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ION EXCHANGE RESINS IN DRUG DELIVERY SYSTEM

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Abstract: Ion exchange resins are widely used in drug delivery systems (DDS) to improve drug stability, modify drug release, and enhance therapeutic efficacy. These resins are insoluble polymers with ionizable groups that can exchange their ions with ions in a surrounding medium. In DDS, ion exchange resins act as carriers that can bind to drugs and release them in a controlled manner, which is beneficial for achieving sustained or targeted drug release. The resins interact with drugs through ionic or electrostatic forces, and by manipulating the resin properties (such as particle size, porosity, and charge), they can influence drug loading and release rates. Applications include improving bioavailability, reducing side effects, masking unpleasant tastes, and protecting sensitive drugs from degradation. These features make ion exchange resins valuable in developing advanced DDS for both oral and topical drug administration.

INTRODUCTION

IER is defined as "Ion exchange resin cross-linked synthetic high molecular weight solid water insoluble usually white or yellowish, fabricated from organic polymer (polyelectrolyte) having ionisable functional group". Novel drug delivery systems are gaining momentum in the recent two decades as these results in reduced frequency of dosing and patient compliance. Intensity and duration of action has been the subject of increasing multidisciplinary research. One of the attractive methods for modified drug delivery systems is the use of ion exchange resins (IER) as carriers for watch systems [1] Complexes between IER and drugs are known as ion exchange resonates, which have been used in pharmaceutical formulations for several decades.

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One of the attractive methods for modified drug delivery systems is the use of ion exchange resins (IER) as carriers for such systems. Ion exchange resins are versatile materials used in a wide variety of applications, ranging from water purification to catalysis. These resins are made up of polymeric materials that have the ability to exchange ions with those in a surrounding solution, making them invaluable in industrial and environmental processes. This article will explore the principles behind ion exchange, the types of resins available, and their key applications.

What are Ion-Exchange resin?

- IER are the water insoluble, high molecular weight, crosslinked polyelectrolytes.
- Resins used are polymers that contain appropriately substituted acidic groups, such as carboxylic and sulfonic for cation exchangers; or basic groups, such as quaternary ammonium group for anion exchangers.
- IER have specific properties like available capacity, acid base strength, particle size, porosity and swelling, on which the release characteristics of drug resonates are dependent.
- An ion exchange resin is exhibited like small bead with a diameter between 1-2 mm.
- It is usually white or yellowish and it is fabricated from an organic polymer substrate backbone.
- Drug resonates are generally prepared with purified resins and appropriate drugs.
- Due to the versatile utility of ion exchange resins, they are being used for various drug delivery and therapeutic applications.
- Based on nature of ionic species interchange the
- IE process is known as either Cation exchange & Anion exchange.
- The drug is released from the resonate by exchanging with ions in the gastrointestinal fluid, followed by drug diffusion.

Properties of Ion exchange resins

- High molecular weight polymeric compounds.
- Cross-linked polymer matrix.
- Cross-linking accomplished by addition of divinyl benzene
- The polymer backbone contains the functional groups, which identifies the type of ion exchange resin.
- The functional group is also called as fixed ions.
- To the fixed ions are attached oppositely charged counter ions. These counter ions are exchangeable with ions of similar charge present in surrounding solution.
- Thus these polymers are called ion exchange resins.
- Insoluble in common solvents such as water.
- Ion exchange is a reversible process in which ions of like sign are exchanged between liquid and solid when in contact with a highly insoluble body.
- Due to the presence of high molecular weight water insoluble polymers, the resins are not absorbed by the body and are therefore inert.
- The most common resins used in formulations are cross-linked polystyrene polymethacrylate polymers. and 12
- There are numerous functional groups that have charge, only a few are commonly used for man- made IER.

➤ These are:
-COOH, which is weakly ionized to -COO,
-SO3H, which is strongly ionized to -SO3,

Advantages of Resinates

- ❖ Advantageous for drugs that are highly susceptible to degradation by enzymatic process.
- ❖ Low running cost.
- ❖ It requires little energy and the regenerated chemicals are cheap.
- ❖ If well maintained, resin beds can last for many years before replacement.
- ❖ Maintain drug levels in desired range
- ❖ Increased patient compliance
- ❖ Need for less dosing
- ❖ Economic and readily available
- ❖ Free from local and systemic toxicities.
- ❖ Drug-resonates can be formulated into various dosage forms like tablets, capsules, suspensions etc. Can be used for several purposes such as taste masking, sustained and rapid release.
- ❖ Effectively useful in low concentration (5-30% w/w).

Limitations of Resinates

- Release rate is proportional to the concentration of the ions present in the area of administration.
- Release rate of drug can be affected by variability in diet, water intake and individual intestinal content.
- Dose dumping is serious problem.

Types of Ion exchangers

- **Strongly Acidic Cation (SAC)**: These resins sport sulfonic acid groups. They're the water softeners, the demineralizers. Perfect for turning hard water into a gentle stream.
- **Strongly Basic Anion (SBA)**: With quaternary amino groups, these resins tackle silica, uranium, and nitrates. They're like the superhero janitors of the ion world.
- **Weakly Acidic Cation (WAC)**: Carboxylic acid groups define them. Great for dealkalization and handling salty streams.
- **Weakly Basic Anion (WBA)**: These resins flaunt primary, secondary, or tertiary amino groups. They're the all-rounders, effective for demineralization and acid absorption.
- And then there are the rebels—chelating resins. They're like the cool kids at the ion party, using iminodiacetic acid and other fancy tricks.

How to Select a suitable IER ?

- ❖ Exchange Capacity
- ❖ Degree of cross linking in Resin matrix
- ❖ Particle size of resin
- ❖ Nature of drug & site if drug delivery
- ❖ Swelling ratio

Method of preparing Drug- resin complex

- "Purification of resin
- "Changing the ionic form
- "Drug /resin reaction.

-Polymer-SO, Na+ Drug.HCI Polymer-SO-Drug+ NaCl
-Polymer-NR, Cr+Drug H
-Polymer-NR,+ Drug+HC1
-Polymer-NR, Drug.CO_2H Polymer-NR,H+Drug CO,
-Polymer-CO,H+ Drug.NH, Polymer-CO, Drug

- **Preparation of Resinate Takes Place By Two Techniques**

Drug loading on IER is equilibrium reaction

a. Batch technique
b. Column technique

Factors affecting Drug resin complex

- pH and temperature of the drug solution
- Molecular weight
- charge intensity
- Degree of cross linking
- particle size of the IE
- Ionic strength of drug
- The nature of the solvent

Application of ion exchange resin in pharmaceutical

1. Stabilization

Vitamin B12 is an example of a molecule that can deteriorate on storage.

2. Tablet Disintegration

Indion 414 as superdisintegrant in formulation of mouth dissolve tablets.

3. Extended Release

INDION Resins are formulated to a required particle size, degree of cross linking and functionalities for specific drug release. These Resins provide uniform, prolonged and predictable drug release characteristics.

Example 1. Nicotine chewing gum.
Example 2. Extended release diclofenac without enating

4. As a active ingredient

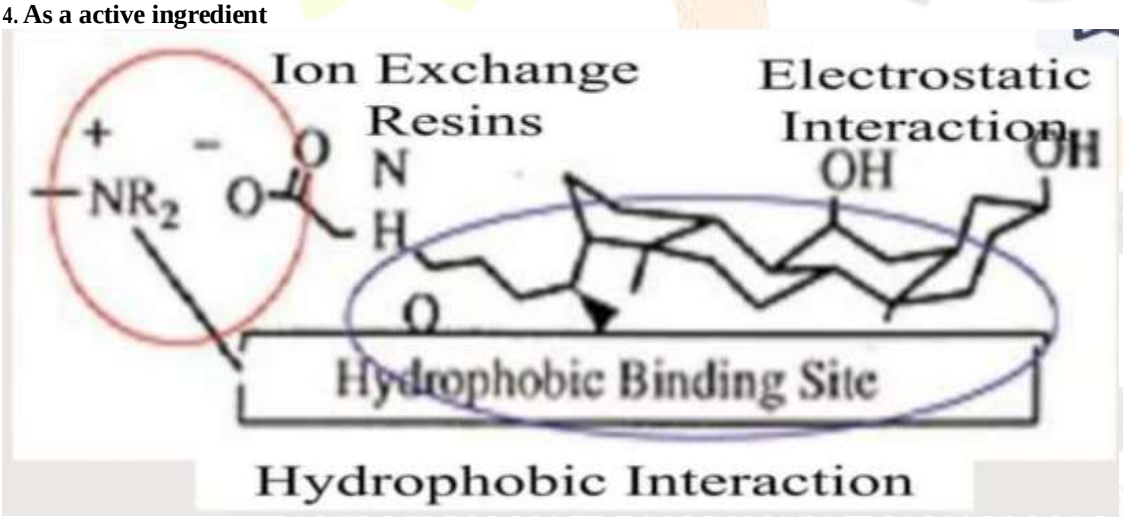

Fig no: 4 Hydrophobic interaction

5. Anti Deliquescence

6. **Polymorphism**

- A drug resinate is an amorphous solid that cannot crystallize or even form hydrates.
- The use of resinates can eliminate any problems with polymorphism.

7. **Antacid Preparations**

Purolite A 830 E MR is an antacid used to control gastric acidity in the treatment of peptic ulcers.

8. Multiple Benefits
9. Physical State
10. Poor Dissolution
11. **Taste Masking**

Bitter drugs are taste masked using ion exchange resins.

E.g. INDION RESIN USED FOR TASTE MASKING

Sr. No	Name of Resin	Name of drug
1	Indion 204	Norfloxacin, Ofloxacin, Roxithromycin, Dicyclomine Hydrochloride, Nalidixic acid
2	Indion 214	Azithromycin
3	Indion 234	Chloroquin Phosphate, Chloroquin sulphate, Ciprofloxacin HCL, Quinine sulphate, Lebexacin HCL, Methoclopramide HCL.
4	Indion 254	Bromhexine HCL, Dextromethorphan HBr, Limoxycin HCL, Pseudoephedrine HCL, Ambroxol HCL.

INDION RESINS USED AS TABLET DISINTEGRANTS

No	Name of the resin	Name of the drug
1	Indion 234	Erythromycin Stearate, Erythromycin Estolate, Streptomycin, Levonorgestrel, Nimesulide, Amoxycillin, Sulphamethaxazole + Trimethoprim
2	Indion 414	Fexofinadine hydrochloride, Ofloxacin, Roxithromycin, Azithromycin, Montelukast sodium

- Indion 414 is a pharmaceutical grade weak acid cation exchange resin

INDION RESIN USED IN SUSTAINED RELEASE DOSAGE FORM

Sr.No	Name of resin	Name of the drug
1	Indion 284	Isoxsuprine HCI, Diltiazem HCI
2	Indion 224	Pseudoephedrine HCI, Ephedrine HCI, Phenephedrine HCI
3	Indion 254	Morphine Sulfate, Codeine Phosphate. Bromhexine HCI, Dextromethorphan HBr, Neomycin sulphate
4	Indion 244	Phentermine, Amphetamine, Noscapine, Diphenhydramine, Theophylline, Lucanthone.

POLYMERS USED WITH RESINS:

Typical Polymer coating material

Sr. No.	Polymer coating material
1	Acrylics
2	Cellulose acetate phthalate
3	Ethycellulose
4	Ethycellulose colloidal dispersions
5	Ethylcellulose/ wax
6	Gelatin based polymer complexes
7	Hydroxypropyl methyl cellulose

Drug Delivery Systems using Ion exchange Resin

Ion-exchange resin	Drug	Types of system	Remarks
Dowex 1X2 1-4, 1-0	Theophylline	Microencapsulated resinate	The pattern of release of the drug was coated by the cross linking of the resin and the coating process used
Amberlite 1R-120 and Amberlite XE-69	PPA	Penn kinetic	Polyethylene glycol pretreatment of resonates to prevent rean hydration and swelling
Eudragit RS and Eudragit 1	Indomethacin	Microspheres	80% of the drug was released by zero-order kinetics
Eudragit RS 100 and Eudragit RL 100	Theophylline	Eudragit retard microcapsules	Microcapsules gave apparent first-order release profile and batch reproducibility
Amberlite IL-120	Metoclopramide	Resinate	Method for determining diffusion-controlled release drug from resonate was presented
Amberlite and Dowex IER	Propranolol	Resinate	Various factors afflicting loading and release studied
Indion CRP 244, Amberlite IR-120 Duolite C 20 and Duolite CB2210	Propranolol HCL CPM maleate Ephedrine HCI	Resonate and microencapsulated resonate	Drug release was influenced by acid-base strength and molecular weight of the drug
Dowex 50 W	PPA HCL PPA	Fibers filled with resinate	Polyurethane fibres encapsulated resonate were prepared and evaluated for is the and in vitro and in vivo release

Recent Patents for the use of Ion Exchange Resin in Drug Delivery

US patent	Issue date	Type of system	Model drugs	Remarks
4.221.778	September 9 1980	Penn kinetic system	PPA HCL Dextromethorphan	swelling of resonate is retarded by polyethylene glycol and coating of cellulose control of drug
4.869.461	August 22 1989	Coated resinate	PPA HCL	HPMC HPC, Sorbital HPS and PVP und an impregnating to improve coating
4.859.462	August 22 1989	Polymer-coated resinate	PPA HCL	HPMC HPC, Sorbital HPS and PVP und an impregnating to improve coating
4.894.239	January 16 1990	Microencapsulated resinate	Dihydrocodeine. PRA and di methyl ephedrine	Polyacrylate polymethacrylate polyamide and acrylate-methacrylate coating for controlling drug release
4,911.920	March 27 1990	Ophthalmic drug delivery Formulation containing IER	Betaxolol hydrochloride timolol	Carbopol and sulfonic acid CER control drug delivery
4.996.047	February 26 1991	Coated resinates	Dextromethorphan, pseudoephedrine	Different oral pharmaceutical Formulations, Chewable tablets, capsules, suspentions

Results and discussion

IER play a major role in the modification of drug release by forming a complex with drug substances.This seminar is review the literature bring to light the chemistry, properties, method of preparation as well as its different applications with the hope that researchers will utilise the resins more effectively in formulating controlled drug delivery systems.Ion exchange resins are widely used in drug delivery systems (DDS) to improve drug stability, modify drug release, and enhance therapeutic efficacy. These resins are insoluble polymers with ionizable groups that can exchange their ions with ions in a surrounding medium. In DDS, ion exchange resins act as carriers that can bind to drugs and release them in a controlled manner, which is beneficial for achieving sustained or targeted drug release. The resins interact with drugs through ionic or electrostatic forces, and by manipulating the resin properties (such as particle size, porosity, and charge), they can influence drug loading and release rates. Applications include improving bioavailability, reducing side effects, masking unpleasant tastes, and protecting sensitive drugs from degradation. These features make ion exchange resins valuable in developing advanced DDS for both oral and topical drug administration.

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