

Intelligent Polymer on Targeted Drug Delivery System

Jeehan Mahamed Choudhary

Student of third year pursuing b. Pharmacy

Date Of Submission: 05-05-2021

Date Of Acceptance: 22-05-2021

ABSTRACT: Intelligent Materials, Also Known as Smart Materials, Are Capable of showing response to Various External Stimuli or Environmental Changes Like Temperature, Ph, Or Any Abnormal Cell Growth Etc. And They Rearrange Their Structure at A Molecular Level and Adapt Functionality Accordingly. Smart Polymers Are Composed of Polymers which optimizes the changes and Respond in A Dramatic Way to Very Slight Changes. Intelligent Polymers Have Proved to Be Useful in Pharmaceuticals and Healthcare. It Is Difficult to Create Drugs That Can Sustain the Extreme Acidity of The Human Stomach as the Stomach pH is Very Acidic; The Delivery of Drugs to Specific Points in The Body Without Deteriorating from Stomach Acid Is Nearly Impossible in Regards to Distribution of Drugs. In Light of This, Many Researchers and Scientists Have Proven Methods with Intelligent Polymers as A Way to Mediate and Control the Release of Drugs Until the Desired Area Is Reached. This Method is useful of Targeted Drug Delivery System.

KEYWORDS :Polymers, Molecular Level, Environmental Changes, External Stimuli, Deteriorating

I. INTRODUCTION

It Is Essential at The Beginning of This Article to Define What an Intelligent Polymer Is. Let us Clarify the Term "Intelligent" With More Accurate Standards, We Need to Look at How the Name Arises, Which Is Borrowed from Science-Fiction Literature as The Opposite of Those That Are Obtuse to Environmental Changes. A Polymer Is A Substance or Material Consisting of Very Large Molecules, Or Macromolecules, Composed of Many Repeating Units of Monomers. Due to Their Broad Spectrum of Properties, Both Synthetic and Natural Polymers Play Different Roles but Unique.

In Everyday Life, For Thousands of Years, Materials Are Instrumental for The Survival and Well-Being of Human Beings on Mother Earth. Early Materials Used Include Stones, Wood, Bark,

Skin, Bones, And Leaves for Shelter, Protection, And Treatment. The Major Categories of Innovations Have Seen Materials Move from Stone Age in The Seventeenth Century, Followed by Electrochemistry in The Eighteenth to The Periodic Table Era in The Twentieth Century. These Developments Have Made Drastic Changes in The Technology In Today's World. Innovations Have Led Us to Find and Also Solve Lots of Problems That We Face in Our Day-to-Day Life. These Problems Also Include Disease Treatment and Intelligent Polymer Is Proven to Be the Future of Medicines. These Innovation Can Also Be Used to Treat Diseases Like Cancer Which Include Abnormal Cell Growth. A Lot Has Been Discovered In Between. Now, The Polymers Piezoelectric, Magnetic, Thermoelectric, And Semiconducting Materials Seem Not Novel Anymore. However, These Materials and Their Devices Have Many Limitations, Such as Self-Control, Adaptability, Sustainability, And Intelligence, Which Are Necessary for The Modern Ways of Living. But, Doing Research and Finding Lots of Other Information About These Intelligent Polymers Can Help Us Resolve These Problems.

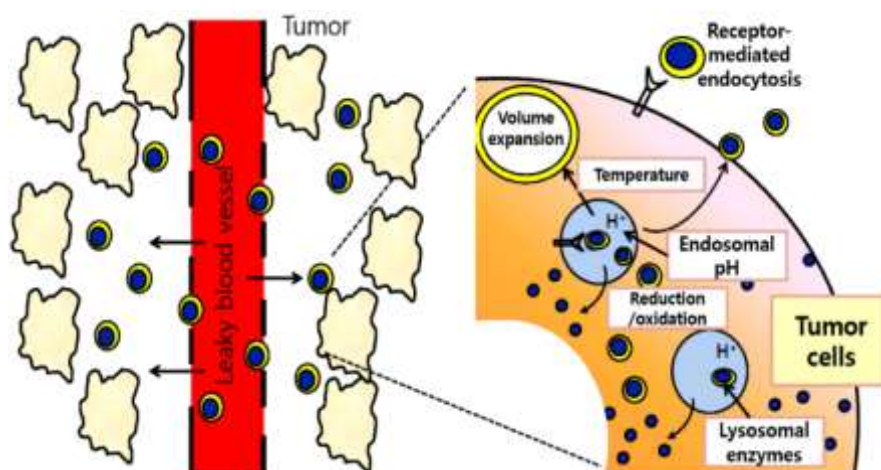
The Unique Properties of Polymers Have Long Been Gaining Attention and Scientists Are Doing Researchon How Can They Be Used in Various Fields. The Characteristics of Different Polymers Rely on How the Long Chains of The Molecules Repeat Themselves and Bond With Each Other. The Inherent Structure, Along with The Way Molecules Arrange Themselves and Cross-Link, and how they React to Environmental Changes. This Is An Important Property Of These Polymers. Intelligent Materials Should Have the Ability to Be Aware of External Stimuli and Learn from It to Optimize Response Behaviours for Achieving Their Choices or Goals to The Greatest Extent Via Applications Performance. From Past Years, Intelligent Polymers Have Been A Focus on Drug Delivery as They have Various Approaches in Healthcare. They Are Proven Effective Against Cancerous Cells. They Detect Them and Set the Target to Destroy Them Based on This Property.

How They Do It We Will Discuss Later in This Article.

Since These Polymers Are Responsive to Stimuli, They Are Able to Respond Quickly to Any Environmental Alterations. Any Change in Electrical Fields, Ph Levels, Temperatures, Wavelengths, And Light Intensity (The Polymers are Classified According to these) Can Also Influence the Intelligent Polymers' Colour, Shape or Other Physical and Chemical Properties. Intelligent Polymers Are So Sensitive to Their Environment That They Are Capable of Detecting the Slightest Change in Their Surroundings. Smart Polymers take Advantage of The Molecular Recognition and Produce Awareness

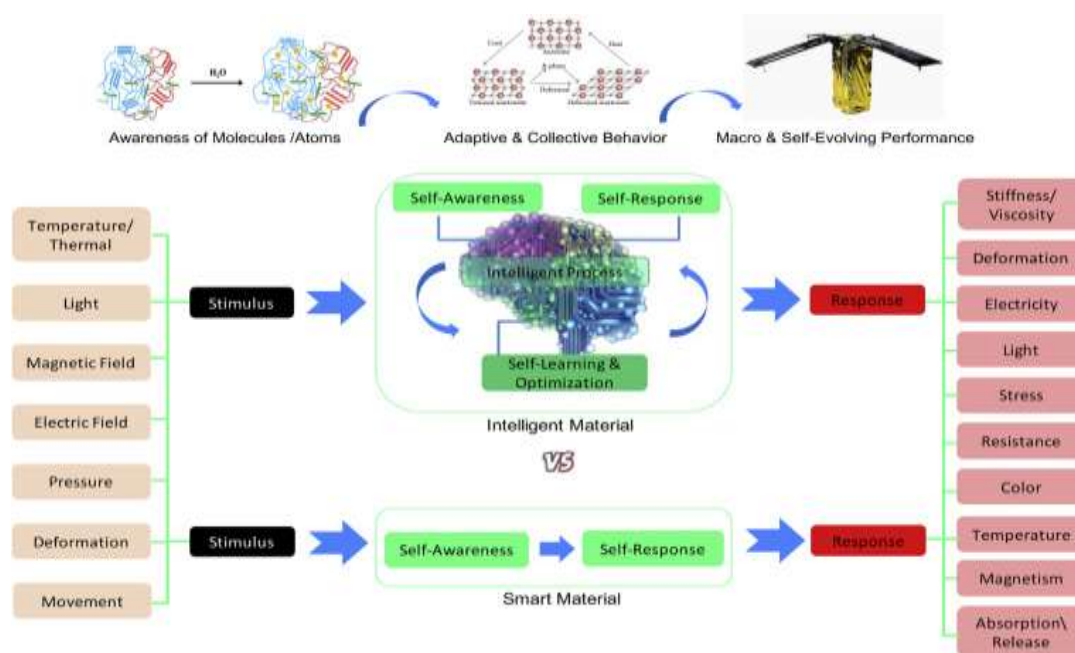
Systems and Polymer-Carriers to Facilitate Drug Delivery in The Body System. Polymers Play the Role of Carriers in Drug Delivery Technology That Can Control the Release of Therapeutic Agents in Periodic Doses.

Such Property of Polymers Are Futuristic and Can Help Us in Treating Many Diseases Which Require Target Drug Delivery. Cancerous Cells Are Abnormal Cells So They Are Detected Through This Targeted System Technology by Intelligent Polymers. On the Other Hand, Some Researchers Have Also Worked on Implementing Artificial-Intelligence Technologies in the Development of Polymers.



These Polymers Detect the Temperature of The Tumour Cells. As We Know When Blood Is Clotted the Temperature Rises in The Body and Around the Tumour Cells as Well. The Smart Polymers Detect the Slight Change and Try to Deliver the Dose in That Particular Part in Which the Tumour Cells Are Present. So Basically, Just

We Need to Create A Drug That Can Help Us Destroy Those Tumour Cells and The Delivery of That Drug Will Be Done with The Help of These Smart Polymers. Isn't It Helpful? Can We Do Think of Applying These in Other Diseases Which Are Life Threatening?



There is a Linear Response of Intelligent Materials in The Scientific Literature Which Judge the Intelligence According to Their Mechanisms, Self - Awareness and Applications. Intelligent Materials in the Existing Literature and Reports, Including Shape Memory Materials, And So on Are Not much Intelligent Enough but are Responsive. Over Here We Get the Difference Between the Intelligent Material and Smart Material. The Smart Material Itself Feels and Acts According to The Awareness. But Whereas the Intelligent Polymers Carries an Optimization Process. The Materials Are Different but When We Research on These Polymers and Their Functions It Will Help Us Understand Their Use and We Can Use Both the Materials for Targeted Drug Delivery System.

These Polymers Are Not Only Useful for Disease Treatment but Also Are Used in Textiles, Medical Devices That Act as A Prophylaxis or In Physical Examination, Robotic E-Skin Etc. But We in This Article Will Talk About These Smart Polymers Used in Pharmaceutical Industry and In Health Care. Thus, We Will Talk About the Advantages of These Polymers to Know What Makes Them Different and Why These Smart Polymers Should Be in Focused and Are Said to Be Future in Drug Treatment.

ADVANTAGES

What Makes These Smart Polymers Different from Other Coatings or I Would Say Other Sort of Technology or Innovation in Most Preferably

Target Drug Delivery System. Some Are Enlisted Below:

1. They Are Non-Thrombogenic -: Some Materials Reacts with The Blood and They Form A Clot, Sometimes the Reactivity of Such Materials Are Harmful for Them to Use in Our Biological System. But In case, Of Smart or Intelligent Polymers They Are Materials Which Do Not Form Thrombus or Clot, As When A Thrombus Is Formed It Blocks the Flow of Blood So Such Materials Which Forms A Clot or Thrombus Cannot Be Used in Our Biological System.
2. They Are Strong, Tough, Flexible -: The Property of These Smart Polymers Are Reliable and These Polymers Can Retain Their Shape in Case of Any Abnormalities in The External Stimuli. Some Polymers Are Not Strong Enough to Maintain Their Shape. The Flexibility of These Polymers Helps in Parts of The Bodies Like Stomach Etc. Where the Stomach pH Destroys Most of The Materials Which Can't Retain Their Structure and Can Be Melted in It. The Toughness of These Materials Carry Similar Explanation to That of Strongness.
3. Easy to Colour and Mould -: These Properties of Smart Polymers Is Really Easy for Manufacturing Such Materials. As Some Materials Are Hard to Colour Because Of Their Shape and Nature. As These Materials

Are Flexible So They Can Easily Be Moulded and Can Easily Be Prepared.

4. They Increase Patient Compliance -: As These Materials and Be Coloured They Show an Attractive Nature of The Drugs So That They Can Be Taken Easily for The Patients. They Are Not Bitter Much in Taste So It Also Deals with How Happy the Patient Would Be in Taking These Medicines. It Is Easy to Handle for The Patient and Don't Miss the Dose of Medicines.
5. Maintain Stability of Drugs -: These Polymers Are Strongly Bind to The Drugs and Even After Going to Certain Parts of Drugs Like Stomach or In Parts Where Some Materials Cannot Oppress the Temperature Or pH, They Maintain Their Shape and Doesn't Lead Out Contents from Drugs, They Are Easily Disintegrated and Also Doesn't Degrade.

CLASSIFICATION OF THESE SMART POLYMERS

1. pH Sensitive Smart Polymers
2. Temperature Sensitive Smart Polymers
3. Polymers with Dual Stimuli Responsiveness
4. Phase Sensitive Smart Polymers
5. Light Sensitive Smart Polymers

1. pH Sensitive Smart Polymers

How Can We Classify Whether the Substance or Solution Is Acidic or Basic? We Do That Is That Acidic Is A Substance That Gives H⁺ Ions or They Are the Substance That Donates Protons and Base Is Which Gives OH⁻ Or That Accepts Protons. pH Sensitive Polymers Detects the Change Based on This and Acts According to It. The Acidic pH Inflammates The Polymers but Basic pH Decreases the Inflammation. Examples Of pH Sensitive Smart Polymers Are Sulphonamide, Polyacrylic Acid, L- Histidine Etc.

2. Temperature Sensitive Smart Polymers

These Polymers Use the Technology of Detecting Temperatures of Their Surrounding When They Enter the Biological System. These Polymers Exhibit Certain Temperature of Their Own and By This They Can Detect the Change in Temperature. They Are Insoluble in Water. So, They Can Be Use in Absence of Solvents as Well. Examples of Temperature Sensitive Smart Polymers Are Polypropylene Oxide, Polyethylene Oxide Etc.

3. Polymers With Dual Stimuli Responsiveness

These Polymers Have the Properties of Both pH Sensitive and As Well As Temperature Sensitive Smart Polymers. They Can Detect Both The pH Change and Temperature Change of The Surroundings. The Cancerous Cells Show Abnormalities in The Parts of The Body So They Can Detect These as The Cancerous Cells Have Different pH And Also There Is Change in Temperature. They Are Made Up of Ionisable and Hydrophobic Functional Groups. This Is Because as We Know to Detect pH We Need To Know The Difference Between Acid And A Base So These Polymers Can Only Work If They Can Be Ionized In Of H⁺ And OH⁻ Ions. They Are Hydrophobic in Nature as They Detect the Temperature Change But Firstly, They Maintain Their Temperature In Water So For This They Need To Be Hydrophobic Nature. Examples of These Type of Polymers Are the Combination Made From pH Sensitive and Temperature Sensitive Polymers Like Acrylic Acid and Polyethyleneimine Etc.

4. Phase Sensitive Smart Polymers

These Polymers Are Mostly Used to Deliver Substances Which Are Not Compatible with The Parts of The Body. Like for Example Some Proteins Are Not Stable in Some Parts of The Body or It Can Be Said That It Is Hard to Be Stable in Stomach Ph So These Smart Polymers Are Used as A Coting Material for Such Types of Drugs So That They Can Easily Be Delivered in The Targeted Cell or Part. They Can Easily Be Manufactured, Doesn't Require Any Special Material or Any Sort of Hectic Work Done. Examples of Such Polymers Are Adding Lysozyme to Poly (D, L – Lactic Acid) Etc.

5. Light Sensitive Smart Polymers

These Polymers Are Biocompatible, They Ease in Controlling the Trigger Mechanism, Accurate, Low Mechanical Strength of Gel, Chance of Leaching Out of Noncovalently Attached Chromophores, Water Soluble. They Undergo Phase Transition in Response to Exposure to Light. Dark toxicity is the Disadvantage of light-responsive polymeric systems. They Are Classified Under Uv And Visible Light Based on The Wave Length. UvLight Have High Energy and Are Colourless with Lower Wavelength Whereas, Visible Have Low Energy Compared to Uv And Are Coloured with More Wavelength Than Uv. Examples of Such Polymers Are Synthesis by Using N – Isopropylacrylamide, N- Butyl Acrylate

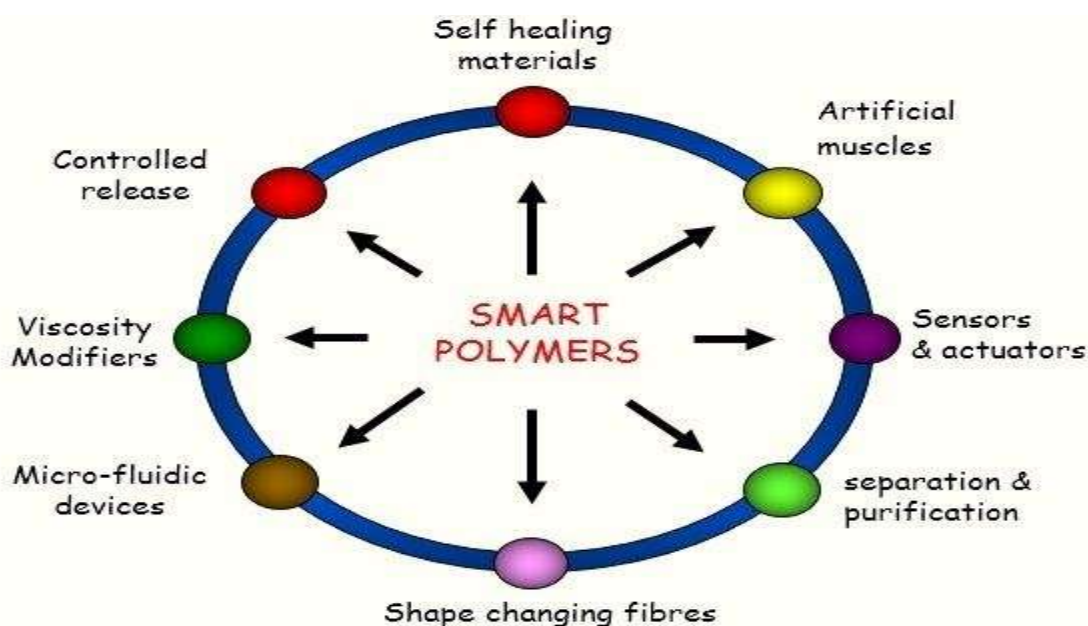
and Chlorophyllin Sodium Copper Salt as Monomers.

APPLICATIONS OF SMART / INTELLIGENT POLYMERS

1. Smart drug delivery system

2. Microfluidics and biomimetic actuators
3. Gene carriers
4. Cardiovascular implants
5. Reversible catalyst
6. Stimuli responsive stimuli

MECHANISM OF INTELLIGENT / SMART POLYMERS



The Smart Polymers Are Composed of All These Materials -:

1. Self-Healing Materials
2. Artificial Muscles
3. Sensors and Actuators
4. Separation and Purification
5. Shape Changing Fibres
6. Micro – Fluidic Devices
7. Viscosity Modifiers
8. Controlled Release

Their Mechanism Itself Is Built with All These Materials Like If We Take Example of Self-Healing Materials Sometimes When We Use These Materials in Some Parts with High Temperature Or pH, They Retain Their Shape Even If They Get Destroyed.

When They Are Made with These Materials, They Basically Show Action Upon These, Like When They Enter into The Body They Detect If There Are Any Change in All the Factors Such as pH Or Temperature Or Any Abnormal Cell

Growth, And After They Detect These They Show Their Action Upon The Site.

II. CONCLUSION

Smart Polymers Have Their Unique Property Which They Differ Themselves and Show A Promising Result in Targeted Drug Delivery Systems. These Polymers Can Be Used to Treat Gastric Diseases Where the Stomach pH Is More. These Polymers Not Only Can Be Used in Drug Technology or In Healthcare Systems but Can Be Used in Other Fields as Well. They Do Have Advantages as Well as Disadvantages Which Includes Problems with Stability, Kinetics Etc. They Can Be Used for Substances Which Are Not Compatible, Bioactive Agents. One of The Major Use of Such Polymers Can Be Used in Accu Check in Which Some Amount of The Blood Can Be Used to Check Futuristic Problems or Any Problems We Have. Currently, Smart Irrigations, Use in Detecting the Water Level in Certain Dams or Moisture Content in Certain Plants, Soil Erosion, Etc. Their Application of Being Controlled Release

Flexible Can Be Used in Many Technology in Future. Also, Many Have Discussed About These Polymersto Be Used in Toilets to Detect Urine and Any Sort of Problems to Identify in Out Body. We Do Urine Test but If We Apply This Technology in Our Own Toilets, We Can Be Able to Find Problems in Our House as Well. Although Intelligent Polymers Are Not Perfect or Completely Risk-Free, due to their stability and other problems.

The Industry Still Wishes to See What Can Be Positively Achieved in future in aspects like healthcare specially with Their Use and Application.

ACKNOWLEDGEMENT

I Would Like to Thank Prof. Masarrat Mukadam In Guiding Me to Publish This Journal

REFERENCES

Intelligent Materials - ScienceDirect	https://www.researchgate.net/publication/311997698_Smart_Polymers
https://www.bing.com/search?q=human+intelligence+on+polymer&qsn&form=QBRE&sp=1&ghc=1&pq=human+intelligence+on+polymer&sc=0-29&sk=&cvid=ABA0901FF30649A6B530CA7DF96CA3FA	https://www.sciencedirect.com/topics/engineering/smart-polymer
An Introduction to Intelligent Polymers (azosensors.com)	SMART POLYMERS: INNOVATIONS IN NOVEL DRUG DELIVERY Abstract (ijddr.in)
polymers-13-01427-v2.pdf	Gil ES, Hudson SM. Stimuli-Responsive Polymers And Their Bioconjugates. Prog Polym Sci. 2004; 29: 1173-1222.
Smart polymer - Wikipedia	Singh S, Singh J. Controlled Release Of A Model Protein Lysozyme From Phase Sensitive Smart Polymer Systems. Intl J Pharma. 2004; 271: 189- 196.
Smart Polymers - ScienceDirect	Stayton PS, Shimoboji T, Long C. Control Of Protein Ligand Recognition Using A Stimuli-Responsive Polymer. Nature J. 1995; 378: 472-475.
Smart Polymer - an overview ScienceDirect Topics	Jones RAL. Biomimetic Polymers: Tough And Smart. Nat Mater. 2004; 3: 209-210.
Smart polymers for the controlled delivery of drugs – a concise overview - ScienceDirect	P. Miaudet, A. Derré, M. Maugey, C. Zakri, P.M. Piccione, R. Inoubli, P. Poulin Shape and temperature memory of nanocomposites with broadened glass transition Science, 318 (2007), pp. 1294-1296