

# Engineering Elasticity: Spanlastics As Smart Vesicular Systems For Enhanced Therapeutic Delivery- A Review

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## ABSTRACT

Spanlastics are innovative, elastic Nano-vesicular carriers designed to improve medication delivery efficiency and overcome the constraints of traditional dosage forms. These systems are made up of non-ionic surfactants and edge activators, which exhibit high deformability and can penetrate biological barriers. Spanlastics may encapsulate both hydrophilic and lipophilic pharmaceuticals, which improves medication stability, bioavailability, and therapeutic efficacy. Their unique structure allows for regulated and targeted medication release, which reduces systemic side effects and dose frequency. In terms of toxicity, biocompatibility, and chemical stability, spanlastics perform better than conventional vesicular systems. Ophthalmic, transdermal, oral, and nasal delivery methods have all shown encouraging outcomes. The improved permeability and retention properties of spanlastics make them an ideal smart vesicular system for site-specific drug delivery. All things considered, spanlastics offer better treatment results and patient compliance, marking a substantial leap in drug delivery based on nanotechnology. This review summarises composition, preparation methods, advantages, evaluation and applications of spanlastics systems.

**Keywords:** Spanlastics; Nano-Vesicular Drug Delivery; Edge Activators; Controlled Release; Targeted Delivery; Non-Ionic Surfactant; Bioavailability Enhancement

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## 1. INTRODUCTION

Poor bioavailability, quick systemic clearance and lack of site-specific targeting are only a few of the major drawbacks of conventional drug delivery methods that eventually reduce therapeutic efficacy. The investigation of sophisticated nanocarrier-based systems can enhance drug stability, permeability and controlled release profiles has been prompted by these difficulties. Recently, spanlastics have become a promising type of elastic nanovesicular carriers with improved delivery capacities among such systems. Spanlastics are surfactant based vesicles made up of edge-activators and non-ionic surfactants that provide the bilayer structure with a high degree of deformability. Both hydrophilic and lipophilic medications can be effectively encapsulated thanks to this formulation, which also shields them from

deterioration in biological settings. These vesicles can more effectively pass through biological barriers like the stratum corneum and mucosal membranes when edge activators are present because they increase membrane fluidity and decrease interfacial tension<sup>[1]</sup>.

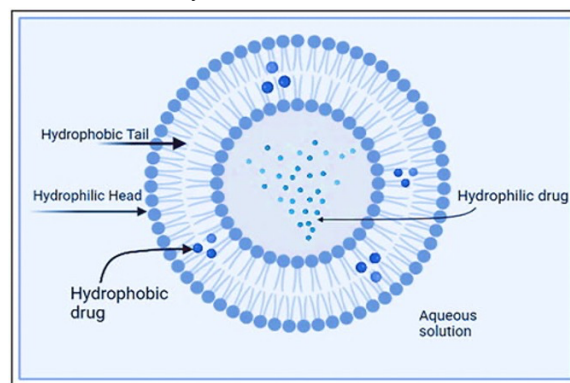


Figure 1. Structure of Spanlastics

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Additionally, spanlastics have benefits such as enhanced physicochemical stability, biocompatibility, and the capacity to deliver targeted and prolonged drug release. These characteristics help to improve bioavailability and lessen systemic adverse effects. Their importance as a smart vesicular system for enhanced therapeutic delivery has been highlighted by recent studies that have shown potential across several routes of administration. For topical, nasal, oral, and ocular administration, spanlastics are a special kind of vesicular carriers that serve as site-specific drug delivery vehicles. long with the summery of the preparation method and the current application, the article highlights a few key elements<sup>[1,2]</sup>.

## Key Characteristics of Spanlastics

Table 1: Characteristics of Spanlastics

Characteristics	Description	Significance in Drug Delivery
Enhanced Penetration	Enhances the passage of drug across biological membranes	Improves efficacy and bioavailability of drugs.
High Elasticity	Vesicle can readily alter shape and are very malleable.	Aids in getting through small skin pores.
Non-ionic Surfactant System	Made up of edge activator and span (sorbitan esters)	Improves stability and lowers toxicity.
Entrapment Efficiency	Capable for holding a large amount of drug	Confirms better drug delivery with less waste.
Biocompatibility	Composed of non-irritating, nontoxic materials	Appropriate for transdermal and topical use
Stability	More stable than	Improves formulation

	liposomes or other traditional vesicles	dependability and shelf life
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## Advantages of Spanlastics

- Spanlastics are non-immunogenic, biodegradable, and show a high degree of compatibility with biological systems since they are composed of non-ionic surfactants.
- Spanlastics provide protective support, Because the medicine may reach the intended site without being turn off, increasing its bioavailability compared to previous traditional one.
- These vesicles can improve the stability of medications that are trapped because they are stable and osmotically active.
- Spanlastics have far greater permeability through the skin and even through thick barrier like nails (transungual delivery) as compared to conventional niosomes.
- Their structure supports prolonged and regulated medication release by extending of drug's systemic circulation.
- When compared to traditional niosomes, spanlastics offer improved ocular permeability due to their extreme elasticity and deformability.
- Because of their flexibility, they can reach tissues including the corneal membrane, vitreous cavity, and retinal pigment epithelium by penetrating both anterior and posterior ocular segments<sup>[3,4]</sup>.

## Limitations of Spanlastics

- Leakage of drugs during storage.
- Particle size may rise as result of high loading of lipophilic medications.
- Vesicle size consistency is difficult to maintain at large volumes.
- Sensitive to temperature.
- Limited short life<sup>[5,6]</sup>

## 2. CLASSIFICATION OF SPANLASTICS

The amount of layers that spanlastics consist of may be used to categorize them, as shown in the table<sup>[8,5]</sup>.

Table 2: Types of Spanlastics

Vesicle Type	Size	Description	Features
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Large Unilamellar Vesicles (LUV)	100-300 nm	Usually consist of a single, massive bilayer.	High aqueous-to-lipid ratio, so able to hold more volume of bioactive substances.
Small Unilamellar Vesicles (SUV)	10-100 nm	Created by size reduction methods, like MLVs by sonication, French press, or extrusion.	Small size, created by size reduction methods.
Multi-Lamellar Vesicle (MLV)	0.5-1.0 μm	Made up of many bilayers. Most commonly used type.	Easy to make and mechanically stable throughout time.

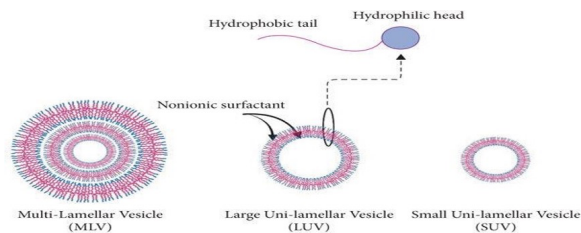


Figure 2. Classification of Spanlastics

### 3. STRUCTURE AND COMPONENT OF SPANLASTICS

Systems of spanlastics are spherical structures made by amphiphilic molecules. These structures serve as matrices for bio-encapsulation. It is made up of concentric bilayers that range in size from 10 to 100 nanometers for unilamellar vesicles (SUVs) and from 100 to 300 nanometers for large unilamellar vesicles (LUVs)<sup>[7]</sup>.

Table 3: Component of Spanlastics

Components	Function/Role/Explanation	Examples
Non-ionic Surfactant	Offers structural stability and forms	Span 20, Span 40,

	primary vesicular bilayer	Span 60, Span 80
Edge Activator	A family of substances known as edge activators has the capacity to cause the lipid bilayer to soften. These molecules, which includes biocompatible surfactants, are mixed with amphiphilic materials to increase the lipid bilayer's flexibility and permeability. The bilayer's deformability is improved as a result of the decreased interfacial tension.	Tween 20, Tween 60, Tween 80, Sodium cholate
Drug/Active Pharmaceutical Ingredient (API)	Therapeutic agent encapsulated in the vesicles to show the therapeutic activity.	Hydrophilic or lipophilic drug
Aqueous Phase	Helps in encapsulation by hydrating the surfactant mixture and creating a vesicle core.	Distilled water, buffer solution
Stabilizer/Additives	Increase shelf life, prevent vesicle aggregation, and improve stability	Cholesterol, antioxidants

### 4. METHODS OF PREPARATION

#### 4.1 Ethanol Injection Method :

To make spanlastics, a set quantity of non-ionic surfactant is combined with an edge activator. The medication is initially dissolved in ethanol that has been mixed with span in order to get it ready for encapsulation. The lipid solution is sonicated for the next five minutes. Now, this solution is constantly injected into a heated aqueous phase with an edge activator (such as Tween 80). For the last 30 minutes,

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this phase has been agitated on a magnetic stirrer at temperatures between 70 and 80 °C and speed between 800 and 1600 rpm<sup>[6,9]</sup>.

## 4.2 Ether Injection :

This approach involves injecting the surfactant into an aqueous phase that has been heated to 600°C at a rate of 25ml/min using a 15-gauge needle. This method requires dissolving the surfactant in 20 millilitres of ether. The ethanol will be extracted from the ether solution using a rotary evaporator. The method will produce vesicles with a single layer once the organic solvent been totally eliminated<sup>[10, 12]</sup>.

## 4.3 Thin Film Hydration Technique :

Span 60 will be properly weighed before being transferred to a round-bottom flask and dissolved in chloroform. When the organic solvent is evaporated at 55°C under vacuum using a rotary evaporator operating at 90 RPM, a thin layer will develop on the flask walls. A present amount of the medication can be dissolved in the aqueous phase using the chosen EA and cosolvent. After the thin film is deposited, it will be mixed with this aqueous phase. The flask will be reattached to the evaporator and spun for 30 minutes at normal pressure, 60°C, and 90 RPM in order to fully remove the lipid layer from its walls. After standing for two more hours at room temperature to completely hydrate, the final distribution will be kept at 4°C overnight<sup>[11]</sup>.

## 4.4 Sonication :

This procedure entails making an aliquot of the medication in an appropriate buffer and mixing it with the surfactant combination in a glass vial that holds ten malletiers. The titanium probe is used to sonicate the mixture<sup>[15]</sup>.

## 4.5 Method of Hand Shaking :

First, an organic solvent like benzene, ether, or chloroform is used to dissolve the surfactant. After that, the pressure is gradually reduced as the solvent is evaporated in a vacuum evaporator using a round-bottom flask. After being rehydrated with an aqueous solution containing the prescribed drugs, the layer is continually agitated. This process causes the surfactant layer to thicken. After swelling, amphiphilic molecules will eventually fold, creating vesicles that act as the medicine's encasing structures<sup>[16]</sup>.

## 4.6 Microfluidization Technique :

In a reaction chamber with a specially constructed microchannel, two fluidized streams-one containing a medication and the other a surfactant interact at

incredibly high speeds. The energy delivered to the system is carefully controlled to keep it within the spanlastics composition range. This phenomenon is commonly referred to as the submerged jet principle. Consequently, the formulation has reduced dimension, increased repeatability, and enhanced consistency<sup>[13, 14]</sup>.

## 5. THE CHARACTERISTICS OF SPANLASTICS :

The in-vitro and in-vivo qualities of the spanlastics formulation must be evaluated using exact and consistent quality control methods.

### 5.1 In-Vivo Study :

Using suitable animal models, the distribution of tissue profiles has been examined. Three sets of healthy albino rats weighing between 100 and 150g were used by the researchers to determine the tissue distribution profile. There were three animals in each group. The first was given free spanlastics without the medication and acted as a control. There were three animals in each group. The first was given free spanlastics without the medication and acted as a control. One the other hand, the second group received free injections of medicine. The formulation strategy was used to treat the third group. After the animals were killed, several organs and tissues were extracted from them, including the liver, spleen, lung, and hearts<sup>[18]</sup>.

The organs were homogenized and centrifuged to help separate their component parts after the tissue was submerged in a pH 7.4 phosphate buffer solution. The amount of drug contained was ascertained by using the supernatant that was obtained in this manner in a suitable assay. The amount of drug in the plasma was measured after both the free drug and the medication enclosed in spanlastics were injected. Three groups of five individuals each were created from the animals. Phosphate-buffered saline (pH 7.4) was injected into the first group, which acted as a control; the second and third groups were given the medication orally in its pure form and encapsulated inside nanovesicles, respectively. The blood samples were taken, centrifuged, and rapidly frozen before being assessed at predetermined intervals using high-performance liquid chromatography (HPLC). The outcomes were then compared to those of the original groups<sup>[5, 17, 19]</sup>.

### 5.2 In-Vitro Study :

Franz diffusion cells, which have donor and receptor compartments divided by a cellophane barrier, can be

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used to measure drug release. The samples were placed on the dialysis membrane in the receptor compartment of a buffer solution with a pH of 6.8. The sample were magnetically stirred at 500 rpm while the temperature was kept at 37°C. The samples are removed at various intervals and examined using UV spectroscopy to ascertain the percentage of medicines released following appropriate dilution<sup>[19]</sup>.

## 5.3 Morphology Analysis :

A transmission electron microscope is used for morphological research. This makes it possible to determine the lamellarity, size, form, and physical stability characteristics of spanlastics<sup>[5, 20]</sup>.

## 5.4 PDI and Vesicle Size :

Dynamic light scattering method is used to evaluate the formulations size and polydispersity index<sup>[21]</sup>.

## 5.5 Zeta Potential :

A device is used as a zeta sizer to assess the spanlastic formulations zeta potential. It is useful in figuring out why the sample are dispersing, flocculating or aggregating<sup>[5, 22]</sup>.

## 5.6 Spanlastics Elasticity :

The deformability index i.e DI is a way to quantify elasticity. Extrusion is a technique that may be used to gauge the elasticity of nanospanlastics. Nano-spanlastics were created using a polycarbonate membrane as a filtering membrane, and they were then extruded at a constant vacuum pressure for 10 minutes. The polycarbonate membrane's pore diameter was 200 nm<sup>[21]</sup>.

## 5.7 Stability of Spanlastics :

For three months, the spanlastics formulation was kept in glass vial at 4°C as part of a stability test. At several points along the process, sample were removed from the system. The degree of encapsulation efficiency (EE%), size distribution, particle size, and drug release were evaluated after 30, 60, and 90 days of storage, respectively<sup>[23]</sup>.

## 6. FACTORS INFLUENCING SPANLASTICS' PHYSIO-CHEMICAL PROPERTIES :

### 6.1 Surfactant Type and Content:

For example, the mean size of the vesicles increased from span 85 (HLB 1.8) to span 20 (HLB) in proportion to the surfactants HLB value. It might be because of surface free energy decreases as the surfactants hydrophilicity rises. The alkyl chain will have a nice, well-organized structure if the material in a gel state, while the bilayer's structure will be more

disorganized if it is in a liquid state. The gel-liquid phase transition temperature is used in the process of characterizing lipids and surfactants. Also, the cause of the impact is the phase shift. A higher degree of entrapment efficiency is provided by span 60, sometimes referred to as entrapment efficiency, which has a higher transition temperature. The HLB value affects spanlastics entrapment efficiency; for example, spanlastics exhibit high entrapment at an HLB of 8.6, where as an HLB value of 14 to 17 is not ideal for their creation<sup>[24]</sup>.

### 6.2 Properties of the Drug :

The drugs entrapment efficiency can be influenced by its molecular weight, lipophilicity, hydrophilic-lipophilic balance, and chemical structure. Pharmacological trapping may causes the vesicles size to increase. The drug particle interacts with the surfactants head group, which probably causes the polymer's charge to raise. The size of the vesicles increases as a result of the surfactant bilayers repelling one another<sup>[26]</sup>.

### 6.3 Additives for Membranes :

The stability of spanlastics can be enhanced by the quantity of additives added to the formulation in addition to the main surfactant and the drug. Numerous additives affect vesicles permeability, shape, and membrane stability. Tweens, for instance, make the generated vesicles more flexible, which facilitates their penetration of the target site<sup>[27]</sup>.

### 6.4 Hydration Temperature :

The form and size of an object can also be influenced by the temperature at which it is hydrated. Temperature changes across the system have an impact on the vesicle formation process. Vesicle shape can also alter as a result of temperature variations. Polyhydral vesicles of C16G2:solulan C24(91:9) are crated at 25°C, however at 45°C they can transform into spherical vesicles. A cluster of spherical but much smaller nano-vesicles forms after the spherical vesicles are cooled from 55 to 49°C<sup>[25]</sup>.

### 6.5 Surfactant Structure :

The shape of vesicles produced during the procedure is also influenced by the necessary packing factor. The vesicle shape appears to be predicted based on the critical packing value. The critical packing parameter can be found using the formula below<sup>[28]</sup>.

$$\text{Critical Packing Parameter (CPP)} = \frac{v}{lc} a_0$$

Where,

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$V$  is the volumes hydrophobic groups.

$L_c$  is the length of the hydrophobic groups at the critical point.

$a_0$  = the Hydrophilic head group area

### 7. APPLICATION OF SPANLASTICS<sup>[28, 29]</sup>

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Table 4: Application of Spanlastics

Application	Description	Advantages
Oral Delivery	By overcoming low solubility, frequent dosage, medication interactions, and systemic adverse effects, spanlastics increase oral bioavailability. Controlled release is possible using enteric coated spanlastic dispersion.	Spanlastics containing sodium pravastatin demonstrated better oral bioavailability in contrast to an aqueous solution.
Transdermal Delivery	Enhances bioavailability and therapeutic efficacy, prevents hepatic metabolism, and permits continuous drug release through skin	Beneficial for better patient compliance and long-term medication administration.
Ocular Delivery	To increase ocular absorption, spanlastics go beyond pre-corneal	Improves medication retention and dispersion in ocular tissues.

	and corneal barriers. May provide site-specific medications to the posterior (choroid, vitreous cavity, epithelium) and anterior (cornea, aqueous humor) parts, able to transport both hydrophilic and lipophilic medications.	
Delivery of Peptides and Proteins	Prevents the breakdown of unstable protein and peptides (such as insulin and bacitracin), increasing bioavailability during management and storage. Supports immunization and oral delivery.	In diabetics, insulin-loaded nanovesicles demonstrated enhanced pharmacokinetics in rats and resistance to deterioration in intestinal and stomach fluids.
Gene Therapy	Nanovesicles aid in the transfer of DNA and other genetic materials, resolving clinical application issues	Being investigated to increase the effectiveness of formulation and distribution.

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	brought on by restricted distribution.	
Delivery of Vaccine	Nanovesicles based on non-ionic surfactant enhance the stability and therapeutic efficiency of vaccination.	Increases the efficacy and safety of vaccinations.

### 8. CONCLUSION:

The development of spanlastics, which are surfactant based vesicles, offer a non-invasive method of drug administration that does away with the necessity of repeatedly injecting medication at the intended site. The obstacles are included in the previously listed concern being addressed. Regarding the instability, rapid disintegration, poor bioavailability, and insolubility of pharmaceuticals. The development of nanovesicular drug delivery devices might be greatly aided by spanlastics. For lipophilic and hydrophilic medications, vesicular systems may be used to provide targeted drug delivery. The middle ear region, oral, topical surface, nasal, ocular area, and nasal cavities are among the anatomical locations to which pharmaceuticals are now administered.

### REFERENCES :

1. Kakkar S, Kaur IP. Spanlastics—A novel nanovesicular carrier system for ocular delivery of ketoconazole: formulation and in vivo evaluation. *J Drug Deliv Sci Technol.* 2025;87:104756.
2. Dahash RA, Ghareeb MM. Design, development, and optimization of spanlastics for delivery of rizatriptan benzoate. *Iraqi J Pharm Sci.* 2025;34(4):125–140.
3. Verma A, Chauhan MK. Spanlastics-Future of Drug Delivery and Targeting. *W J Pharm Res,* 2017; 12(6): 429-46.
4. Hunter CA, Dolan TF, Coombs G and Baillie AJ: Vesicular systems (niosomes and liposomes) for delivery of sodium stibogluconate in experimental murine visceral leishmaniasis. *Journal of Pharmacy & Pharmacology* 1988; 40: 161-5.
5. Almohamady HI, Mortagi Y, Gad S, Zaitone S, Alshaman R, Alanazi FE, et al. Spanlastic nano-

vesicles for improving dissolution, bioavailability, and pharmacokinetic behavior of famotidine. *Pharmaceutics.* 2024;17(12):1614.

6. Ibrahim SS, Abd-Allah H. Spanlastic nanovesicles for enhanced ocular delivery of vanillic acid: design, in vitro characterization, and in vivo evaluation. *Int J Pharm.* 2022;625:122068.
7. Sharma A, Pahwa S, Bhati S, Kudeshia P. Spanlastics: A Modern Approach For Nanovesicular Drug Delivery System. *Int J Pharma Sci Res,* 2020; 11(3): 1057-65.
8. Badria, F.; Fayed, H.A.; Ibraheem, A.K.; Mazyed, E.A. Formulation of Sodium Valproate Nanospanlastics Promising Approach for as a Drug Repurposing in the Treatment of Androgenic Alopecia. *Pharmaceutics* 2020, 12, 866.
9. Aml I, Mekkawy AI, Nermin E, Eleraky, Ghareeb M, Soliman, Mohamed G, Elnaggar G Et Al. Combinatorial Therapy Of Letrozole- And Quercetin-Loaded Spanlastics For Enhanced Cytotoxicity Against MCF-7 Breast Cancer Cells *Pharmaceutics,* 2022; 14: 2-21.
10. Akbarzadeh A, Rezaei-Sadabady R, Davaran S, Joo SW, Zarghami N, Hanifehpour Y, et al. Methods of liposome preparation: formation and control factors of versatile nanocarriers for biomedical applications. *Pharmaceutics.* 2022;14(3):543.
11. Farghaly DA, Aboelwafa AA, Hamza MY, Mohamed MI. Topical Delivery of Fenopropfen Calcium Via Elastic Nano-Vesicular Spanlastics: Optimization Using Experimental Design And In Vivo Evaluation. *AAPS Pharm Sci Tech,* 2017; 8: 1-6.
12. Kaur IP, Rana C, Singh M, Bhushan S, Singh H, Kakkar S. Development And Evaluation Of Novel Surfactant-Based Elastic Vesicular System For Ocular Delivery Of Fluconazole. *J Ocular Pharma Ther,* 2012; 1-13.
13. Rawas-Qalaji M, Cagliani R, Al-Hashimi N, Al-Dabbagh R, Al-Dabbagh A, Hussain Z. Microfluidics in drug delivery: review of methods and applications. *Pharm Dev Technol.* 2023;28(1):61–77.
14. Khadka P, Ro J and Kim H: Pharmaceutical particle technologies: An approach to improve drug solubility, dissolution and bioavailability. *Asian Journal of Pharmaceutical Science,* 2014; 9: 304-16.
15. Devos C, Bampouli A, Brozzi E, Stefanidis GD, Dusselier M, Van Gerven T, et al. Ultrasound

## Engineering Elasticity: Spanlastics as Smart Vesicular Systems for Enhanced Therapeutic Delivery- A Review

- mechanisms and their effect on solid synthesis and processing: a review. *Chem Soc Rev.* 2025;54:85–115.
16. Abdelbary G, El-Gendy N. Niosomes: composition, formulation techniques, and recent progress as drug delivery systems. *Pharmaceutics.* 2024;16(2):223.
  17. El-Refaie WM, Elnaggar YSR, Elsherif MA, Abdallah OY. Brain-targeted spanlastic nanovesicles: in vivo pharmacokinetics and biodistribution evaluation. *J Drug Deliv Sci Technol.* 2024;84:104509.
  18. Gupta I, Adin SN, Rashid MA, Alhamhoom Y, Aqil M, Mujeeb M. Spanlastics as a potential approach for enhancing the nose-to-brain delivery of piperine: in vitro prospect and in vivo therapeutic efficacy. *Pharmaceutics.* 2023;15(2):641.
  19. Yassin Ge, Reham I. Amer, Ahmed M, Fayez. Carbamazepine Loaded Vesicular Structures for Enhanced Brain Targeting Via Intranasal Route: Optimization, In Vitro Evaluation, And In Vivo Study. *Int J App Pharm,* 2019; 11(4): 264-74.
  20. Ubhe AS. Imaging of liposomes by negative staining transmission electron microscopy and cryogenic transmission electron microscopy. *Methods Mol Biol.* 2023;2622:245–251.
  21. Sallam NM, Abdel R, Sanad B, Ahmed MM, Khafagy EL, Ghorab M, Gad S. Impact of The Mucoadhesive Lyophilized Wafer Loaded with Novel Carvedilol NanoSpanlastics On Biochemical Markers in The Heart of Spontaneously Hypertensive Rat Models. *Drug Deliv. And Transl. Res,* 2020; 1-30.
  22. Abdelbari MA, El-Mancyss, Elshafeeyah, Abdelbaryaa. Implementing Spanlastics For Improving the Ocular Delivery of Clotrimazole: In Vitro Characterization, Ex Vivo Permeability, Microbiological Assessment And In Vivo Safety Study *Int J Nanomedicine,* 2021; 16: 6249–6261.
  23. Abdelmonema R, Nabarawib M, Attiaa A. Development of Novel Bioadhesive Granisetron Hydrochloride Spanlastic Gel and Insert for Brain Targeting and Study Their Effects on Rats Drug Delivery, 2018; 25(1): 70-77.
  24. Abdelbary G, El-Gendy N. Niosome-encapsulated gentamicin for ophthalmic controlled delivery: influence of surfactant type and cholesterol. *AAPS PharmSciTech.* 2022;23(5):178.
  25. World Journal of Pharmaceutical Research. Spanlastics and niosomes: formulation factors affecting vesicle characteristics. *World J Pharm Res.* 2023;12(20):227–235.
  26. Karati D, Mukherjee S, Prajapati BG. Unveiling spanlastics as a novel carrier for drug delivery: a review. *Pharm Nanotechnol.* 2025;13(1):133–142.
  27. Wagdi M, Salama A, El-Liethy MA, Shalaby E. Comparative study of niosomes and spanlastics as a promising approach for enhancing benzalkonium chloride topical wound healing. *J Drug Deliv Sci Technol.* 2023;84:104456.
  28. Kralchevsky PA, Nagayama K. Predicting lipid self-assembly using critical packing parameter and molecular geometry. *Colloids Surf B Biointerfaces.* 2022;211:112298.
  29. Alharbi WS, Hareeri R H, Bazuhair M, Alfaleh M A, Alhakamy N A, Fahmy U an Et Al. Spanlastics As A Potential Platform for Enhancing the Brain Delivery of Flibanserine: In Vitro Response-Surface Optimization and In Vivo Pharmacokinetics Assessment. *Pharmaceutics,* 2022; 14(2627): 1-16.