeted Approach Not Only Improves The Efficacy Of Treatment But Also Reduces The Likelihood Of Side Effects And Enables Personalized Medical Care Tailored To Individual Patients.

KEY COMPONENTS OF BIOELECTRONICS DRUG DELIVERY SYSTEM:

1. Biocompatibility:

Definition: Biocompatibility Refers To The Ability Of The Material Used For The Reservoir To Safely Interact With Biological Tissues Without Causing Inflammation, Toxicity, Or Immune Rejection.

2. Stability Of The Drug:

Definition: Refers To The Drug's Ability To Maintain Its Chemical Integrity, Potency, And Sterility Over Time While Stored Inside The Reservoir.

3. Sensing And Feedback Mechanism:

*Real-Time Monitoring Of Biological Markers (E.G., Glucose, Ph, Cytokines).

*Detect Disease-Related Events Or Changes In The Body.

*Trigger Or Modulate Drug Release Based On Sensor Input.

*Improve Efficacy And Safety By Preventing Over- Or Under-Dosing*Enable Personalized Medicine By Adapting To Patient-Specific Condition.

TYPES OF BIOELECTRONICS DRUG DELIVERY SYSTEM:

Bioelectronic Drug Delivery Systems Can Be Categorized Based On Delivery Mechanisms, Site Of Action, Method Of Activation, Or Form Factor (E.G., Implantable, Wearable). Below Are The Main Types, Organized By How They Function And Where They Are Used:

1. Implantable Bioelectronic Drug Delivery Systems:

Implantable Bioelectronic Drug Delivery Systems Are Medical Devices Designed To Be Surgically Placed Within The Body, Typically In Close Proximity To The Targeted Tissue Or Organ. These Systems Enable Long-Term, Localized, And Programmable Drug Administration, Offering A High Level Of Precision And Control Compared To Traditional Drug Delivery Methods.

#**Key Characteristics:**

Localized Delivery: Drugs Are Released Directly At Or Near The Disease Site, Minimizing Systemic Side Effects And Improving Therapeutic Efficiency.

Long-Term Operation: Once Implanted, These Systems Can Function For Extended Periods—Weeks, Months, Or Even Years—Reducing The Need For Frequent Dosing Or Hospital Visits.

Programmable Release: The Device Can Be Programmed To Release Drugs At Specific Times, Doses, Or In Response To Physiological Signals (E.G., Changes In Ph, Temperature, Or Neural Activity.

2. Electroresponsive Drug Delivery Systems (EDDS):

- Description

Electro-responsive Drug Delivery Systems Use External Or Internal Electrical Stimuli To Precisely Control The Timing, Location, And Amount Of Drug Released. These Systems Are Engineered To Respond To Electrical Signals By Releasing Therapeutic

Agents In A Controlled, Repeatable, And On-Demand Manner.

This Approach Is Especially Useful In Localized Or Implantable Therapies Where Minimally Invasive, Programmable Control Is Critical.

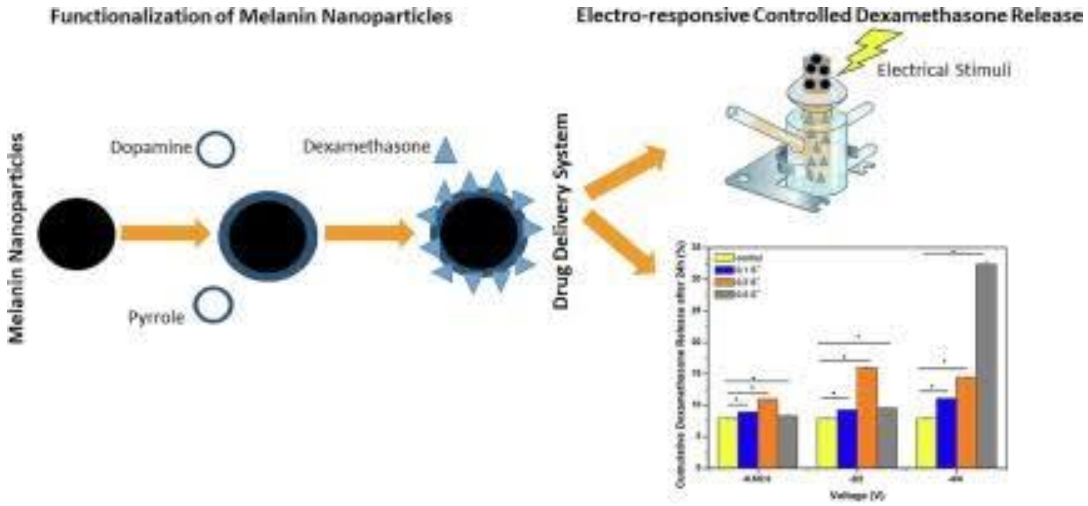


Fig. Electroresponsive Drug Delivery System

MECHANISM OF BIOELECTRONICS DRUG DELIVERY SYSTEM:

Bioelectronic Drug Delivery Systems (Bioelectronic Dds) Represent A Convergence Of Biotechnology, Electronics, And Pharmacology. These Systems Use Electrical Signals To Precisely Control The Release Of Therapeutic Agents—Often At The Cellular Or Even Subcellular Level. They Offer Dynamic, Real-Time, And Localized Drug Delivery, Which Is Particularly Useful For Treating Neurological Disorders, Chronic Pain, Inflammation, And More.

Following Are The Mechanisms Which Are Used In Bioelectronics Drug Delivery Systems:

1. Electrically Stimulated Drug Release
2. Ion Pumping Drug Delivery System
3. Neural Interface–Mediated Control (Closed-Loop Systems)

1. Electrostimulation-Controlled Drug Release:

Mechanism:

This Method Utilizes Externally Applied Electric Fields Or Electrical Pulses To Initiate The Release Of Therapeutic Agents From Specially Engineered Carrier Materials Such As Hydrogels, Conducting Polymers, Or Nanoparticles. These Carriers Are Often Designed To Undergo A Physical Or Chemical Transformation In Response To Electrical Stimulation, Which Facilitates The Controlled Release Of The Embedded Drug Molecules.

When An Electrical Current Is Applied, It Can Alter The Molecular Structure, Charge Distribution, Or Permeability Of The Drug Carrier. This Change Can Cause The Carrier To Swell, Contract, Or Undergo Oxidation-Reduction Reactions, Leading To The Regulated Release Of The Drug At The Targeted Site

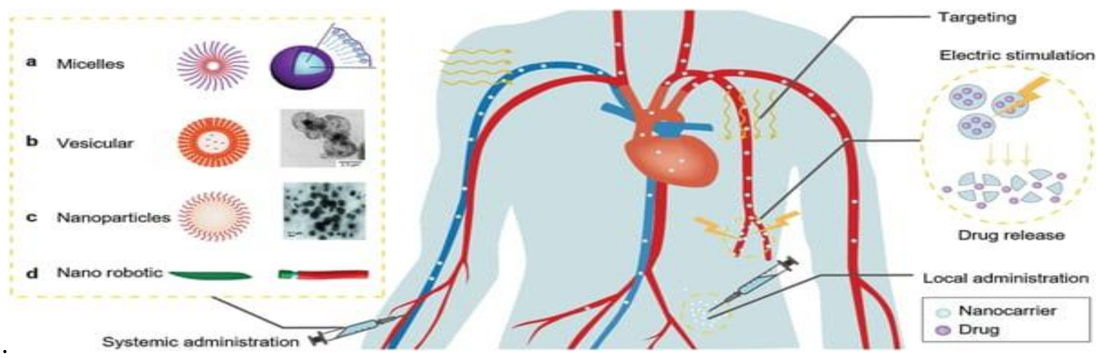
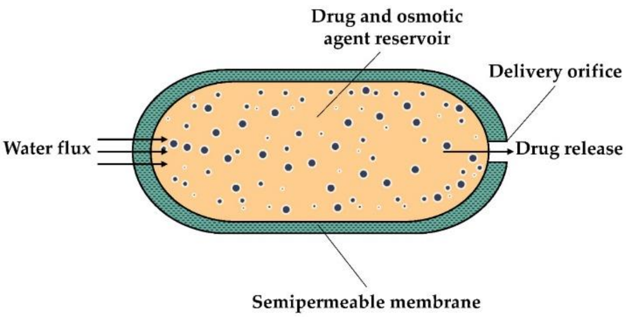


Fig. Electrostimulation Controlled Released Mechanism

2. Ion Pumping / Electrophoretic Drug Delivery

Mechanism Overview:

Ion Pumping, Also Known As Electrophoretic Drug Delivery, Involves The Controlled Movement Of Ions Or Charged Drug Molecules Across A Membrane Using An Externally Applied Electric Field. This Method Enables Highly Targeted And Minimally Invasive Delivery Of Therapeutic Agents, Especially In Sensitive Tissues Such As The Nervous System.



Microfabricated Ion Pumps Are Engineered With Ion-Selective Membranes That Allow Only Specific Ions Or Charged Molecules To Pass Through. When A Low Voltage Is Applied, These Pumps Generate An Electric Field That Drives The Transport Of The Drug Ions From A Reservoir Toward The Target Tissue. The Direction And Rate Of Delivery Can Be Precisely Modulated By Adjusting The Voltage And Duration Of The Stimulation.

Precise Dosing In Small Or Delicate Areas (E.G., The Brain Or Retina)

3. Closed-Loop Feedback Systems In Bioelectronic Drug Delivery:

Mechanism Overview:

Closed-Loop Feedback Systems Represent An Intelligent Approach To Drug Delivery, Wherein The Release Of Medication Is Dynamically Regulated Based On Real-Time Physiological Signals. These Systems Integrate Biosensors And Actuators Into A Single Platform, Creating A Self-Regulating Loop That Ensures Drugs Are Administered Only When Necessary And In The Appropriate Dosage.

Applications:

One Of The Most Well-Known And Impactful Examples Of Closed-Loop Systems Is The Glucose-Responsive Insulin Delivery Device For Diabetes Management.

In This System, A Biosensor Continuously Measures The Glucose Concentration In The Interstitial Fluid Or Bloodstream.

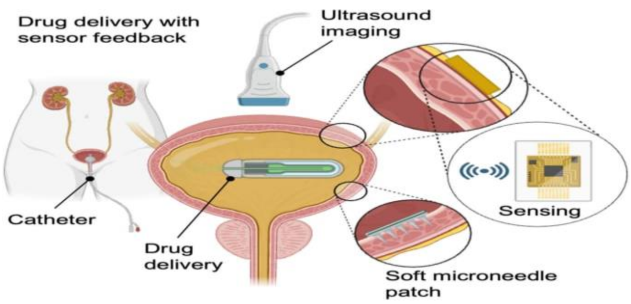


Fig. Closed Loop Feedback Systems

DESIGNING CONSIDERATIONS:

Designing Bioelectronic Drug Delivery Systems Involves Integrating Biology, Electronics, And Controlled Pharmacology To Precisely Deliver Therapeutic Agents. These Systems Are Aimed At Improving Drug Delivery Precision, Reducing Side Effects, And Enabling Real-Time Therapeutic Control. Below Are The Key Design Considerations:

Key Designing Considerations In Bioelectronics Drug Delivery System:

1. Electrically-Triggered Drug Release

Mechanism: Application Of An Electrical Signal Causes A Physical Or Chemical Change In The Drug Carrier Material, Leading To Drug Release.

How It Works:

Conductive Polymers Or Hydrogels Change Their Porosity Or Degrade Upon Electrical Stimulation.

Example: Polypyrrole Or Polyaniline Matrices Release Charged Drug Molecules When Voltage Is Applied.

2. Drug Compatibility And Stability

Requirement: The System Must Preserve Drug Activity Over Time.

Considerations:

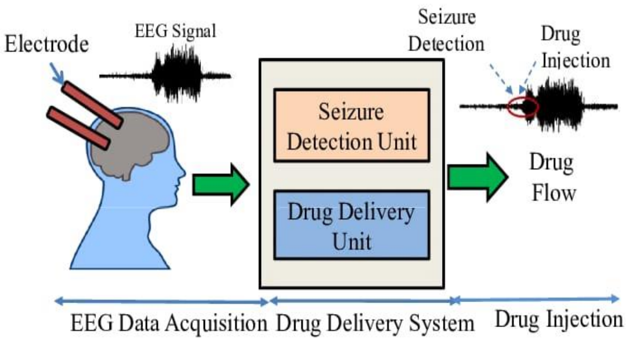
Protection From Degradation (Ph, Temperature, Light)

Encapsulation Methods That Prevent Premature Leakage

Compatibility With Small Molecules, Proteins, Or Biologics

3. Miniaturization And Implantability

Requirement: Devices Should Be Small Enough For Implantation Or Wearable Applications.



Following Are The Applications Of Bioelelectronic Drug Delivery System:

1. Targeted Drug Delivery

Bioelectronic Devices Offer Precise Control Over The Timing And Location Of Drug Release Within The Body. This Targeted Approach Significantly Reduces Systemic Side Effects While Enhancing The Therapeutic Effectiveness Of The Medication.

For Example, Implantable Microchips Or Nanoscale Electronic Systems Can Deliver Drugs Directly To Specific Sites Such As Tumors Or Inflamed Tissues, Ensuring That The Treatment Acts Exactly Where It Is Needed Most.

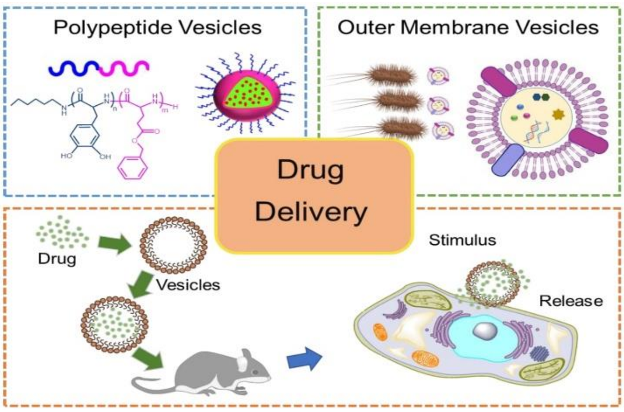


Fig. Targeted Drug Delivery System.

2. Neurological Disorders And Bioelectronic Drug Delivery:

Bioelectronic Drug Delivery Systems Offer A Novel And Highly Targeted Approach To Managing Neurological Disorders By Combining Precise Electrical Control With Pharmacological Therapy. These Systems Are Capable Of Detecting Abnormal Physiological Signals—Such As Irregular Brain Activity Or Changes In Neural Patterns—And Responding By Delivering Neuroactive Drugs Directly To Specific Brain Regions Or Nerves In Real Time.

This Level Of Precision Allows For Personalized And Adaptive Treatment Strategies, Especially In Conditions Where Timing, Dosage, And Localization Of Drug Administration Are Critical. By Delivering Medication Only When And Where It Is Needed, These Systems Can Significantly Reduce Systemic Side Effects And Improve Therapeutic Outcomes.

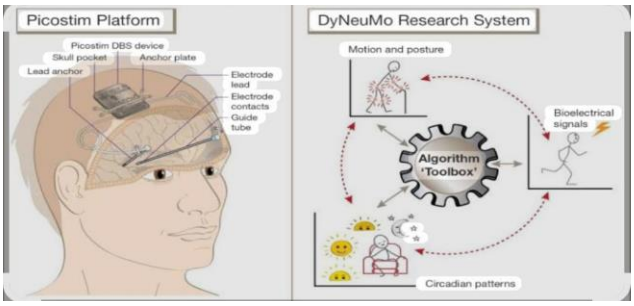


Fig. Bioelctronic Devices Used In Neurological Disorders

3. Diabetes Management Through Closed-Loop Insulin Delivery (Artificial Pancreas)

Closed-Loop Insulin Delivery Systems, Often Referred To As Artificial Pancreas Systems, Represent A Major Advancement In The Management Of Diabetes, Particularly Type 1 Diabetes. These Systems Integrate Three Core Components: A Continuous Glucose Monitor (Cgm), An Insulin Pump, And A Control Algorithm That Links Them Together In Real Time.

The Continuous Glucose Monitor Measures Glucose Levels In The Body At Regular Intervals—Usually Every Few Minutes—And Sends This Data To The Control Algorithm. Based On The Glucose Readings, The Algorithm Calculates The Precise Amount Of Insulin Needed And Instructs The Insulin Pump To

Deliver The Appropriate Dose. This Process Occurs Automatically, Mimicking The Natural Function Of A Healthy Pancreas.

Unlike Traditional Insulin Therapy, Where Patients Must Manually Monitor Glucose Levels And Administer Insulin, Closed-Loop Systems Significantly Reduce The Burden Of Self-Management. They Help Maintain Blood Glucose Within A Target Range, Thereby Minimizing The Risks Of Hyperglycemia (High Blood Sugar) And Hypoglycemia (Low Blood Sugar).

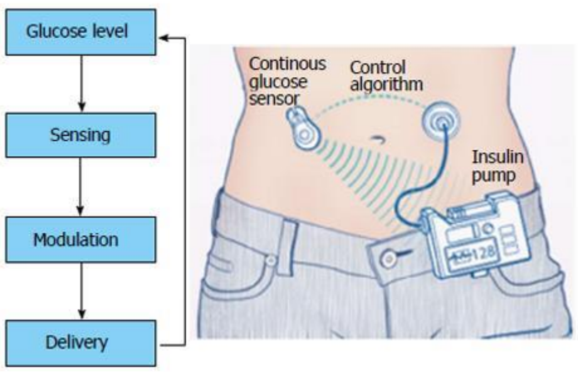


Fig. Closed Loop Insulin Delivery System

4. Wound Healing And Tissue Regeneration Through Bioelectronic Drug Delivery Systems:

Bioelectronic Drug Delivery Systems Are Revolutionizing The Field Of Wound Care And Tissue Regeneration By Enabling Precise, Real-Time, And Localized Drug Administration. These Systems Combine Biosensors, Smart Materials, And Sometimes Electric Stimulation To Enhance Healing, Reduce Infection Risk, And Promote Tissue Repair.

When These Indicators Cross A Certain Threshold, The System Triggers The Localized Release Of Antibiotics Directly At The Wound Site. This On-Demand Delivery Ensures Timely Intervention, Enhances Therapeutic Efficacy, And Minimizes Systemic Side Effects.

The Application Of Controlled Electric Fields Not Only Enhances The Delivery Of These Growth Factors But Can Also Direct Cellular Movement And Accelerate Healing, Mimicking The Body's Natural Bioelectric Signals Involved In Wound Repair. This Technology Holds Great Potential For Use In Chronic Wounds, Post-Surgical Recovery, Burn Treatment, And Regenerative Medicine

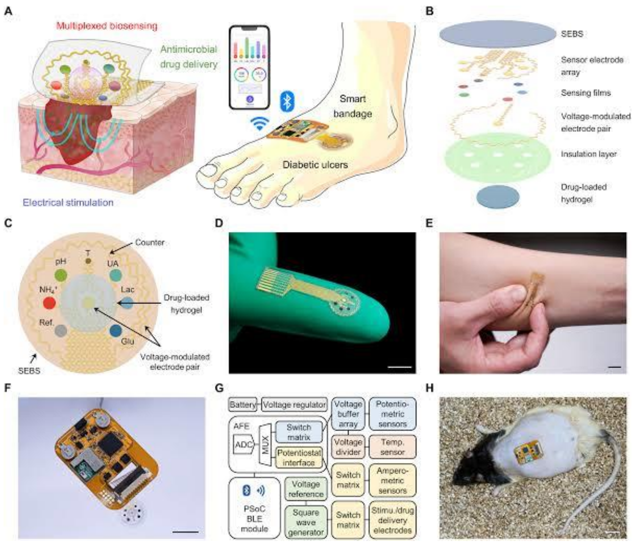


Fig. Wound Healing In Bioelectronics Drug Delivery System

CHALLENGES REGUARDING BIO ELCTRONIC DRUG DELIVERY SYSTEM:

1. Biocompatibility And Long-Term Stability:

One Of The Primary Challenges In Developing Bioelectronic Drug Delivery Systems Is Ensuring That Implanted Devices Can Operate Safely And Effectively Within The Human Body Over Extended Periods. These Devices Must Be Made From Materials That Are Biocompatible, Meaning They Do Not Provoke Adverse Immune Reactions Or Cause Damage To Surrounding Tissues.

2. Power Supply And Energy Efficiency:

A Critical Challenge For Bioelectronic Drug Delivery Systems Is Providing A Reliable And Long-Lasting Power Source To Operate Sensors, Processors, And Drug Delivery Mechanisms Continuously. These Devices Often Require A Steady Supply Of Energy To Perform Real-Time Monitoring And Precise Drug Administration Without Interruption.

3. Complexity Of Integration:

One Of The Major Challenges In Developing Bioelectronic Drug Delivery Systems Lies In The Seamless Integration Of Multiple Components—Such As Biosensors, Drug Reservoirs, Microprocessors, And Actuators—Into A Single, Compact, And Fully Functional Device. Achieving This Integration Is Crucial For Ensuring That The System Operates Reliably And Efficiently Within The

Limited Space Available, Especially For Implantable Devices.

4. Sensor Reliability And Accuracy:

Accurate And Reliable Sensing Is Fundamental To The Success Of Bioelectronic Drug Delivery Systems, As These Devices Rely On Real-Time Physiological Data To Make Critical Decisions About Drug Administration. Any Inaccuracies Or Failures In Sensing Can Lead To Inappropriate Dosing, Which May Compromise Patient Safety And Treatment Effectiveness.

One Major Issue Is Sensor Drift Over Time. As Sensors Operate Continuously Within The Body, Their Sensitivity And Calibration Can Gradually Degrade Due To Exposure To Biochemical And Mechanical Factors. This Drift Can Cause The Sensor Readings To Become Less Accurate, Resulting In Incorrect Feedback For The Drug Delivery System.

5. Drug Stability And Storage:

A Significant Challenge In Bioelectronic Drug Delivery Systems Is Maintaining The Potency And Stability Of Drugs Stored Within The Device Over Extended Periods. Many Therapeutic Agents, Particularly Biological Drugs Such As Insulin And Growth Factors, Are Highly Sensitive To Environmental Conditions, Which Can Compromise Their Effectiveness If Not Properly Managed.

One Of The Primary Concerns Is The Temperature Sensitivity Of These Drugs. Biological Molecules Often Require Strict Temperature Control To Prevent Denaturation Or Loss Of Activity.

6. High Cost And Manufacturing Complexity:

The Development And Large-Scale Production Of Bioelectronic Drug Delivery Systems Face Significant Financial And Technical Hurdles, Making Them Expensive To Manufacture And Limiting Their Widespread Accessibility. These Costs Arise From Several Key Factors Related To Materials, Fabrication Processes, And Customization Requirements.

First, The Use Of Advanced, Biocompatible Materials And Sophisticated Electronics Necessary For Implantable Devices Often Involves High-Cost Components. Manufacturing Techniques Such As Microfabrication, Cleanroom Processing, And Precise Assembly Require Specialized Equipment And Expertise, Further Driving Up Production Expenses.

7. Patient Acceptance And Usability:

A Critical Challenge For Bioelectronic Drug Delivery Systems Is Ensuring That Patients Are Willing And Able To Adopt These Often Complex And Sometimes Implantable Devices. Successful Treatment Depends Not Only On The Technology Itself But Also On The User's Trust, Comfort, And Ease Of Use.

Many Patients May Experience Fear Or Discomfort At The Idea Of Having Electronic Devices Implanted Within Their Bodies

FUTURE TRENDS:

1. Advanced Wireless And Energy Harvesting Technologies:

A Major Focus In The Future Development Of Bioelectronic Drug Delivery Systems Is The Creation Of Ultra-Efficient Wireless Power Transfer Technologies. These Advancements Aim To Enable Implants That Can Operate For Extended Periods Without The Need For Bulky Batteries Or Frequent Recharging. By Improving The Efficiency And Range Of Wireless Energy Transmission, Devices Implanted Deep Within The Body Can Receive A Continuous And Stable Power Supply, Enhancing Their Reliability And Patient Convenience.

2. Flexible, Wearable, And Minimally Invasive Devices

Future Bioelectronic Drug Delivery Systems Are Shifting Away From Traditional Bulky Implants Toward More Flexible, Lightweight, And Skin-Conformable Devices. These Next-Generation Technologies Include Wearable Patches And Microneedle Arrays Designed To Deliver Medications In A Painless, Continuous, And Controlled Manner.

3. Multimodal Sensing And Multi-Drug Delivery:

Combining Multiple Sensors To Monitor A Broader Range Of Biomarkers (E.G., Glucose, Ph, Oxygen, Inflammation) For Comprehensive Health Monitoring.

Devices Capable Of Delivering Multiple Drugs Or Combination Therapies With Precise Timing And Dosing Tailored To Complex Diseases.

4. **Closed-Loop Systems With Enhanced Feedback Control**

Advancements In Bioelectronic Drug Delivery Are Increasingly Focused On Developing Closed-Loop Systems That Can Automatically Regulate Therapy By Continuously Monitoring Physiological Signals And Adjusting Drug Administration In Real Time. These Systems Use Integrated Sensors To Gather Precise Data On The Patient's Condition—Such As Glucose Levels, Heart Rate, Or Other Relevant Biomarkers—And Employ Sophisticated Algorithms To Make Instantaneous Decisions About Dosage And Timing

5. **Personalized And Precision Medicine:**

The Future Of Bioelectronic Drug Delivery Is Closely Tied To Advances In Personalized And Precision Medicine, Where Treatments Are Tailored To The Unique Biological Makeup Of Each Individual. By Leveraging Detailed Information From A Patient's Genomic And Proteomic Profiles, Clinicians Can Design Customized Drug Formulations And Delivery Schedules That Optimize Therapeutic Effectiveness While Minimizing Side Effects.

Genomic Data Provides Insights Into A Patient's Genetic Variations That Affect How Drugs Are Metabolized, Transported, Or Interact With Their Targets. Proteomic Analysis Reveals The Expression Levels And Modifications Of Proteins Involved In Disease Processes, Allowing For A Deeper Understanding Of The Patient's Current Physiological State.

6. **Regulatory And Ethical Frameworks:**

As Bioelectronic Drug Delivery Systems Become More Advanced And Widely Used, There Is An Increasing Need To Establish Comprehensive Standards And Regulations Tailored Specifically To These Devices. Unlike Traditional Pharmaceuticals Or Medical Devices, Bioelectronic Systems Often Combine Hardware, Software, And Biological Components, Creating Unique Challenges For Regulatory Bodies. Developing Clear Guidelines Will Ensure The Safety, Efficacy, And Quality Of These Devices While Fostering Innovation Within A Well-Defined Framework.

CONCLUSION

In conclusion, the Wireless Vehicle Black Box system is a forward-thinking solution designed to enhance road safety by providing comprehensive data on vehicle accidents and driver behavior. By integrating sensors for real-time monitoring, GPS for location tracking, and GSM for rapid emergency alerts, this system ensures timely and accurate response during critical incidents. Future enhancements could include dash cam video recording and advanced analytics for predictive insights, potentially reducing accident risks further. This accessible and robust technology ultimately aims to support safer driving environments, aiding both accident analysis and emergency response efforts to protect lives on the road.

REFERENCES

1. Y W. Chien, Novel Drug Delivery Systems, 2nd edition, revised and expanded, Marcel Dekker, Inc., New York, 1992.
2. Robinson, J. R., Lee V. H. L, Controlled Drug Delivery Systems, Marcel Dekker, Inc., New York, 1992.
3. Pavlov, V. A., & Tracey, K. J. (2017). Neural regulation of immunity: Molecular mechanisms and clinical translation. Nature Neuroscience, 20(2), 156–166. https://doi.org/10.1038/nn.4477
4. N.K. Jain, Controlled and Novel Drug Delivery, CBS Publishers &Distributors, New Delhi, First edition 1997 (reprint in 2001).
5. S.P. Vyas and R.K. Khar, Controlled Drug Delivery -concepts and advances, VallabhPrakashan, New Delhi, First edition2002.
6. Wang, J., & Gao, W. (2014). Nano/microscale motors: Biomedical opportunities and challenges. ACS Nano, 6(7), 5745–5751.
7. Ultrasound-triggered drug delivery using stimuli-responsive hydrogels. (2025). Wikipedia. [Smart hydrogels activated by ultrasound for targeted release]

8. Fluidic enabled bioelectronic implants: opportunities and challenges. (2023). PMC Article. [Microfluidic, optofluidic and diffusion-controlled delivery systems through bioelectronic membranes] PMC
9. Hosseinidoust, Z., Mostaghaci, B., Yasa, O., Park, B. W., Singh, A. V., … Uspal, W. E. (2025). Biohybrid microswimmer. Wikipedia. [Biohybrid microrobots using RBCs and bacteria for precise drug delivery] Wikipedia
10. Biosensor Integrated Drug Delivery Systems as New Materials for Biomedical Applications. (2024). ChemRec, 24(2), e202300217. [Stimuli-responsive polymer systems & conductive composites in drug delivery] PubMed
11. Deshkar, S. S., Ovhal, K. G., Kothapalli, L. P., Shirolkar, S. V., & Pagar, R. R. (2024). Unveiling current advances in bioelectronic medicine: A comprehensive review. Drug Delivery Letters. [Review, Pune, India] Eureka Select
12. Google images.

HOW TO CITE: Saad Shaikh*, Mhaske Shubham, Shaikh Aman, Jagdish Nikam, Bhusal Dnyaneshwar, Thorat Prasad, Bhramharakshas Subadra, Gadekar Pratiksha, Ghorpade Trupti, Ghuge Prajakta, Bioelectronic Drug Delivery System:The Future Of Medicine, Int. J. Sci. R. Tech., 2026, 3 (5), 575-583. https://doi.org/10.5281/zenodo.20254918