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Review Article

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A SCIENTIFIC REVIEW ON EUDRAGIT RS 100 AND RL 100 POLYMER BLENDS FOR COLON-SPECIFIC ORAL NANOPARTICULATE DRUG DELIVERY SYSTEM

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ABSTRACT
Colon-targeted oral drug delivery offers significant therapeutic advantages for local and systemic treatment of diseases such as inflammatory bowel disease, Colorectal Cancer, and parasitic infections. This study investigates the potential of combining 'Eudragit RS 100' and 'RL 100' polymers in nanoparticulate drug delivery systems to achieve controlled and site-specific drug release in the colon. The two polymers are water-insoluble and pH-independent, and the amount of quaternary ammonium groups can be varied, thereby enabling adjustment of permeability and drug release rate. Tailored release profiles can be achieved by varying the RS: RL ratio to meet specific clinical needs. Using this combination, nanoparticles demonstrated improved encapsulation, inhibition of early drug degradation, mucoadhesion, and longer colonic retention. The clinical relevance and versatility of these polymeric systems are also evident, as disease-specific applications have been noted, including indications for ulcerative colitis, Crohn's disease, and Colorectal Cancer. Overall, the Eudragit mixture of RS and RL provides a compelling basis for developing colon-specific nanomedicine.

INTRODUCTION

Colon-Targeted Drug Delivery Systems (CTDDS) have attracted significant interest in the field of pharmaceutical science because of their ability to deliver drugs to the large intestine, where many localized diseases, such as ulcerative colitis, Crohn's disease, and Colorectal Cancer, occur. Oral medications in the conventional dosage forms do not consistently deliver the drug to the target site, which causes the premature deterioration of medications in the stomach or the small bowel and limits the effectiveness of the drugs [1]. Nanoparticulate drug delivery systems, especially the ones intended to be administered via the oral route, provide an advanced alternative [2]. These systems offer agile drug encapsulation, surface adhesion to increase cohesion at the colonic site, and prolonged or regulated drug release, thereby achieving optimal pharmacokinetics and pharmacodynamics. Nanoparticle formulations using polymeric carriers are part of this technology, and the polymers employed are of particular significance relative to methacrylate-based polymers, namely Eudragit RS 100 and RL 100 [3].

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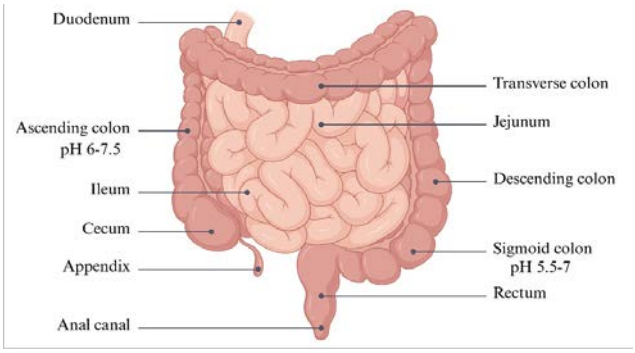

Figure 1: Anatomical structure of the Colon

AIM AND OBJECTIVES

This review critically evaluates the role of Eudragit RS 100 and RL 100 polymer blends in the development of colon-targeted oral nanoparticulate drug delivery systems. While several studies have described the physicochemical properties and individual applications of RS 100 and RL 100, a systematic discussion of their combined use as a dual-polymer platform for colon-specific nanoparticle formulations remains limited.

The specific objectives of this review are:

1. To summarize and analyse the physicochemical characteristics of Eudragit RS 100 and RL 100 that make them suitable for colon-targeted drug delivery.
2. To examine fabrication approaches, drug encapsulation strategies, and release profiles of RS/RL-based nanoparticulate systems.
3. To compare RS/RL combinations with other colon-targeted polymer systems in terms of performance, clinical relevance, and translational challenges.
4. To identify limitations in current research and highlight areas requiring further investigation for successful clinical application.

RESEARCH GAP

Although Eudragit RS 100 and RL 100 polymers have been widely investigated in pharmaceutical formulations, most existing studies focus on their individual applications in microspheres, tablets, or coating systems. Limited attention has been given to their combined use in the design of oral nanoparticulate carriers specifically for colon targeting. The available literature often remains descriptive, emphasizing polymer chemistry or fabrication techniques, without systematically examining how variations in RS: RL ratios affect drug encapsulation efficiency, release kinetics, mucoadhesion, and therapeutic outcomes in colonic diseases. Moreover, few reviews compare RS/RL nanoparticulate systems against alternative polymers or critically analyse their translational challenges, including scalability and clinical validation. This lack of comprehensive evaluation leaves a significant gap in guiding rational formulation design. Addressing this gap is essential to establish Eudragit RS/RL blends as a reliable platform for colon-targeted drug delivery in both experimental and clinical settings.

'Eudragit RS 100' and 'RL 100': Chemistry and Functional Attributes

Evonik Industries has created the Eudragit polymers, which are manufactured from synthetic copolymers of methacrylic acid and methyl methacrylate. The primary difference between the two, 'Eudragit RS 100' and 'RL 100', comes in the form of the extent to which quaternary ammonium groups are included in the materials. Eudragit RL 100 has more of these functional groups and, consequently, becomes more permeable and capable of absorbing more water [4]. Conversely, the number of ammonium groups is lower in 'Eudragit RS 100', resulting in reduced permeability and a more stable release profile. The two polymers are water-insoluble, may be swollen, and form semipermeable matrices during hydration, making them highly applicable in controlled-release drug delivery systems [5]. Moreover, they are cationic, which further enhances adhesion to the negatively charged colonic mucosal lining and promotes prolonged nanoparticle retention and improved therapeutic efficacy in the affected area [6].

Mechanism of Colon-Targeted Drug Delivery

The colon, whose pH is between 6.5 and 7.5, has limited digestive enzymes, a favourable microbial population, and a variety of microbial populations, making it an ideal site for drug delivery. Compared with the pH-sensitive Eudragits (e.g., Eudragit L or Eudragit S), RS/RL lack pH sensitivity and instead rely on swelling behaviour and matrix permeability to regulate drug release [7]. After reaching the acidic stomach and small intestine, these nanoparticles enter the colon and swell because the comparatively neutral pH and the prolonged residence time there are conducive to drug absorption via the polymer matrix [8]. The presence of colonic microflora can also degrade the matrix, particularly when blended with biodegradable excipients, thereby further facilitating site-specific release [9].

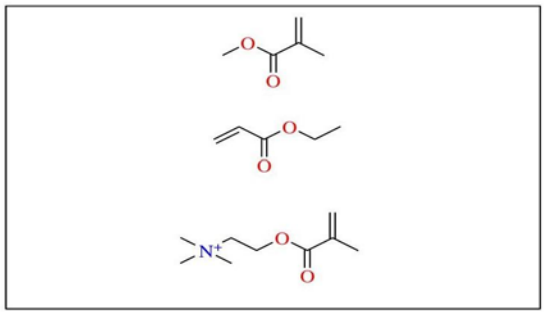

Figure 2: Eudragit RS

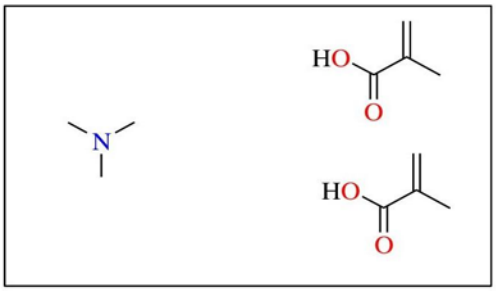

Figure 3: Eudragit RL

Combination of RS100 & 'RL100': Tuning the Drug Release

One of the key advantages of using Eudragit RS and RL in combination is the ability to fine-tune the drug release profile. The porous nature of the nanoparticles can also be modulated by varying the RS: RL ratio, thereby altering drug permeability and release profiles [10]. The higher the RL content, the more quickly the drug is released due to its high permeability, whereas a higher RS content slows the release dynamics [11]. A 1:1 may frequently appear as a balanced formulation that enables the drug to diffuse in the first phase and release slowly and steadily in the second phase. It is also beneficial, especially in treating chronic diseases such as IBD, in which there is a need to provide medication continuously over many hours to achieve the most effective results[12].

Nanoparticle Fabrication and Physicochemical Characteristics

Nanoparticle RS/RL combinations are typically produced by evaporation methods, with solvent-diffusion quasi-emulsification being the most commonly used. In the technique, the material is dissolved in an organic solvent. It also contains ethanol or acetone, which are emulsified in an aqueous medium using surfactants, such as Polyvinyl Alcohol (PVA), and then the liquids are allowed to dry under controlled conditions to obtain stable nanoparticles [13]. The type of solvent, surfactant concentration, stirring speed, and temperature significantly affect the resulting particle size, zeta potential, and encapsulation efficiency [14]. Physicochemical characteristics of RS/RL nanoparticles may be described in the following way:

The reason for the combination of 'Eudragit RS 100' and 'RL 100' used for the colon-targeted drug delivery system

Colon-targeted drug delivery systems (CDDS) aim to deliver therapeutic agents specifically to the colon to treat local diseases or to enhance the systemic absorption of drugs susceptible to degradation in the upper gastrointestinal tract. Among the various strategies and materials investigated for this purpose, 'Eudragit RS 100' and 'RL 100', both methacrylate-based copolymers, have emerged as leading candidates for nanoparticulate delivery systems [15]. Their combined use is particularly advantageous due to their tunable, pH-independent release properties and robust polymeric characteristics [16].

Both 'Eudragit RS 100' and 'RL 100' are water-insoluble, biocompatible, and non-biodegradable polymers composed of ethyl acrylate, methyl methacrylate, and a small proportion of methacrylic acid ester with quaternary ammonium groups [17]. The key difference lies in the proportion of quaternary ammonium functional groups: RS 100 contains a lower concentration (~5%), whereas 'RL 100' contains a higher concentration (~10%) [18]. These groups provide ionic permeability through the polymer matrix. As a result, RS 100 exhibits low permeability and sustains drug release, while 'RL 100' allows higher permeability and faster drug release. The combination of the two polymers enables a customized release profile, which is critical for ensuring that the drug is not released in the acidic stomach or proximal small intestine, but rather in the colonic environment, where drug absorption or local action is desired [19]. By adjusting the RS: RL ratio, commonly 1:1, 2:1, or 3:1, formulators can fine-tune release kinetics, encapsulation efficiency, and particle stability. For example, greater RS content is desired in delayed-release formulations, and prolonged release or higher RL content would enhance drug diffusion, which is beneficial when a faster onset is required upon drug arrival in the colon [20].

In addition, such polymers are not pH-dependent, unlike pH-sensitive systems, which often fail to work due to inter-individual variation in gastrointestinal pH. This guarantees more formulation ruggedness and multicentricity within patients. Additionally, the RS/RL nanomatrix exhibits mucoadhesion, thereby prolonging its residence time in the colon and increasing

local bioavailability [21]. It is also protective against enzymatic degradation in the GI tract and is particularly important for peptides or biologics. To conclude, the strategic mixture of Eudragit RS 100 and RL 100 takes advantage of their mutually compatible permeability pattern as a way of accomplishing correct, colon-specific discharge of medications, and the mixture is thus an impressive choice for the formulation of confided, patient-friendly, and curative, effective colon delivery nanoparticles for drug delivery.

Clinical Relevance and Disease-Specific Applications

Drug delivery specific to the colon is necessary in such diseases as Inflammatory Bowel Disease (IBD), which includes ulcerative colitis and Crohn's disease. They are chronic, relapsing inflammatory diseases that thus require local, persistent action in the colon to reduce systemic adverse effects [22]. The U.S. Centers for Disease Control and Prevention (CDC) estimated that IBD affects almost 3.1 million adults in the U.S., and it also costs about 6 billion dollars to treat the related illnesses [23]. The administration of drugs such as corticosteroids, amino salicylates, and immunomodulators using RS/RL nanoparticles has great potential to increase local therapeutic efficacy and diminish systemic toxicity [24]. Satranidazole-loaded RS/RL nanoparticles, formulated at a 1:1 polymer ratio, had an entrapment efficiency of 83.5%. In one such study, more than 95% of the drug was released within 16 hours at colonic pH. These in vitro results are highlighted by the efficacy of RS/RL systems in achieving extended and direct delivery. Other therapeutics, such as Mesalamine, Metronidazole, and curcumin, also yielded similar results, suggesting the broad applicability of the polymer in the formulation of hydrophilic and lipophilic drugs [25].

Table 1: Parameter and RS/RL Combination of 'Eudragit RS 100' and Eudragit 'RL 100'

Parameter	'Eudragit RS 100'	Eudragit 'RL 100'	RS/RL Combination	Ref.
Quaternary Ammonium Groups	Low	High	Modifiable based on the ratio	[10,11]
Water Permeability	Low (sustained release)	High (faster release)	Adjustable (modulated release profiles)	[13,14]
Mucoadhesiveness	Moderate	Strong	Enhanced retention in colonic mucosa	[16,17]
pH Sensitivity	Non-pH sensitive	Non-pH sensitive	Functional across GI tract; optimal at colon	[20,21]
Drug Release Profile	Sustained over 24 h	Faster, sometimes burst release	Tunable, hybrid burst + sustained	[23,24]
Particle Size Range (NPs)	100-300 nm	150-400 nm	100-350 nm, depending on fabrication method	[26]

Problem Statement and Rationale

Despite rapid advances in pharmaceutical technology, colon-targeted drug delivery remains a formidable challenge. The colon, being the terminal part of the gastrointestinal tract, is a favourable site for local treatment of diseases such as' Inflammatory Bowel Disease (IBD)', 'Irritable Bowel Syndrome (IBS)', and 'Colorectal Cancer' [26]. It also provides opportunities for systemic delivery of peptides, proteins, and chronotherapeutic agents. However, the hostile physiological environment of the upper gastrointestinal tract, characterized by acidic pH, digestive enzymes, and variable transit times, often degrades or prematurely releases drugs before they reach the colon [27]. Consequently, site-specific delivery to the colon remains largely suboptimal using conventional oral dosage forms. Statistical data reinforces the urgency of overcoming these limitations. Globally, more than 6.8 million people suffer from IBD. In the United States alone, the prevalence of IBD among adults reached approximately 3.1 million in 2015, and this number has been steadily increasing [28]. Additionally, 'Colorectal Cancer' ranks as the third most common cancer worldwide and the second leading cause of cancer-related deaths, with over 1.9 million new cases diagnosed in 2020[29]. These statistics underscore the pressing need for reliable, targeted, and efficient drug-delivery systems that improve therapeutic outcomes while reducing systemic side effects.

Traditional colon-targeting strategies, such as pH-dependent coatings and time-dependent release systems, often fall short due to interindividual variability in pH, gastrointestinal motility, and enzymatic activity. Consequently, there is growing enthusiasm for advanced nanotechnology-based strategies that provide more precise and controlled drug delivery. Polymeric nanoparticles have demonstrated significant potential owing to their desirable biopharmaceutical properties, including drug encapsulation, gastrointestinal stability, mucosal adhesiveness, and controlled release [30]. Nevertheless, a key challenge is selecting an appropriate polymer for colon-targeted nanoparticulate systems [31]. This substance should not only survive the conditions of

the stomach and small intestine, but also be released in a controlled or triggered manner in the colon. It should preferably have mucoadhesive properties to increase retention in the colon and enhance absorption at the local site [32]. Moreover, it must be biocompatible, scalable for manufacturing, and capable of encapsulating both hydrophilic and hydrophobic drugs[33].

'Eudragit RS 100' and 'RL 100' are widely studied methacrylate copolymers that meet several of these criteria[34]. While both are water-insoluble and pH-insensitive, they differ in the number of quaternary ammonium groups, which modulate their permeability and, hence, drug release behaviour. 'Eudragit RS 100', with a lower degree of ammonium functionality, exhibits a more prolonged release profile, whereas 'RL 100' allows for quicker release due to its higher permeability [35]. The ability to blend these polymers in varying ratios offers a significant advantage for tailoring the drug-release profile to specific clinical needs [36]. The problem, however, lies in the limited systematic exploration of the combined use of RS 100 and 'RL 100' in the context of colon-targeted oral nanoparticulate systems[37]. Most current studies have focused either on single-polymer systems or on their use in microspheres, tablets, or coatings, rather than specifically on nanoparticles designed for colon delivery [38]. Moreover, although it is established that blending RS and RL modulates release kinetics, a knowledge gap remains in determining the optimal blend ratios, fabrication conditions, and physicochemical parameters required to develop a stable, reproducible, and therapeutically effective nanoparticle formulation [39]. From a pharmaceutical standpoint, designing such systems also presents manufacturing and scale-up challenges. The choice of organic solvent, stabilizer, particle size, zeta potential optimization, and entrapment efficiency are critical variables that can affect the final product's clinical viability [40]. Furthermore, while in vitro studies provide promising data, there is a lack of robust in vivo models and clinical translation, limiting real-world applicability [41]. Another pressing concern is patient compliance and convenience. The chronic nature of colonic diseases necessitates long-term drug administration [42]. Nanoparticulate systems that enable reduced dosing frequency and fewer side effects could substantially improve the quality of life and adherence to therapy, particularly in pediatric and geriatric populations [43]. Given that over 70% of patients with ulcerative colitis experience relapse within the first year of remission, a robust colon-targeted nanoparticulate system could prevent relapse by ensuring steady, localized drug delivery[44]. Hence, the rationale for this research lies in the apparent clinical and technological gaps in the current colon-targeted drug-delivery landscape [45]. A comprehensive exploration of 'Eudragit RS 100' & 'RL100' as a combined polymer matrix for the development of colon-targeted oral nanoparticles could address a critical unmet need [46]. By focusing on optimizing formulation parameters, characterizing physicochemical & biopharmaceutical properties, and evaluating in vitro release behaviour under simulated GI conditions, this study aims to provide valuable insights into targeted drug delivery [47]. Additionally, this research aligns with the broader goals of personalized medicine, in which tailored drug-release kinetics can be matched to disease pathology, patient-specific factors, and therapeutic goals [48]. It also supports pharmaceutical sustainability by potentially reducing drug doses and administration frequency, thereby lowering treatment costs and minimizing side effects [49].

Comparative Evaluation of Eudragit RL/RS vs. Other Polymers

The selection of polymeric carriers plays a decisive role in the success of colon-targeted drug delivery systems. Among the wide range of natural and synthetic polymers, Eudragit RL 100 and RS 100 have gained prominence due to their favorable balance of physicochemical stability, mucoadhesion, and tunable permeability [50]. Compared with other widely used polymers, such as chitosan, alginate, pectin, and cellulose derivatives, distinct advantages and limitations emerge. Natural polymers such as chitosan and alginate are biodegradable and biocompatible, making them attractive for nanoparticulate delivery [51]. Nonetheless, their activity is frequently impaired by lot-to-lot variability, rapid hydrolysis by GI tract enzymes, and the inability to develop reproducible large-scale formulations. Pectin and guar gum also have a shortcoming: they are vulnerable to microbial degradation; hence, although this property is beneficial for colon targeting, they tend to leak early in patients with altered enteral flora [52]. In contrast, Eudragit RS/RL are synthetic, chemically stable, and exhibit repeatable batch-to-batch performance, enabling reliable drug release.pH-sensitive polymers (Eudragit L and S), hydroxypropyl methylcellulose phthalate (HPMCP), and cellulose acetate phthalate (CAP) were intended to dissolve at intestinal pH, providing site-specific release[53]. However, because they rely on luminal pH, they are unreliable in conditions such as IBD,

where local pH can vary considerably. Instead, both Eudragit RS and RL do not exhibit pH-dependent responses and rely on swelling and diffusion, thereby providing greater control over release profiles across colonic pH conditions. In addition, polymer ratio combinations, particularly the RS/RA mixture. Single, natural, or pH-sensitive polymers rarely allow this level of control. Consequently, natural polymers and pH-responsive polymers are not fully overcome; Eudragit RL/RS hybrids provide a superior, more predictable delivery vehicle for colon-targeted nanoparticle delivery.

Table 2: Clinical Relevance and Disease-Specific Applications of 'Eudragit RS 100'/'RL 100'-based nanoparticulate drug delivery system

Clinical Condition	Current Challenges in Treatment	Role of Eudragit RS/RL-Based Nanoparticles	Expected Therapeutic Outcomes	Ref.
Ulcerative Colitis (UC)	Frequent relapses requiring long-term therapy- Poor site-specific drug availability- Systemic side effects from corticosteroids or aminosalicylates	Targeted delivery to inflamed colonic mucosa- Sustained release reduces dosing frequency- Minimizes upper GI absorption & systemic side effects	Better disease control- Improved mucosal healing- Reduced systemic toxicity- Enhanced patient compliance	[30]
Crohn's Disease (CD)	Involvement of distal ileum and colon- Limited drug retention in affected regions- Low patient adherence	Mucoadhesive properties increase retention time- Combination polymer allows tailored release at specific GI segments	Prolonged remission- Reduced need for systemic immunosuppressants- Improved adherence	[31, 32]
Colorectal Cancer (CRC)	Need for high local drug concentration- Systemic chemotherapy causes off-target toxicity- Resistance issues	Localized release increases concentration at tumour site- Reduced systemic exposure- Can co-encapsulate chemotherapeutics and resistance modulators	Enhanced tumour reduction- Lowered systemic toxicity- Potential for combination therapy	[33]
Amebiasis/ Parasitic Infections	Requires delivery to colon- Risk of incomplete eradication with systemic drugs- Poor compliance with multi-dose regimens	Site-specific release in colon improves eradication- Once-daily dosing possible due to controlled release	Complete parasite elimination- Shorter treatment cycles- Higher compliance	[37]
Irritable Bowel Syndrome (IBS)	Fluctuating symptoms (diarrhoea, pain, bloating)- Poorly targeted treatments- Psychological side effects from systemic drugs	Can encapsulate spasmolytics or serotonergic agents for targeted release- Improved control of drug kinetics	Symptom relief with fewer side effects- Better quality of life	[38]
Colon-targeted Protein/ Peptide Delivery	Proteins/peptides degrade in the stomach and upper intestine- Low bioavailability- Enzymatic hydrolysis.	Eudragit polymers protect from enzymatic degradation- Nanoparticles enhance mucosal uptake and bioavailability	Enhanced systemic absorption- Viability for oral insulin, interleukins, or vaccines	[39]

Recent Trends in Targeted Drug Delivery of RL/RS

Several notable innovations have defined recent years in the application of Eudragit RL and RS polymers, particularly in the modification of complex colon-targeted nanomedical medicines. Some of the more eye-catching include setting through polymer blending methodologies, where the proportions of RS and RL can be customized to achieve a specified release profile that specifically meets therapeutic demands [55]. Examples include 1:1 or 2:1 blends that provide longer, sustained drug diffusion of 16-24 hours, and higher RL concentrations that provide more rapid diffusion in colonic environments [54]. Another emerging trend is the inclusion of RS/RL nanoparticles alongside other operational materials. For example, hybrids with biodegradable polysaccharide formulations, such as chitosan or guar gum, offer the added benefit of enzymatic degradation by colonic microflora and controlled permeability via Eudragit [56]. Similarly, lipid-polymer hybrids with Eudragit and phospholipids have been engineered into nanoparticles to increase instability, enhance functionality and encapsulation, and increase adhesion time to mucosa. Technological innovations in fabrication techniques are also shaping recent trends. Beyond traditional solvent evaporation, nanofiber production via electrospinning and microfluidics-driven nanoprecipitation is under development to achieve homogeneous size distributions and scalable growth [57]. Such strategies are promising for presenting laboratory findings to industry. Multifunctional RL/RS-based drug-delivery nanoparticles are currently under study for clinical use. They are under research not only as standard anti-inflammatory and antimicrobial agents but also as biologics, such as peptides and proteins, and vaccines, where they are essential in counteracting the effects of gastric degradation. In parallel, stimuli-responsive

trigger smart delivery systems, enzyme-sensitive linkers, microbiota-activated coatings, and redox-responsive material-incorporated Eudragit matrices are also being coated with Eudragit to improve site-specificity and therapeutic efficacy further. Overall, the recent landscape of RL/RS studies supports a transition of descriptive formulation studies to multifunctional, hybrid, and clinically translatable delivery systems. Such trends highlight the continued topicality of these polymers in colon-targeted oral nanomedicine and their role in shaping future treatments.

Review methodology

A systematic literature review was conducted to identify studies examining the use of Eudragit RS 100 and RL 100 for the oral delivery of nanoparticulate drugs with colon-targeted effects. The search was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria to ensure transparency and reproducibility. The search coverage of electronic databases was PubMed, Scopus, Web of Science, Embase, and Google Scholar. The search was limited to studies published between January 2000 and March 2025, thereby encompassing both pillars and recent developments in this area. The following search terms and Boolean operators were used in various combinations:

- Eudragit RS 100/ Eudragit RL 100 or RS/RL polymer blend.
- nanoparticle OR nanoparticulate system OR nanocarrier.
- colon-targeted OR colonic delivery OR oral colon delivery.

A manual search of reference lists of relevant articles and review papers was also conducted to ensure completeness.

Table 3: Databases and Search Terms

Database	Search String Example	Time Frame
PubMed	(“Eudragit RS 100” OR “Eudragit RL 100”) & (“nanoparticle” OR “nanocarrier”) & colon	2000–2025
Scopus	TITLE-ABS-KEY (“Eudragit RS” & “RL”) AND (“colon” AND “nanoparticulate”)	2000–2025
Web of Science	(“RS 100” OR “RL 100”) AND (“colon-targeted delivery” AND “nanoparticles”)	2000–2025
Embase	(‘Eudragit RS/RL’/exp AND ‘colon drug delivery’/exp AND ‘nanoparticles’/exp)	2000–2025
Google Scholar	“Eudragit RS RL nanoparticles” + “colon-targeted oral delivery”	2000–2025

Table 4: Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Study Type	Experimental research articles, full-text peer-reviewed studies	Reviews, conference abstracts without full data, editorials, and patents
Formulation Focus	Nanoparticles/nanocarriers prepared using Eudragit RS 100, RL 100, or their blends for oral delivery	Formulations not using RS/RL or not intended for colon targeting
Outcomes Reported	At least one quantitative parameter (particle size, zeta potential, EE, release profile, or in vivo data)	Studies with only qualitative descriptions or lacking release/characterization data
Language	English	Non-English (without translation)
Publication Period	2000–2025	Published before 2000

Study Selection Process

Two reviewers independently screened titles and abstracts for relevance. Full-texts of potentially eligible studies were then assessed against the inclusion criteria. Disagreements were resolved by consensus or consultation with a third reviewer. Data were extracted into structured tables covering formulation details, polymer ratios, drug encapsulation, particle size, zeta potential, entrapment efficiency, and release profiles.

Challenges and Future Directions

Despite their promising properties, Eudragit RS/RL systems are not without limitations. Batch-to-batch variation in polymer properties, challenges in large-scale nanoparticle production, and potential long-term toxicity require careful consideration [58]. Stability of nanoparticles during storage, interactions with excipients, and scalability of the solvent-evaporation process also pose hurdles. Furthermore, in vivo studies are still relatively limited, and clinical data supporting the superiority of RS/RL nanoparticles over traditional systems remain sparse. Future research should focus on integrating responsive systems, such as those triggered by colonic enzymes or gut microbiota, to further enhance the precision of drug release. Combining RS/RL with biodegradable or natural polysaccharide carriers may also offer synergistic effects and improved biocompatibility. Hence, the combination of 'Eudragit RS 100' and 'RL 100' provides a highly versatile and customizable platform for developing colon-targeted oral nanoparticulate drug delivery systems. Their differing permeability profiles, combined with strong mucoadhesive properties and ability to remain stable in the

gastric and intestinal environments, make them ideally suited for colonic delivery. The ability to adjust the RS-to-RL ratio enables fine-tuning of drug-release kinetics, and the system is sufficiently flexible to meet a variety of therapeutic requirements. Given that colorectal diseases are increasingly prevalent worldwide and that site-specific drug therapies are gaining considerable momentum, the RS/RL nanoparticle system represents an important advance in oral drug delivery. Further studies, particularly those on in vivo performance and scalable manufacturing, will remain pertinent to their optimal clinical applications.

CONCLUSION

Oral delivery to the colon is a critical area of study in contemporary pharmaceutical research, particularly for targeting disease sites in the lower GI tract, such as IBD, Colorectal Cancer, and parasitism. Advanced polymeric nanoparticles have been explored as highly appealing, precision-targeted, sustained-release delivery systems. Among such desirable materials, a mixture of Eudragit RS 100 and RL 100 has proven effective and adaptable for colon-specific nanoparticulate delivery. Eudragit RS100 & RL100 are both synthetic methacrylate polymers that are insoluble in water and pH-independent, but they differ in permeability due to differences in quaternary ammonium group content. RS 100 that has fewer cluster ammonium groups contains a more protracted & delayed discharge; meanwhile, a greater permeability, the special 100, or what is also known as the RL 100, allows the diffusion to be faster. By combining these polymers, one can manipulate the drug-release profile by self-adjusting the proportions used. This versatility can be particularly instrumental in tailoring release kinetics to meet the therapeutic needs of different colon diseases. During the study, it was found that nanoparticles prepared at this RS: RL ratio can be used to load both hydrophilic and lipophilic drugs, protect against premature release in the upper GI tract, and provide prolonged residence time in the colon due to their mucoadhesive properties. Fabrication via the solvent evaporation method and emulsification technique also helped fine-tune the uniformity of the manufactured particles, their stability, and their high encapsulation efficiencies, as well as their zeta potentials, which are favourable in their own right. The combination system further addresses most shortcomings of traditional drug-delivery systems, including premature drug release, enzymatic degradation, and pH-dependent variability in release. Nonetheless, issues of scale-up potential, long-term viability, and overall in vivo and clinical testing remain to be addressed to ensure successful translation. In conclusion, Eudragit RS 100 and RL 100, in combination, provide a potential surface for a controlled, colon-specific oral nanoparticulate drug delivery system. Such formulations are more effective therapeutically, reduce systemic side effects, improve patient compliance, and align with the increasing demands of precision medicine. Future research should continue to optimize formulations, evaluate patient-specific applications, and validate clinical outcomes, paving the way for next-generation treatments in gastrointestinal pharmacotherapy.

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NIL

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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