ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

RECENT ADVANCES IN ELECTRO-ACTIVE SMART POLYMERS AS BIOSENSORS

Anupam Bhardwaj[*1], Pragya[2] & Sachin Kumar[3]
[*1,2] Amity University, Lucknow, [3]MVPG College, Lucknow)

ABSTRACT
Electroactive biomolecules are a part of a new generation of "smart" biomaterials that allow the direct delivery of electrical, electrochemical and electromechanical stimulation to cells. Conducting polymers have already found applications in various diversified areas, like display monitors, fuel cells, micro-surgical tools and bio-material. These materials are bio-degradable and bio-compatible, and can optimised for specific applications. This paper presents in a theoretical review of conductive polymers, their biocompatibility, synthesis, biomolecule doping and biomedical applications.

Keywords: *Conducting Polymer, doping, biocompatibility*

I. INTRODUCTION

Earlier all the polymers with carbon as their base were considered as insulators. But lately electronics industry has been using plastics widely due to its exceptional conducting property. Due to this unique property a new class of polymers emerged which was known as Electroactive of conducting polymers. The electrical conductivity of these polymers is due to the delocalization of pi-electrons or charge present as the essential part of the polymer chain. In conjugated polymers these pi-bonds are enormously sensitive to chemical or electrochemical reduction or oxidation. The nature of these conducting polymers can be extrinsic or intrinsic. Addition of dopant in the polymeric backbone can alter these physical properties. The electrical properties of these polymers can change over several orders of magnitude by altering the pH, applied potential and their environments.

These electroactive organic polymers are extremely selective, specific and stable in nature. These conducting polymers are implicated in diversified applications extending from photovoltaic equipment's, rechargeable cells, molecular electronics, biomaterials and microsurgical equipment's due to their useful electronic, redox and optical properties.

II. PROPERTIES AND STRUCTURE

In metals the high conductivity is due to the high mobility of free electrons throughout their structure whereas in polymers the it is due to the delocalization of pi-electrons in polymeric chain. Polyacetylene has a remarkable electronic properties and conjugated molecular structure, due to which it has been universally studies as a prototype for other electronically conducting polymers. For being electrically conducting a polymer must own charge carriers in addition to orbital system that allows the charge carriers to move. The conjugated structure provides the second requirement thrua continuous overlapping of pi-orbitals inside.

Doping
Organic polymers do not contain intrinsic charge carriers by nature therefore requirement of charge carriers is fulfilled by p-doping (fractional oxidation) of the polymeric chain with acceptor electrons or by n-doping (fractional reduction) of the polymeric chain with electron donor. The charge defects inherited due to such doping process are available as the charge carriers.

Electrochemical Doping
Due to high conjugation of pi-electrons, conjugated polymers can be fractionally oxidized or fractionally reduced acting as either electron source or electron sink.

Table 1: shows the dopant and conductivity of different electronically Conducting Polymer

S.No.	Polymer	Dopent	Conductivity (Ω^{-1} cm^{-1})
1.	Polyacetylene	I_2 Br_2, Li, Na, AsF_6	10000
2.	Polypyrrole	BF_4^-, ClO_4^-	500-7500
3.	Polythiophene	BF_4^-, ClO_4^-	1000
4.	poly phenyleneveinyl	AsF_3	100000
5	poly phenylene	AsF_3, Li, Na	1000
6	Polyaniline	HCl	200
7	Polyfuran	BF_4^-, ClO_4^-	100
8	PEODT	BF_4^-, ClO_4^-	50

Photo-doping
When exposed to radiation by the light energy of more than its band gap the conjugated polymer macromolecules can promote electrons into the conduction band example of which can be trans-polyacetylene. Although this type of photo generated charge carriers will disappear as the irradiation ceases, if an appropriate potential difference is applied during irradiation then electrons can be separated from holes, leading to photoconductivity.

III. APPLICATIONS

Due to different mobilized functional groups conducting polymers are used is specific applications involving biological, pharmaceutical or electrical properties. These applications can be summarized as,

Control Drug release
The drug delivery system currently used are best and effective with controlled output of drugs. The usage of conducting polymers in this area of bioanalytical science is of wide interest since their biocompatibility brings new possibilities of using them in vivo biosensor applications for continuous check of drugs in biological fluids or as initiative of opening up the field to a variety of new analytes. The release of various drugs and therapeutic proteins like nerve growth factor and heparin can be employed by the electrical stimulation of conduction polymers. The drug delivery system provides various new possibilities for the treatment of cancer and also least aggressive techniques for various neural and cardiovascular applications.

Biosensor
An analytical device, which includes sensing elements such as receptors, enzymes, nucleic acids, antibodies, cell, etc is termed as Biosensor. Enzymatic biosensor utilises bio specificity of a chemical reaction, with an electrode that produces potential difference for quantitative analysis.

For studying the effect of electrical stimulation on tissues and excitable cells for neuronal and cardiac engineering applications electro-active polyaniline forms are highly helpful.

The GO_x biosensor used as hydrogel PPy/P(HEMA) membrane is prepared by polypyrrol with enzyme also helps in screening of physiological disturbances of ascorbic acid, uric acid and acetaminophen.

Bio electrode

Due to easy synthesis procedure and their inherent electrical conductivity owed to electrochemical polymerization which happens on the surface, conducting polymers are attractive compounds for neural electrode alteration. Exchange of ions between tissues around and the electrodes is facilitated by the large surface area and porous structure. Alteration in conducting polymers can improve the differentiation and adhesion of nerve cells, like for example; enhanced nerve cell adhesion and spreading were seen on laminin fragment altered polypyrrole. Enhanced nerve cell differentiation was also seen and observed on polymers that were electrically conducting after electrical stimulation.

Bio actuators and Artificial muscle

Bio actuators are elements that can be used to recreate mechanical force, which can be used as artificial muscles and in close agreement to mimicking the natural muscle system.

The phenomenon of change in the volume of the conducting polymer scaffold upon electrical input has been utilized in the making of artificial muscle by creating bio actuators. Here two layers of conducting polymers are placed in a three-layer arrangement, here the middle layer comprises of a non-conductive material. When potential difference is applied across the two conducting polymer films, one of them gets oxidized and the other is reduced. The film that was oxidized expands due to the inflow of dopant ions, whereas the reduced film shrinks as it expels the dopant ions. [9]

They can then be monitored and controlled for injecting the target biomolecules at the fixed time and controlled speed. Anti-inflammatory (dexamethasone), anticancer (5-fluorouracil), anticoagulant (heparin) and antirheumatic (2,6-anthraquinone disulphonic acid) drugs have been used successfully and is injected with help of conducting polymers. The redox process causes a decrease in the volume of the conducting polymer as an outcome of uptake and expulsion of anions or cations as the polymers swell with ion uptake and shrink with ion expulsion

MicroPump

Change in the volume of conducting polymer in controlled way can be used to implement a micro pump system capable of moving fluids at a micro flow rate with high accuracy and precision.

Integrated Cell Sensor

Sensors based on Cell technology for sensing applications, starting from smell detection to pathogen classification are being developed. The structures used for confining the cells are micro-vials which can be open or close the path way using polypyrrole(pPy) bilayer actuators.

e caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract," will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named "Heading 1," "Heading 2," "Heading 3," and "Heading 4" are prescribed.

IV. CONCLUSION

Conducting polymers have found diversified applications in various fields like drug delivery, devices for neurosciences, cardiovascular equipment's, bioactuators, biosensors and the medical industry. The surface modifications that can brought about in conducting polymers should (i) facilitate the movement of charge carriers in between the tissue and implanted device , (ii) facilitate large difference in mechanical modulus, (iii) Reduce impedance to improve the sensitivity of the recording site (electrode), and (iv)Possess biocompatibility and display stability in the physiological environment. Functionality of conducting polymers with various biomolecules /

dopants has allowed biomedical engineers to change conducting polymers with biological sensing elements, and to turn on and off various signaling paths needed for different cellular processes. Conducting polymers provide an effective opportunity for implementing and fabricating highly stable, biocompatible, specific, selective, cheap and handy biomedical devices.

REFERENCES

1. *https://www.nobelprize.org/nobel./advanced-chemistryprize2000.pdf*
2. *DOI: 10.4028/www.scientific.net/MSF.42.207*
3. *Murat Atesa et. al , Conducting Polymers and their Applications, Current Physical Chemistry, 2, 224-240, 2012.*
4. *S.K. Mondal,et. al,Analysis of electrochemical impedance of polyaniline films prepared by galvanostatic, potentiostatic and potentiodynamic methods, Synth Met, 148 (2005), pp. 275–286*
5. *M. Gerard et. al, Application of conducting polymers to biosensors, Biosensors and Bioelectronics, vol 17(5), 345-359, 2005*
6. *Kumar S. et. al Phys. Lett A, 327(198) 2004.*
7. *Monika et. al, Synthesis of conducting polymer and charecterization. Ind. J. of Pure and App. Physics vol 48 , 523-526, 1010*
8. *R. Balint et.al. "Conductive Polymers: Towards asmart biomaterial for tissue engineering," Acta Biomaterialia , vol 10, pp 2341-2353, 2014 9. http:dx.doi.org/10.1155/2012/502707.*