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Eudragit Nanofiber for Effective Coating in Colon-Targeted Drug Delivery

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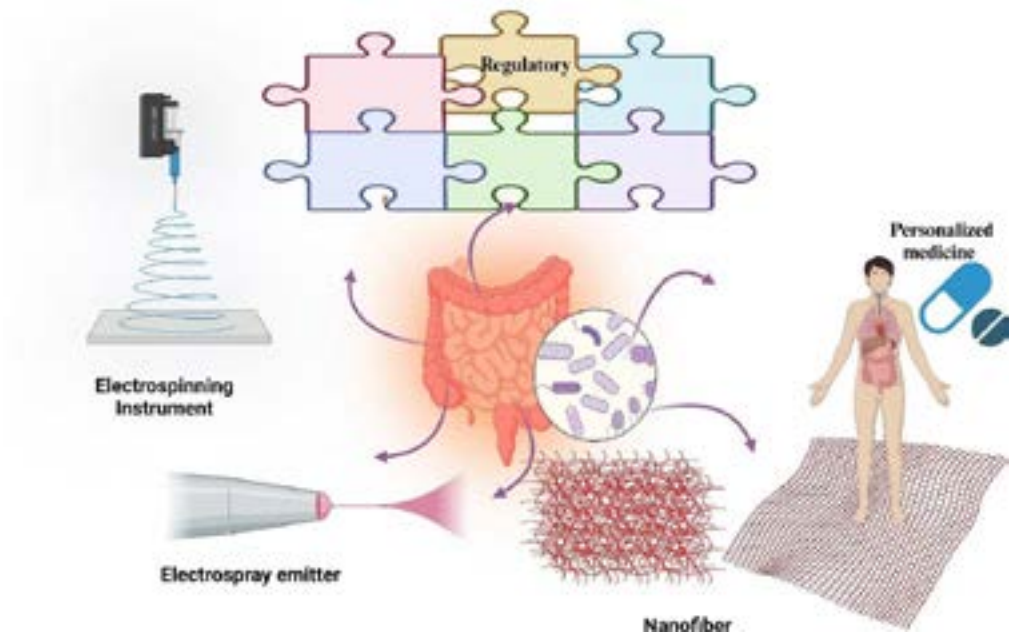
ABSTRACT

Eudragit nanofiber-based drug delivery systems offer a novel and promising solution for colon-targeted therapies. This review extensively covers the unique properties, fabrication methods, and therapeutic applications of Eudragit nanofibers in treating colonic diseases. Known for their pH-responsive solubility, Eudragit polymers enable targeted drug release in the colon, protecting the drug from early release in the stomach's acidic environment. The electrospinning process, essential for creating Eudragit nanofibers, facilitates high drug loading and controlled, sustained release. In vitro studies have shown these nanofibers' effective drug release, mucoadhesive properties, and permeability. In vivo animal studies demonstrate promising targeting efficiency, biodistribution, and therapeutic efficacy, especially for inflammatory bowel disease (IBD), colorectal cancer, and colonic infections. Despite their advantages, challenges remain, including maintaining consistent fiber morphology, scaling up production, and navigating regulatory hurdles. Nonetheless, the benefits—such as enhanced therapeutic efficacy, reduced systemic side effects, and better patient compliance—highlight Eudragit nanofibers as a superior option for advanced drug delivery. Future research should focus on developing smart, responsive nanofiber systems, personalized medicine approaches, and exploring new therapeutic applications. This review highlights the transformative potential of Eudragit nanofibers in colon-targeted drug delivery, aiming to improve treatment outcomes for patients with colonic disorders.



1. Introduction

Advancements in colon-targeted drug delivery systems have revolutionized the treatment of colonic disorders such as colorectal cancer, inflammatory bowel disease (IBD), and localized infections. These innovative systems have significantly improved the success rates of treating these conditions. These technologies improve the effectiveness of therapy, minimize unwanted side effects, and encourage patients to follow their treatment plans. The unique pH levels, enzyme activity, and microbiota found in the colon require specialized delivery techniques. Polymer coatings play a crucial role in ensuring that medications are not released too early and are protected from degradation in the upper gastrointestinal tract (GIT). This is especially important for colon-specific administration. Eudragit is a widely used polymer that is recognized for its ability to respond to changes in pH[1] . It is particularly effective at dissolving and releasing drugs in the higher pH environment of the colon. In addition, enzyme-responsive polymers are designed to degrade when exposed to colonic enzymes, which helps to improve the targeted release of the medication. Hybrid nanofiber systems have become a prominent area of study in the field of colon-targeted drug delivery, according to recent research. These systems utilize the power of nanotechnology and advanced polymer science to develop cutting-edge delivery platforms that surpass the constraints of conventional drug delivery methods. Hybrid nanofibers, created using methods like electrospinning, provide excellent surface area-to-volume ratios, enhanced drug loading capacities, and precise release profiles, making them ideal for targeted delivery applications[2]. This review offers a comprehensive examination of the recent advancements and challenges in the realm of hybrid nanofiber systems for drug delivery to the colon, specifically highlighting the application of polymer coatings. The importance of selecting polymers and designing nanofibers for precise drug release in the colon is emphasized. The significance of this research is highlighted by the statistical data. The management of IBD in the US leads to healthcare costs that surpass $6 billion each year, highlighting the importance of effective treatment strategies[3]. Eudragit polymers provide significant benefits, such as re-

lease that is sensitive to pH and enzymes, along with the ability to be formulated in various ways[4]. These systems improve the specificity of drug release, allowing medications to be released selectively in the pH range of the colon. They also offer durability and protection against the enzymatic and acidic conditions found in the upper gastrointestinal tract. Eudragit polymers offer a distinct advantage over traditional delivery technologies by providing precise control over release kinetics, ensuring consistent release rates. Researchers are currently investigating different methods to improve the efficiency of these delivery systems. For instance, researchers are currently exploring the combination of biodegradable polymers and bioactive compounds to develop versatile nanofibers that offer therapeutic advantages beyond just drug delivery. Developing stimuli-responsive systems that can accurately release drugs in response to specific triggers in the colonic environment, such as changes in pH or the presence of certain enzymes, has garnered significant interest. This review emphasizes the significance of Eudragit polymers and the crucial role they play in developing effective treatment plans. This article delves into the growing fascination and possibilities of hybrid nanofiber systems in drug delivery specifically targeting the colon. Although there has been notable advancement, there are still significant obstacles in achieving precise and effective drug delivery to the colon. This review aims to offer valuable insights for future studies and contribute to the advancement of colon-targeted drug delivery systems, making them more efficient and reliable[5]. This study explores the strategies used to formulate, fabricate, and characterize hybrid nanofibers.

2. Eudragit Polymers: An Overview

Eudragit polymers, a class of copolymers derived from methacrylic acid and its esters, have found widespread application in the pharmaceutical industry for precise and regulated drug delivery systems. The unique characteristics of these substances make them well-suited for a range of drug delivery purposes, such as targeted delivery to the colon. In this section, we will explore the chemical composition, drug release mechanisms, applications, advantages, and current research developments associated with Eudragit polymers[6].

2.1 Chemical composition and properties

Eudragit polymers are classified according to their functional groups and specific applications:

Eudragit L and S: Eudragit L and S are copolymers of methacrylic acid and methyl methacrylate with an anionic nature. Eudragit L dissolves at a pH higher than 6.0, whereas Eudragit S dissolves at a pH higher than 7.0. This pH-dependent solubility is well-suited for enteric coatings, guaranteeing the drug's release in the intestine rather than the stomach. This solubility characteristic safeguards the drug from the acidic environment of the stomach, enabling precise release in the colon.

Eudragit RL and RS: Eudragit RL and RS are copolymers of ethyl acrylate and methyl methacrylate with a low content of methacrylic acid esters. These substances are not soluble in water, but they can still expand and allow substances to pass through them. Eudragit RL exhibits a high level of permeability, while Eudragit RS demonstrates a lower permeability, rendering them appropriate for sustained-release formulations. The permeability of these polymers can be fine-tuned to regulate the drug release rate, resulting in a sustained therapeutic effect.

Eudragit NE: This versatile copolymer, a blend of ethyl acrylate and methyl methacrylate, boasts a neutral composition. It forms a flexible film that can withstand acids and alkalis, making it an excellent protective layer for medications. Eudragit NE's versatility is evident in its frequent use for protective coatings, thanks to its exceptional film-forming ability[5].

2.2 Different types of Eudragit

Eudragit E Series Composition: Eudragit E is a copolymer made from dimethylaminoethyl methacrylate and neutral methacrylic acid esters.

Characteristics: Eudragit E, a copolymer made from dimethylaminoethyl methacrylate and neutral methacrylic acid esters, has a unique ability to dis-

solve in gastric fluids with a pH below 5.0. This property makes it an ideal choice for drugs that require release in the stomach. Additionally, it is renowned for its exceptional taste-masking properties, making it a top choice for coating drugs with a bitter taste.

Uses: Eudragit E is commonly employed in immediate-release formulations, as well as for taste masking and moisture protection purposes. It is frequently used in oral dosage forms like tablets, granules, and powders.

Eudragit L and S Series Composition: Eudragit L and S are copolymers composed of methacrylic acid and methyl methacrylate, known for their anionic properties. The proportion of these components varies, as Eudragit L has a 1:1 ratio while Eudragit S has a 1:2 ratio.

Characteristics: These polymers demonstrate solubility that is influenced by pH levels. Eudragit L dissolves when the pH is higher than 6.0, while Eudragit S dissolves when the pH is higher than 7.0. This feature enables them to safeguard drugs from the acidic environment of the stomach and deliver them in the comparatively neutral or alkaline conditions of the intestine or colon.

Applications: Eudragit L and S are commonly employed for enteric coatings, providing protection for drugs that are sensitive to acid and enabling precise drug release in the intestine and colon. They are well-suited for medications designed to target the lower parts of the gastrointestinal tract (GIT), such as treatments for inflammatory bowel disease (IBD) and other colonic conditions[7].

Eudragit RL and RS Series Composition: Eudragit RL and RS are copolymers of ethyl acrylate and methyl methacrylate with a small amount of methacrylic acid esters. Eudragit RL has a higher concentration of quaternary ammonium groups compared to Eudragit RS.

Characteristics: Both polymers exhibit the unique property of being unable to dissolve in water, yet

Table 1: Various grades of Eudragit and their benefits in different dosage forms

Eudragit Grade	Drug Name	Dosage form/Delivery System	Method of Preparation	Application	Advantages	References
Eudragit S100	5-fluorouracil (5-FU) and leucovorin	Nanoparticles microencapsulated with enteric polymers	Ionic gelation followed by a solvent evaporation method	Chemotherapy for colon cancer that targets specific drugs for delivery to the colon.	Targeted drug delivery to colon, reduces systemic side effects	(9)
Eudragit RL100	Atazanavir	Nanoparticles	Nanoprecipitation method	To improve bioavailability in prolonged drug release	Enhanced bioavailability, prolonged release	(10)
Eudragit L100	Insulin	Thiolated Eudragit-based nanoparticles with reduced glutathione	Nanotechnology	Facilitate insulin permeation through the intestinal epithelium	Improved intestinal absorption of insulin	(11)

Table 1, continued.

Eudragit L100-55	Omeprazole	Nanoparticles	Ultrasonic dispersion and diffusion solidification	Nanoparticles showed a strong pH-sensitive release in vitro	pH-sensitive release, protects drug in acidic environment	(12)
Eudragit L100-55	Insulin	Enteric nanoparticles	Complex coacervation method	Complex coacervation process using chitosan and Eudragit L100-55 polymers may provide a useful approach for entrapment of hydrophilic polypeptides without affecting their conformation	Protects insulin from degradation, enhances intestinal absorption	(13)
Eudragit S100	Peptide Val-LeuPro-Val-Pro-Arg (VLPVPR)	Enteric-coated nanoparticles	Double emulsion method followed by freeze-drying	Nanoparticles almost completely released at pH 7.4 after 8 h, reduced blood pressure for more than 30 h	Prolonged blood pressure reduction, targeted release in the colon	(14)
Eudragit RS100 and RL100	Cloricromene	Nanoparticle suspensions	Quasi-emulsion solvent diffusion technique	Improves the shelf life and bioavailability of this drug after ophthalmic application	Enhanced stability and bioavailability, suitable for ophthalmic use	(15)
Eudragit RS100	Terbinafine hydrochloride	Positively charged controlled-release polymeric nanoparticles as an eye drop	Nanoprecipitation method	Increased drug means residence time and improved ocular bioavailability four-fold	Improved ocular retention, enhanced bioavailability	(16)
Eudragit RSPO	Ibuprofen	Microspheres	Solvent evaporation technique	Sustained release, reduced gastrointestinal side effects	Reduced GI side effects, prolonged pain relief	(17)

Table 1, continued.

Eudragit L	Tacrolimus	Enteric-coated capsules	Spray-drying method	Improved stability and bioavailability for immunosuppressive therapy	Enhanced stability, improved bioavailability, reduced dosing frequency	(18,19)
Eudragit E100	Propranolol hydrochloride	Floating matrix tablets	Direct compression	Prolonged gastric retention and sustained drug release	Prolonged gastric retention, consistent blood levels	(7)
Eudragit RLPO	Metoprolol tartrate	Transdermal patches	Solvent casting method	Enhanced transdermal permeation and sustained release for hypertension management	Improved patient compliance, sustained drug release	(20)
Eudragit NE30D	Diltiazem hydrochloride	Sustained-release pellets	Extrusion-spheronization	Controlled release for once-daily dosing in hypertension	Consistent drug release, improved patient adherence	(21)

they have the ability to expand and allow substances to pass through. Eudragit RL has a high level of permeability, while Eudragit RS exhibits a lower level of permeability. The variation in permeability enables the adjustment of drug release rates.

Applications: Eudragit RL and RS are commonly utilized in sustained-release formulations to achieve controlled drug release over an extended period of time. These delivery systems are ideal for situations where extended drug release is preferred, such as oral and transdermal applications.

Eudragit NE Series Composition: Eudragit NE is a copolymer made up of ethyl acrylate and methyl methacrylate, creating a neutral formulation.

Characteristics: This polymer creates a flexible film that is highly resistant to acids and alkalis, providing exceptional protective qualities. It does not dissolve in the gastrointestinal tract, but instead swells to regulate the release of drugs through diffusion.

Eudragit NE has various applications, including its use in protective coatings and sustained-release formulations. It is highly beneficial for safeguarding against moisture and improving the stability of drugs[5].

Eudragit NM Series Composition: Eudragit NM is a copolymer made from a combination of methyl methacrylate and methacrylic acid esters.

Characteristics: This polymer can create extremely flexible films that are resistant to cracking, which makes it perfect for long-lasting coatings.

Eudragit NM is commonly employed in film coatings for tablets and pellets to offer sustained-release characteristics and safeguard the active pharmaceu-

Table 2: Patents on Eudragit-based novel pharmaceutical formulation for drug delivery (https://patents.google.com/, accessed on 1 January 2020).

Sr. No	Title of the Patent	Essence of the Invention	Patent Number	Inventors	Date	Polymer(s) Used	Target Area
1	Sustained release pharmaceutical composition	Controlled dissolution of the active principle independently of the pH, which consists of microparticles containing the active principle, coated with a mixture of ethyl cellulose and Eudragit RS	EP0322277	H. Stevens, M. Chariot, F. Arnold, G. Lewis	22 /08/ 1992	Ethyl cellulose, Eudragit RS	General sustained release
2	Ketoprofen micro granules, the method for preparing same and pharmaceutical compositions	Ketoprofen micro granules of Eudragit RL and RS exhibited prolonged release	WO/2000/064432	L. C. Marechal, D.S. Pascal	2 /11/ 2000	Eudragit RL, Eudragit RS	General sustained release
3	Improved stabilization of misoprostol	Misoprostol was complexed with various grades of Eudragit RS series, Eudragit RL series, Eudragit S, and Eudragit L. The solid dispersions were stable and showed sustain release	EP0896823	C. David Tsay, R. Jen Lin Hue In Lu Shu-bin	25/09/ 2002	Eudragit RS, Eudragit RL, Eudragit S, Eudragit L	General sustained release

Table 2, continued.

4	Formulation stabilizer for proton pump inhibitors	The polymeric base is cholestyramine-OH, Eudragit EPO, chitosan, or a mixture thereof. The composition stabilizes the benzimidazole derivative proton pump inhibitor in a humid environment	US 20060013880	F. Robert, R. Narayan, Z. Joseph H. Ping	19 /01/ 2006	Eudragit EPO, Chitosan	Stomach
5	Modified release tablet formulations with enhanced mechanical properties	Eudragit L100-55 for a said pharmaceutical formulation achieves the desired hardness for tablets made from the formulation	US 20070104782	S. H. Amir C.E. Melissa	8/02/ 2007	Eudragit L100-55	General sustained release
6	Colonic delivery using zn/pectin beads with a Eudragit coating	The systems include pectin beads cross-linked with zinc or any divalent cation of interest, which beads are then coated with Eudragit®-type polymers	US 20080124279	A. Andremont H. Huguet	29 /05/ 2008	Eudragit	Colon
7	Colonic delivery of metal-dependent enzymes	Pectin beads are crosslinked with zinc ions, and the pectin beads are coated with a Eudragit® polymer.	US 20080199528	A. Andremont, H. Huguet	21/08/ 2008	Eudragit	Colon

Table 2, continued

8	Coated senna extract granules	Senna extract with 20% sennosides is granulated with Eudragit L 100 and then coated with Eudragit L 30 D 55	WO/2011/014976	P. H. Jorge	2 /10/ 2011	Eudragit L100, Eudragit L 30 D 55	General sustained release
9	Ursodeoxycholic acid-synthetic hydrotalcite-Eudragit hybrid, a pharmaceutical composition containing the same method for preparing the same	The ursodeoxycholic acid synthetic hydrotalcite-Eudragit hybrid was used for bitter taste-blocking effect and improved body absorption rate with high solubility	US 20120156263	J.H. Choy, G.E. Choi, M. C. Park, H. C. Chang	21/06/ 2012	Eudragit	General sustained release
10	Curcuminoid complexes with enhanced stability, solubility, and/or bioavailability	Curcuminoid–Eudragit complex, which enhances the bioavailability of the curcumin component	US20140271530	H. Tummala, S. Kumar	18/09/ 2014	Eudragit	General sustained release
11	Oral drug delivery formulations	One active substance and at least one coat comprising Eudragit E. The formulation may be used for releasing up to about 55% of a total dose as a loading dose to manage pain	US 20150250733	O. Isa	10 /09/ 2015	Eudragit E	General sustained release

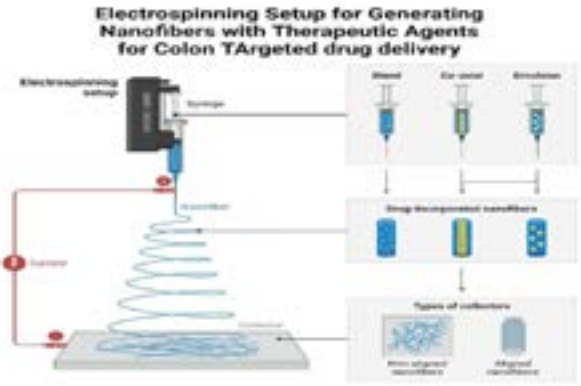


Figure 1. Formulation and development of Nanofiber using Electrospinning Technique.

tical ingredient (API) from external factors.

Eudragit polymers possess a wide array of properties that render them exceptionally adaptable for the creation of cutting-edge drug delivery systems. Through careful selection of the suitable Eudragit polymer, formulators can create drug delivery systems that cater to the unique requirements of the therapeutic agent, promote patient adherence, and enhance therapeutic results. For a wide range of pharmaceutical applications, Eudragit polymers offer reliable solutions, whether it is for immediate release, enteric protection, or sustained release[8].Table 1 highlights the various grades of Eudragit used for various dosage forms according to its suitability.

2.3 Applications in pharmaceutical formulations

Eudragit polymers are widely used in the pharmaceutical industry due to their versatility and unique properties. They allow for the development of various drug delivery systems tailored to specific therapeutic needs. These include enteric coatings, sustained release formulations, taste masking, moisture protection, targeted drug delivery, controlled release formulations, and film coatings for tablets and pellets. Enteric coatings protect drugs from the acidic environment of the stomach and ensure their release in more neutral or alkaline conditions of the intestine. Eudragit L and S are primarily used for enteric coatings due to their ability to dissolve at pH above 6.0 and above 7.0, allowing for targeted drug release in the small intestine or colon. This helps protect acid-sensitive drugs, minimize gastric irritation, and enhance drug bioavailability. Sustained release formulations aim to release the drug slowly over an extended period, providing a prolonged therapeutic effect and improving patient compliance. Eudragit RL and RS are commonly used in these formulations, with Eudragit RL allowing for faster drug release and Eudragit RS providing a slower release[20]. Taste masking is essential for improving the palatability of orally administered drugs, especially those with a bitter or unpleasant taste, thereby enhancing patient compliance. Eudragit E is used for taste masking due to its solubility in gastric fluids below pH 5.0, which allows it to effectively mask the taste until the drug reaches the stomach. Moisture protection is crucial for drugs sensitive to humidity and moisture, and Eudragit NE and NM are used to provide moisture-resistant coatings. These polymers form flexible, durable films that protect the drug from environmental moisture, ensuring consistent efficacy and safety. Targeted drug delivery aims to release the drug at a specific site within the gastrointestinal tract, such as the colon, to treat local conditions or enhance systemic absorption.[22] Eudragit L and S are used for colon-targeted drug delivery due to their pH-dependent solubility profiles and the ability to degrade in response to specific enzymes in the colon. Controlled release formulations control the release rate of the drug, providing a steady release over a specific period. Eudragit NE and NM are used for film coatings, with Eudragit NM being known for forming highly flexible films resistant to cracking[23].

3. Nanofiber Technology in Drug Delivery

Nanofiber technology is a highly promising and innovative approach in the field of drug delivery, thanks to its exceptional properties and versatile capabilities. This cutting-edge technology provides a multitude of benefits that can greatly improve the efficiency, precision, and efficacy of drug delivery

systems. This section offers a thorough exploration of nanofiber technology, delving into its fundamental principles, diverse fabrication techniques, significant benefits, and extensive applications in drug delivery. Through a comprehensive understanding of these aspects, researchers can harness the power of nanofiber technology to create state-of-the-art drug delivery systems that effectively tackle existing therapeutic obstacles and enhance patient outcomes[24,25].

3.1 Basics of nanofiber technology

The special qualities and possibilities of nanofiber technology make it a ground-breaking method of medication delivery. With widths often between 50 and 500 nm, these ultra-thin fibres provide several benefits for uses in drug delivery. Their large surface area-to-volume ratio increases drug loading capacity and speeds up drug release. They also produce porous structures that, during manufacture, may be regulated to enable effective drug encapsulation and release. Because nanofibers are very strong mechanically, they may be used in a variety of structurally sound drug delivery applications. Their versatility in materials—natural, synthetic, and hybrid—allows for customisation to suit certain therapeutic requirements. Nanofiber production requires several fundamental ideas and methods. Based on the application of a high-voltage electric field to a polymer solution, electrospinning is the most often utilized technique for producing nanofibers[26]. A polymer solution must be prepared, an electric field must be applied, a Taylor cone must be formed, a charged jet of polymer solution must be ejected, the polymer must solidify into nanofibers, and the nanofibers must be gathered on a grounded surface. Melt spinning, self-assembly, and phase separation are more techniques for producing nanofibers. High surface area, porosity, mechanical strength, and adaptability are just a few of the many advantages that nanofiber technology provides for drug delivery applications[27].Table 2 provides a details abouts the patents on Eudragit based formulations.

3.2 Methods of nanofiber fabrication

Nanofiber fabrication encompasses a variety of techniques, each with its own unique benefits and constraints. These methods are essential for creating nanofibers with specific properties and functionalities for drug delivery applications. Here is a concise overview of the frequently employed techniques for nanofiber production[28].

3.2.1 Electrospinning

Electrospinning is a commonly employed method for creating nanofibers, which utilizes a high-voltage electric field to transform a polymer solution or melt into delicate fibers. The process entails the preparation of the polymer solution, the application of an electric field, the formation of a Taylor cone and jet, and the subsequent stretching and solidification of the jet. The solvent evaporates, leading to the formation of solid nanofibers. This technique provides precise control over fiber diameter and morphology, allowing for the incorporation of various polymers and drugs. It is also scalable for large-scale industrial production. The process entails the application of a significant voltage between the needle and a grounded collector, leading to the creation of sturdy nanofibers[29].

3.2.2 Phase separation

Phase separation is a fascinating process that results in the formation of nanofibers by separating a polymer solution into two distinct phases. This process entails dissolving the polymer and drug in a shared solvent, which leads to phase separation as a result of temperature fluctuations or solvent evaporation. The phase rich in polymers forms nanofibers when the solvent is removed or the temperature is adjusted. This method is highly effective for certain polymers that are not compatible with electrospinning, resulting in the formation of distinct microstructures[30].

3.2.3 Self-assembly

Self-assembly is a fascinating phenomenon in which

polymers effortlessly come together to create nanofibers, without any need for external forces. The process includes the preparation of a polymer solution, triggering self-assembly by manipulating environmental conditions, and creating nanofibers through non-covalent interactions such as hydrogen bonding and hydrophobic forces. This method can generate nanofibers with exceptional uniformity and organization, rendering it ideal for the administration of sensitive pharmaceuticals that may deteriorate when exposed to elevated voltage or temperature[31].

3.2.4 Melting Spinning

Melt spinning is a fascinating process that involves heating a polymer to its melting point, then extruding it through a spinneret to create fibers. These fibers are then cooled and solidified using either air or liquid quenching. This method is ideal for heat-stable polymers and drugs, as it eliminates the use of solvents, making it more environmentally friendly.

Every nanofiber fabrication method has its own unique advantages and is well-suited for various types of polymers and applications. Electrospinning is a highly versatile and widely utilized technique known for its remarkable capability to generate nanofibers with precise diameters and morphologies. Phase separation and self-assembly offer different methods for polymers that are not suitable for electrospinning. Melt spinning provides a sustainable solution for materials that can withstand high temperatures. Having a deep understanding of these fabrication methods enables researchers to choose the most suitable technique for creating advanced nanofiber-based drug delivery systems that are customized to meet specific therapeutic requirements[32,33].

3.3 Advantages of nanofibers in drug delivery

Nanofiber technology provides numerous benefits for drug delivery systems, such as a significant surface area-to-volume ratio, precise release control, adaptability, improved drug absorption, and compatibility with living organisms. The expansive surface area of nanofibers enables greater drug loading capacities and accelerated drug release rates, thereby improving the dissolution rate of drugs with low water solubility. Nanofibers can be designed in such a way that they can release drugs in a controlled manner, which can greatly improve the effectiveness of treatment while minimizing any potential negative effects. They can be created using different polymers, enabling the customization of drug delivery systems to meet specific therapeutic requirements. The enhanced dissolution rate and bioavailability of poorly water-soluble drugs are attributed to the small size and high surface area of nanofibers, resulting in more effective treatments. In addition, numerous polymers that form nanofibers are compatible with the human body and can break down naturally over time. This helps minimize the chances of negative responses and makes it easier to deliver medication safely. Biodegradable nanofibers can break down into harmless substances, reducing any potential long-term consequences[34].

4. Rationale for Using Eudragit Nanofibers in Colon-Targeted Drug Delivery

The utilization of Eudragit nanofibers for colon-targeted drug delivery stems from their exceptional characteristics and the distinct obstacles linked to administering drugs to the colon. This section provides an explanation for choosing Eudragit nanofibers for this purpose, emphasizing their benefits in terms of pH-responsive behaviour, controlled release, and improved therapeutic efficacy[35].

4.1 Unique properties of Eudragit for colon targeting

Eudragit polymers are a highly effective drug delivery system that offers great versatility, making them an excellent choice for targeted treatment in the colon. Their solubility, which responds to changes in pH, enables accurate and effective delivery of therapeutic agents to the colon, thereby improving the treatment of colonic diseases. Various forms of Eudragit can dissolve at specific pH levels, enabling precise drug release in the gastrointestinal tract

(GIT)[36]. These characteristics guarantee the drug's safeguard against the stomach's acidic environment and its release exclusively in the colon's higher pH conditions. Eudragit polymers offer the ability to carefully control and maintain the release of drugs through precise adjustments to the polymer composition and fabrication process. Options like Eudragit RL and RS are commonly employed for controlled release purposes because of their varying levels of permeability. By manipulating the ratio of these polymers, one can achieve the desired release profile. Having precise control over drug release is essential for maintaining optimal drug levels in the colon, enhancing effectiveness, and minimizing the need for frequent dosing. Eudragit polymers provide exceptional protective properties for encapsulated drugs, guaranteeing their stability and integrity until they reach the desired location. These drugs are designed to safeguard against stomach degradation and enzyme exposure, allowing for extended usage in chronic conditions such as inflammatory bowel disease (IBD)[37]. Eudragit polymers provide a wide range of options and can be tailored to address specific therapeutic requirements. This adaptability enables the creation of specialized drug delivery systems for various methods of administration. The properties of Eudragit formulations, such as mechanical properties, degradation rate, and drug release kinetics, can be customized by modifying the polymer composition and processing conditions. The exceptional composition of Eudragit polymers, especially when utilized in nanofiber form, amplifies drug loading capacity and enables precise control over release profiles. Effective drug delivery to the colon, improved treatment outcomes for colonic diseases, and enhanced patient compliance are all benefits of Eudragit polymers, thanks to their high drug loading and controlled release properties[38].

4.2 Benefits of nanofiber formulations

Nanofiber formulations are incredibly efficient for drug delivery applications, especially for targeting the colon specifically. These formulations possess exceptional characteristics, including a remarkable surface area-to-volume ratio, impressive mechanical strength, and remarkable versatility in drug loading and release. Nanofibers possess a remarkable drug loading capacity owing to their expansive surface area-to-volume ratio. This unique characteristic enables the integration of a greater quantity of active pharmaceutical ingredient (API) into the nanofibers. The extensive surface area of nanofibers allows for increased drug attachment, resulting in enhanced drug loading capacity. The electrospinning process utilized for the creation of nanofibers enables the efficient encapsulation of drugs within the fiber matrix, safeguarding them from degradation and bolstering their stability[39,40]. Achieving controlled and sustained drug release is possible by manipulating the composition of nanofibers and the fabrication process, specifically by adjusting electrospinning parameters. This enables controlled release profiles, sustained release, and enhanced bioavailability. The enhanced dissolution rate of poorly water-soluble drugs is attributed to the high surface area and small diameter of nanofibers, resulting in improved bioavailability[41].Polymers such as Eudragit can be utilized for precise drug delivery, thanks to their pH-responsive properties that guarantee the drug is released exclusively in the intended location. This specialized release mechanism ensures that the medication remains shielded from the harsh acidity of the stomach and is instead released in the more alkaline conditions of the colon. Nanofiber formulations offer a shielding matrix for enclosed drugs, boosting their stability and safeguarding them from deterioration[42]. They shield medications from environmental elements like moisture, light, and oxygen, which can deteriorate the medication and diminish its effectiveness. Enclosing drugs within nanofibers provides a protective barrier against enzymatic degradation in the upper gastrointestinal tract, allowing the drug to remain intact until it reaches its intended destination(7). Nanofiber technology provides a wide range of options for drug formulation and various methods of drug delivery. This technology has the capability to transport a diverse array of

medications, encompassing small molecules, peptides, proteins, and nucleic acids. Furthermore, it offers multiple administration options, such as oral, topical, transdermal, inhalation, and injectable delivery. Several polymers utilized in nanofiber formulations possess biocompatibility and biodegradability, rendering them suitable for drug delivery applications. Through harnessing these advantages, researchers can create sophisticated drug delivery systems that enhance treatment results and encourage patient adherence[43,44].

5. Fabrication of Eudragit Nanofibers

The production of Eudragit nanofibers requires a series of intricate procedures and methods aimed at producing nanofibers with distinct characteristics ideal for drug delivery to the colon. An effective technique for producing Eudragit nanofibers is electrospinning, enabling precise manipulation of fibre size, structure, and drug containment. This section provides an overview of the electrospinning process, formulation considerations, and post-processing techniques for Eudragit nanofibers[45].

5.1 Electrospinning process for Eudragit nanofibers

Electrospinning is a technique employed to produce nanofibers from polymer solutions by utilizing a high-voltage electric field. The process entails choosing an appropriate polymer, like Eudragit L, S, RL, or RS, depending on the desired properties. The polymer is dissolved in a solvent, such as ethanol, acetone, or dichloromethane, to create a uniform solution. The active pharmaceutical ingredient (API) is carefully incorporated into the polymer solution, guaranteeing consistent drug dispersion within the nanofibers[46,47].

5.1.1 Equipment and setup

The polymer solution is carefully placed into a syringe using a fine needle. A high-voltage power supply is then connected between the needle and a grounded collector. The collector can either be a flat plate or a rotating drum, depending on the desired fiber alignment and morphology[48,49].

5.1.2 Process parameters

The electric field induces a charge on a polymer solution, forming a Taylor cone at the needle tip. When the field strength exceeds a critical value, a charged jet of polymer solution is ejected. This charged jet undergoes stretching and thinning, forming nanofibers. As the solvent evaporates, the polymer solidifies into nanofibers, which are collected on a grounded target. The solidified nanofibers form a non-woven mat of Eudragit nanofibers[50].

5.2 Formulation considerations

Eudragit nanofibers are carefully formulated with a range of factors to achieve the specific properties and performance that are desired. The viscosity and fiber diameter of the polymer solution are influenced by the concentration of Eudragit. Thicker fibers are observed when higher concentrations are used. The selection of solvent and solvent mixture also has a significant impact on solution properties, evaporation rate, and fiber morphology. Ensuring a consistent distribution and ideal release profiles, careful control of the drug content in the polymer solution prevents any negative impact on fiber formation and stability. The polymer solution is carefully injected into a syringe using a precise needle, while a powerful electrical current is connected between the needle and a grounded collector. The collector can either be a flat plate or a rotating drum, depending on the desired fiber alignment and morphology[46,51].

5.2.1 Solvent selection

The choice of a suitable solvent or solvent system plays a vital role in the successful production of Eudragit nanofibers through electrospinning. The selected solvent should have the ability to dissolve both the polymer and the drug, possess the required solution properties for electrospinning,

and prioritize safety and minimal environmental impact. Various solvents commonly employed for Eudragit nanofibers encompass ethanol, acetone, dichloromethane (DCM), methanol, tetrahydrofuran (THF), and dimethylformamide. Understanding polymer solubility is crucial for achieving a uniform solution, as Eudragit L, S, RL, and RS exhibit distinct solubility characteristics. It is important for the solvent to have the ability to dissolve the active pharmaceutical ingredient (API) to achieve consistent drug distribution within the nanofibers. Instability in the electrospinning process can arise when solvents with high volatility are used. Ensuring safety and minimizing toxicity are crucial considerations, particularly in meeting the stringent regulatory standards for pharmaceutical applications. It is imperative to have minimal residual solvents in the final product. Understanding the importance of viscosity and conductivity is essential for achieving stable electrospinning and successful fiber formation[52]. The choice of solvent plays a vital role in achieving the desired viscosity and conductivity of the polymer solution, which are essential for ensuring stable electrospinning and fiber formation. Environmental impact is also considered, with a preference for solvents that are less harmful and more environmentally friendly. Popular solvents for Eudragit nanofibers include ethanol because of its favourable solubility characteristics and relatively low toxicity, acetone for its high volatility, dichloromethane for its quick solvent evaporation during fiber formation, methanol for its capability to dissolve Eudragit polymers, tetrahydrofuran for its versatility, and dimethylformamide for its improved solubility[53] Various solvent mixtures are commonly employed to achieve a harmonious blend of volatility, solubility, and viscosity characteristics. Examples include combinations like ethanol/acetone, DCM/MeOH, and THF/DMF. These combinations aid in attaining the desired solution thickness and drug dissolvability, making it easier to create consistent nanofibers[54].

5.2.2 Drug-polymer interactions

The interaction between drugs and polymers is of utmost importance in the production of Eudragit nanofibers, which are used for delivering drugs specifically to the colon. These interactions have a significant impact on the physical and chemical characteristics of the nanofibers, as well as the efficiency of drug encapsulation, drug release patterns, and the overall effectiveness of the therapy. The interaction between functional groups of the drug and the polymer can significantly improve the drug's stability within the nanofiber matrix and have an impact on the rate at which the drug is released. The presence of Van der Waals forces, ionic interactions, hydrophobic interactions, and covalent bonds can have a profound impact on the efficiency of drug loading, the stability of encapsulation, and the profiles of drug release. Enhancing drug-polymer interactions can significantly improve the encapsulation efficiency, resulting in a greater incorporation of the drug into the nanofibers. Maximizing efficiency can be accomplished by fine-tuning the formulation parameters to encourage beneficial interactions. The stability of nanofibers can be influenced by the interactions between the drug and polymer, which help prevent drug crystallization and ensure a consistent distribution within the fibers. Positive interactions contribute to the preservation of the drug's amorphous state, thereby improving its bioavailability[55]. The nature and strength of drug-polymer interactions have a significant impact on drug release profiles. Powerful interactions can cause a more gradual and prolonged release, whereas less potent interactions may result in a quicker release. Customizing the interactions can assist in achieving the desired release profile, which is essential for successful drug delivery to the colon. The drug-polymer interactions can also have an impact on the mechanical properties of the nanofibers, including their tensile strength and flexibility. The enhanced mechanical properties guarantee the steadfastness and long-lasting nature of the drug delivery system based on nanofibers[56].

5.3 Post-processing techniques

Post-processing techniques can be employed to enhance the properties and performance of Eudragit

nanofibers. Performing crosslinking improves the mechanical strength and stability, while drying eliminates any remaining solvents using methods such as air, vacuum, or freeze-drying. Techniques such as plasma treatment or polymer coating can be used to modify the surface of nanofibers. This modification can improve the drug release profiles and biocompatibility of the nanofibers. These additional steps are essential for optimizing the performance and expanding the potential applications of the nanofibers across different industries[57].

6. Characterization of Eudragit Nanofibers

Eudragit nanofibers show great potential as a material for drug delivery purposes, especially when it comes to delivering drugs to the colon. Thorough characterization entails evaluating the physical, chemical, and functional properties of these nanofibers. Some of the methods used in this field include scanning electron microscopy (SEM), transmission electron microscopy (TEM), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), nuclear magnetic resonance (NMR) spectroscopy, tensile testing, in vitro drug release studies, X-ray diffraction (XRD), and atomic force microscopy (AFM)[58]. Scanning electron microscopy (SEM) is a powerful tool for analyzing the surface morphology and structure of nanofibers. It produces high-resolution images that offer detailed insights into fiber diameter, uniformity, surface texture, and the presence of any defects or beads. TEM, on the other hand, is used to analyze the internal structure and intricate morphology of nanofibers. DSC is used to analyze the thermal characteristics of nanofibers, including their melting point, glass transition temperature (Tg), and crystallinity[59]. TGA evaluates the thermal stability and composition of nanofibers by measuring the change in weight with increasing temperature. FTIR analysis reveals the presence of functional groups and chemical bonds within the nanofibers, providing insights into the interactions between the drug and polymer[60,61]. NMR spectra offer intricate insights into the chemical structure and molecular interactions, delving into the depths of intellectual exploration. Tensile testing examines the mechanical strength and flexibility of nanofibers, while in vitro drug release studies analyse the release profile of the encapsulated drug from the nanofibers under simulated gastrointestinal conditions. X-ray diffraction (XRD) is a powerful technique that allows for the characterization of the nanofibers and the encapsulated drug, revealing valuable insights into their crystalline or amorphous structure. AFM offers precise topographical imaging and accurately assesses surface roughness and mechanical properties at the nanoscale. To summarize, a thorough analysis of Eudragit nanofibers requires the use of multiple analytical techniques to evaluate their morphological, thermal, chemical, mechanical, and functional properties. These techniques guarantee that Eudragit nanofibers fulfill the necessary requirements for efficient drug delivery to the colon, resulting in enhanced therapeutic results and increased patient adherence[62,63].

6.1 In vitro drug release studies

Studying the release of drugs in vitro is essential in understanding the properties of Eudragit nanofibers for delivering drugs specifically to the colon. These studies offer crucial insights into the drug release kinetics, stability of the drug within the nanofiber matrix, and the efficacy of the nanofiber formulation in achieving controlled and targeted drug release. The goals of these studies involve analyzing the release profile, replicating physiological conditions, evaluating controlled release, and assessing drug stability[64]. The experimental setup consists of Eudragit nanofiber samples containing the drug of interest, dissolution media, USP dissolution apparatus, analytical instruments, and sample preparation. The release study is conducted in stages to mimic the journey of the nanofibers through the gastrointestinal tract. The dissolution procedure requires placing the nanofiber samples in the dissolution apparatus with SGF, keeping the temperature at 37°C, and stirring the medium at a designated speed[65]. Subsequent to the predetermined intervals, samples are extracted

from the dissolution medium and subsequently analysed in SIF and SCF for further examination. Drug quantification is carried out using UV-Vis spectrophotometry, HPLC, or another appropriate method[66]. Calibration curves are prepared using known concentrations of the drug to accurately determine the amount of drug released. The cumulative release calculation is performed to generate the release profile plot. When it comes to data interpretation, one must carefully analyse release data to understand the release kinetics. These kinetics can be classified into various models such as zero-order, first-order, Higuchi, Korsmeyer-Peppas, and Weibull. These models assist in maximizing the formulation and attaining the desired therapeutic results. The primary mechanism of drug release from the nanofibers is determined by diffusion, erosion, and swelling. Stability and consistency are assessed during the release process by comparing the initial and final amounts of the drug and ensuring uniformity in the release profile across multiple batches of nanofibers to confirm reproducibility. Ultimately, conducting in vitro drug release studies is crucial for understanding the properties of Eudragit nanofibers and verifying their efficacy in delivering drugs to the colon. Through the simulation of physiological conditions and the utilization of suitable analytical techniques, researchers can create drug delivery systems based on nanofibers. These systems provide controlled, sustained, and targeted release of medication, resulting in enhanced patient compliance and treatment effectiveness[45,66,67].

7. Mechanisms of Drug Release from Eudragit Nanofibers

Gaining a deep understanding of the intricate processes involved in drug release from Eudragit nanofibers is crucial to develop highly efficient drug delivery systems, especially for applications that require precise targeting and controlled release. The release of drugs from nanofibers can be affected by a range of factors, such as the polymer's properties, the drug's characteristics, and the conditions in the gastrointestinal tract. This section provides an overview of the main mechanisms involved in drug release from Eudragit nanofibers and discusses the various factors that can affect these mechanisms[45,68].

7.1 pH-dependent release

Diffusion is the main mechanism responsible for drug release from Eudragit nanofibers. It occurs due to a concentration gradient. The drug molecules flow through the polymer matrix, gradually releasing into the surrounding medium. The rate of diffusion is influenced by factors such as the concentration gradient, drug diffusion coefficient, and nanofiber porosity. Various factors contribute to the diffusion process, such as the composition of the polymer, properties of the drug, and the morphology of nanofibers. Eudragit RL, which has a higher permeability, enables faster diffusion in comparison to Eudragit RS. Understanding the properties of different drugs and the impact of nanofiber morphology on diffusion is crucial in determining the speed and path length of drug diffusion[69].

7.2 Enzymatic degradation

Enzyme-Responsive release is a technique that utilizes specialized enzymes in the colon to liberate drugs from nanofibers. Eudragit formulations may undergo degradation when exposed to colonic enzymes such as glycosidases and proteases. This degradation process leads to the breakdown of the polymer matrix and enables the release of the drug. Several factors contribute to the effectiveness of this release, such as the presence of enzymes and modifications made to the polymer. These factors can significantly improve the responsiveness of the release to colonic enzymes[70].

7.3 Diffusion-controlled release

Diffusion is the main mechanism for drug release from Eudragit nanofibers, propelled by a concentration gradient. The drug molecules flow through the polymer matrix, gradually releasing into the sur-

rounding medium. The rate of diffusion is influenced by factors such as the concentration gradient, drug diffusion coefficient, and nanofiber porosity. Various elements impact the process of diffusion, such as the composition of the polymer, the properties of the drug, and the morphology of the nanofiber. Eudragit RL, which has a higher permeability, enables faster diffusion in comparison to Eudragit RS. Understanding the properties of different drugs and the impact of nanofiber morphology on diffusion can provide valuable insights into their behavior[71,72].

8. In Vitro and In Vivo Studies

The development and assessment of Eudragit nanofiber drug delivery systems need both in vitro and in vivo experiments. Essential first data are provided by in vitro techniques like drug release profiling, mucoadhesion testing, and permeation investigations. Tests of the Eudragit nanofiber formulations in animal models are conducted in vivo to get information on biodistribution, effectiveness, safety, and therapeutic effects. Drug release rate and extent from Eudragit nanofibers under simulated gastrointestinal circumstances are determined in vitro using assessment techniques. Among the techniques include assembling a USP dissolving apparatus or Franz diffusion cells, churning the medium at a predefined speed, taking samples at predefined intervals, and replacing with new medium to maintain sink conditions. the drug content of the removed samples being analysed by HPLC, UV-Vis spectroscopy, or other suitable techniques. Plotting the drug release profile and calculating the total quantity of drug released at each time point are two ways that data analysis helps to ascertain the release kinetics and processes[73].Testing Eudragit nanofibers' adherence to mucosal surfaces is crucial to guaranteeing their long-term colonic retention. Using a modified tensile tester or texture analyzer, a sample of the nanofiber is applied to the mucosal surface, the force needed to remove the nanofiber is measured, and the peak adhesive force and work of adhesion are recorded. To determine the best composition, data analysis evaluates the adhesive qualities of many formulations. Studies of drug permeability via biological membranes determine the possibility of medication absorption in the gastrointestinal system. Franz diffusion cells may be put up, or changed utilizing chambers, synthetic membranes or resected intestinal mucosa, and routinely taking samples from the receptor compartment. Drug transport rate across membrane is evaluated, permeability coefficients are found, and cumulative quantity of drug absorbed is computed using data analysis[74].Tests of the Eudragit nanofiber formulations in animal models are part of in vivo assessment techniques to get information on biodistribution, effectiveness, safety, and therapeutic results. The highly defined physiology and simplicity of handling of animal models make them popular for colon-targeted administration. The treatment consists of giving the animals the nanofiber formulation orally or rectally, taking tissue samples at regular intervals from different sections of the gastrointestinal system, and utilizing the proper analytical techniques to detect the drug concentration in the tissues[75].Assessments of therapeutic effectiveness and safety examine the formulations of Eudragit nanofibers. Approaches include safety precautions, therapy, and illness models. Applications in the treatment of colonic diseases include the treatment of localized infections such as Clostridium difficile infection, the delivery of anti-inflammatory and antimicrobial drugs to inflamed diverticula, and the delivery of chemotherapy drugs directly to the colonic tumour site. Finally, the creation and assessment of Eudragit nanofiber drug delivery systems depend on in vitro and in vivo research. These investigations guarantee the efficacy, safety, and ability to enhance patient outcomes in a variety of colonic diseases using Eudragit nanofiber-based drug delivery systems by providing crucial early data and thorough insights into the therapeutic potential and safety of these formulations[65,76,77].

9. Comparative Analysis with Other Delivery Systems

Eudragit nanofibers show great potential as a viable option to traditional oral tablets and capsules

for the advancement of drug delivery systems. These nanofibers provide precise and regulated drug release, improved bioavailability, and a large capacity for drug loading, making them ideal for delivering drugs to the colon. Nevertheless, the construction of these systems can be more intricate compared to traditional ones, and their exceptional surface area-to-volume ratio enhances the rate at which poorly water-soluble drugs dissolve and become bioavailable(69). Traditional oral tablets and capsules offer benefits like straightforward manufacturing, patient comfort, and the possibility of systemic side effects. Nevertheless, they frequently lead to widespread drug distribution, resulting in decreased drug concentrations at the desired location and the possibility of systemic side effects[78]. Variable release profiles may not offer the precise and consistent release required for specific therapeutic applications. Microencapsulation and microspheres offer numerous benefits, including high efficiency in encapsulation, the ability to achieve versatile release profiles, and the flexibility to vary release profiles. Nevertheless, they also face production challenges and the possibility of burst release. Hydrogels possess numerous benefits, including their remarkable ability to swell, their compatibility with biological systems, and their ability to release substances at different rates[79]. However, their mechanical strength is often lacking, necessitating the need for additional support to maintain their structural integrity. Liposomes provide a reliable structure, controlled release, and targeting abilities, although they may be susceptible to instability and necessitate meticulous optimization of formulation parameters. Nanoparticles offer numerous benefits, including a large surface area, prolonged release, and flexible formulation[80]. Nevertheless, they can be quite intricate and necessitate specialized equipment for manufacturing. Nanoparticles can easily penetrate biological barriers and deliver substances directly to cells. However, it is important to note that over time, these particles may aggregate, which can impact their stability and how readily they are available for biological processes[81]. Certain nanoparticle formulations may offer a briefer period of drug release in comparison to nanofibers. Ultimately, Eudragit nanofibers present distinct benefits and drawbacks in comparison to alternative drug delivery systems. They provide precise and regulated drug release, improved bioavailability, and a large capacity for drug loading, making them ideal for delivering drugs to the colon. Nevertheless, the fabrication process can be more intricate than traditional systems, requiring researchers to carefully evaluate these factors to make well-informed decisions regarding the most suitable delivery system for their specific therapeutic applications[82].

10. Challenges and Future Perspectives

The development and application of Eudragit nanofiber-based drug delivery systems present numerous challenges and offer promising prospects. These factors encompass attaining uniformity and replicability in fiber structure, refining production methods, expanding manufacturing capabilities, choosing and reclaiming solvents, maximizing encapsulation effectiveness and drug durability, securing regulatory clearance, ensuring safety and biocompatibility, maintaining quality control, and minimizing environmental consequences[83,84].There are several technical challenges that need to be addressed in order to achieve desired outcomes in the field. These challenges include maintaining consistent fiber morphology, drug loading, and release profiles during the fabrication process. It is also important to standardize electrospinning parameters and optimize process conditions. Another hurdle is transitioning from lab-scale to industrial-scale production, which requires careful consideration. Additionally, ensuring safe and efficient solvent selection and recovery is crucial, as is optimizing polymer-drug compatibility[85]. Lastly, minimizing the environmental impact of solvent use and waste generation is an important aspect to be taken into account. Obtaining regulatory approval is essential for successfully navigating intricate regulatory pathways, adhering to guidelines regarding nanomaterials and drug delivery systems, and guaranteeing the safety and biocompatibility of Eudragit nanofibers. Establishing quality control measures

is crucial, and adopting green chemistry principles can help minimize environmental impact. Future research directions and potential innovations encompass cutting-edge fabrication techniques, individualized medicine, precise therapies, intelligent and adaptable systems, broadening applications beyond colon-targeted drug delivery, extensive in vivo studies, and models for chronic diseases. These areas will assist researchers in the development of drug delivery systems that are more effective, safe, and versatile, providing significant therapeutic benefits[86].The potential advancements in Eudragit nanofibers are exciting, with promising developments in advanced fabrication techniques, personalized medicine, targeted therapies, smart drug delivery systems, and expanded applications. By prioritizing these areas, researchers can enhance the development of drug delivery systems that are more efficient, secure, and adaptable, resulting in substantial therapeutic advantages. By tackling these challenges, researchers can create drug delivery systems that are more efficient, secure, and adaptable, resulting in substantial therapeutic advantages[50,72].

11. Conclusion

Eudragit nanofiber-based drug delivery systems provide a highly promising method for precise and regulated release of therapeutics in the colon. These systems possess distinct characteristics, including solubility that responds to pH, increased capacity for loading drugs, and the ability to precisely manipulate morphology and properties through electrospinning. Nevertheless, there are still obstacles to overcome when it comes to expanding production and guaranteeing consistency between batches. Studies conducted in a laboratory setting have shown that Eudragit nanofibers possess impressive drug release profiles, mucoadhesive properties, and permeation capabilities. Studies conducted in live animal models have yielded encouraging findings regarding the effectiveness of targeting, distribution throughout the body, and therapeutic effectiveness. Eudragit nanofibers have demonstrated promise in the treatment of a range of colonic ailments, such as inflammatory bowel disease (IBD), colorectal cancer, and infectious diseases affecting the colon. They provide localized drug delivery, which helps minimize systemic side effects and enhances therapeutic results. The potential impact of Eudragit nanofibers in colon-targeted drug delivery encompasses a range of benefits, including enhanced therapeutic effectiveness, minimized systemic side effects, improved patient adherence, and increased flexibility in drug formulation. Eudragit nanofibers can encapsulate a diverse array of therapeutic agents, such as small molecules, peptides, proteins, and nucleic acids. Upcoming advancements in this area involve cutting-edge nanofiber systems that intelligently release drugs based on specific physiological cues and personalized medicine strategies. Through tackling technical and regulatory obstacles and persistently pushing the boundaries of innovation, Eudragit nanofibers possess the capacity to completely transform the approach to managing colonic disorders. This has the potential to enhance therapeutic results and elevate the overall quality of life for patients. □

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