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Microsponge Technology as a Novel Approach for Topical Drug Delivery: An Acquainted Review

Shailesh SHARMA[o*], Manjinder KAUR[***], Simranpreet KAUR[****]

[*]*ORCID-0000-0003-0149-3217, Pharmaceutical Research Division, Department of Pharmaceutics, Amar Shaheed Baba Ajit Singh Jujahr Singh Memorial College of Pharmacy, BELA (Ropar) Punjab, India*
[***]*ORCID- 0000-0002-3769-6481, Pharmaceutical Research Division, Department of Pharmaceutics, Amar Shaheed Baba Ajit Singh Jujahr Singh Memorial College of Pharmacy, BELA (Ropar) Punjab, India*
[****]*ORCID- 0000-0002-1001-2422, Pharmaceutical Research Division, Department of Pharmaceutics, Amar Shaheed Baba Ajit Singh Jujahr Singh Memorial College of Pharmacy, BELA (Ropar) Punjab, India*
Corresponding Author: Dr. Shailesh Sharma,
Professor Pharmaceutical Research Division, Department of Pharmaceutics,
Amar Shaheed Baba Ajit Singh Jujahr Singh Memorial College of Pharmacy,
BELA (Ropar) 140 111 Punjab, India

Summary
Microsponge drug delivery system offers a promising opportunities in multiple pharmaceutical implementations as it has distinctive characteristics such as enhanced product quality and elegance, expanded release, enhanced drug release profile, decreased discomfort, enhanced physical, chemical, and thermal stability, making it easy to develop novel product form. These are modern drug delivery systems capable of entrapping higher concentration of drugs due to networks or pores that interconnect. They can be prepared primarily by two techniques based on liquid suspension polymerization and solvent diffusion depending upon the physicochemical properties of the drug to be loaded. Microsponge delivery system was initially designed for the delivery of drugs topically or through the skin. Nowadays, Microsponges are often used for topical delivery carriers for anti-fungal, anti-inflammatory, anti-ulcer therapy and constitute major components of variety of dermatological and cosmetic products such as creams, gel, lotion etc. Microsponges can also be used for oral delivery of drugs by using water soluble and bio-erodible polymers. Microsponges have a bright future in the coming era in various pharmaceutical applications which make them superior to the microcarriers of today. The present review introduces about various formulation approaches, characterization, applications, present market scenario, patents and future prospects on microsponge technology.

KEYWORDS: *Topical drug delivery, Microsponges, release mechanisms, Nanosponges, suspension polymerization, Applications*

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I. Introduction

Present scenario of research in pharmaceutical sciences focuses on improved health, effectiveness and patient compliance by integrating an existing medication into a new drug delivery system [1-5]. Many approaches are being used to advance new drug delivery systems to improve the safety and effectiveness of the delivery of drugs to patient [6-10]. In the field of topical drug delivery, the microsponge system was first introduced to reduce the systemic and local side effects of the drug by providing controlled and desired release of active drugs [11]. The approach is being used to enhance the protection and effectiveness of certain active ingredients that can be administered through the skin, but is not appropriate for the administration of those drugs whose main target is the skin itself [12]. The (Figure 1) shows number of problems with the conventional topical drug delivery systems [13].

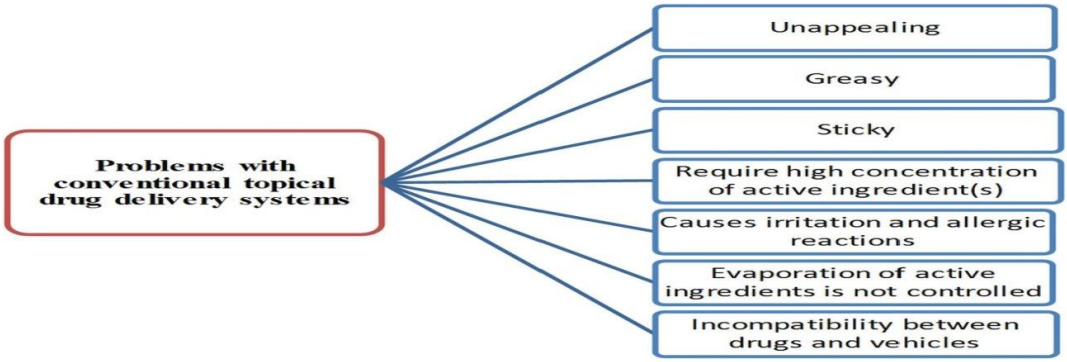

Figure 1: Problems with conventional topical delivery systems

Microsponges are modern drug delivery systems capable of entrapping higher concentration of drugs due to networks or pores that interconnect. Also, the medium- sized microsponges are not small enough to permeate the skin and to be topically absorbed by the body; thus, microsponges are considered as drug delivery systems for topical use. Microsponges cannot pass through the skin themselves, but accumulate in the small nooks and skin crannies, and gradually release the entrapped drug or substance as skin requires [14-16].

Defining Microsponge: Microsponge delivery system (MDS), also known as "solid phase porous microsphere" is a patented microparticulate system, comprising of highly cross-linked, polymeric porous microspheres having numerous interconnected voids in the particle, loaded with an active agent within a collapsible structure with a large porous surface. The measurement of the MSPs ranges from 5-300 µm [17] in diameter and a regular 25 µm sphere can have up to 2,50,000 pores and an interior pore shape equivalent to 10 feet in length, imparting a complete pore volume of about 1 ml/g [18,19] for extensive drug retention. The surface can be diverse from 20 to 500 m^2/g and pore volume range from 0.1 to 0.3 cm^2/g [20]. This results in a great reservoir within every MSP that can be loaded with its very own weight of active agent. MSPs are extremely small, inert, indestructible spheres that do not pass through the skin. Rather, they accumulate in the tiny nooks and crannies of the skin and slowly launch the entrapped drug. [21]

Microsponge History: In 1987, the microsponge technology was developed from Won and the authentic patents were assigned to Advanced Polymer Systems, Inc. In addition to OTC and generic pharmaceutical products, this organization developed a massive range of variations of the system and applied those to attraction. This technology has currently been licensed to Cardinal Health, Inc. for use in topical formulations. [22-29]

CHARACTERISTICS OF MICROSPONGE BASED DELIVERY SYSTEMS

When a microsponge is applied topically, the release of bioactive compound to the skin is done with excellent efficacy and minimal irritation in response to stimuli such as temperature, rubbing or the pH effect. Microsponges have several characteristic features, e.g. they are stable over pH 1 to 11 range. Such formulations are thermostable and can withstand up to 130°C temperature. The presence of porous structure (pore size approx. 0.25µm) creates a self-sterilizing feature which prevents penetration of the bacteria. The particle spherical form provides a free-flowing property, improved compressibility and enhanced loading performance.[30]

POLYMERS EXPLORED FOR MICROSPONGE FABRICATION

Various polymers used in fabrication of microsponges for topical use produce a microsponge 'cage'. As per the published literature polymers explored so far include: Polymethacrylates, Eudragit polymers [Eudragit RS100, Eudragit RSPO, Eudragit S100], Polylactide co-glycolic acid, Polylactic acid, Polydivinyl benzene, Polyhydroxy bu-tyrate, Ethyl cellulose etc.

- Among these, Eudragit RS100 is most broadly studied polymer, due to its versatile nature. The wide variety of Eudragit polymers, specific in charge, solubility and water permeability, allows for custom-tailor release characteristics on this system, enabling a wide range of alternatives to benefit from the chosen performance.
- Polymers belonging to the polymethacrylate class are approved by FDA (Food and Drug Administration), safe, non-poisonous and economic excipients, widely used within the pharmaceutical industry. The versatility of combining different polymethacrylate polymers enables better management of drug-release behavior, particularly due to interaction between drug-methacrylate and polymer.
- Ethyl cellulose is also used as a base fabric for microsponges due to its non-irritating, risk-free and non-allergic nature.

- Another polymer, polydivinyl benzene, has been pronounced using liquid-liquid suspension polymerization technique for manufacturing of porous microspheres [31-35].

Besides the polymers and active ingredients, the formulation of strong, stable and efficient microsponge formulations require a few different excipients. For example, plasticizer (triethylcitrate) is added to stabilize the buoyant microsponges, and porogenic materials such as hydrogen peroxide or sodium bicarbonate may also be added, resulting in the formation of uniformly dispensed and interconnected pores that provide large surface area for drug load in these systems. Additionally, the pores boom the entrappment efficiency of this microcolloidal transport system for drugs. In some studies, sucrose and pre-gelatinized starch were used as pore inducers to increase the rate of release of drugs. In the quasi-emulsion solvent diffusion technique, PVA (polyvinyl alcohol) and cellulose ethers had been reported as emulsifiers to preserve the viscosity of the aqueous section. [36-38]

II. Preparation Methods Of Microsponges

The process to be used to prepare microsponges mainly depends on the drug's physicochemical properties and its solubility characteristics with the polymer(s) used for encapsulation. Microsponges can be prepared by following two techniques based on the physicochemical properties of the drug that will be loaded.

Liquid–Liquid Suspension Polymerization: In this step, the monomers are dissolved in an appropriate solvent along with the active ingredients and then surfactant, suspending agents, etc. is added as aqueous phase. Polymerization is triggered by introducing a catalyst or the temperature is raised. The polymerization process continues the formation of the spherical structure along with reservoir type of system. Finally the solvent is removed with spherical structures to obtain porous microsphere. When the medication is prone to polymerisation conditions, the two-step procedure should be utilized. Accordingly, the preparation of microsponges by this method involves following steps that are shown as flow chart in (Figure 2).

1. Selection of monomer or different monomers in combination.
2. Polymerization will cause monomer chain formation.
3. Cross-linking between the monomeric chains will form ladders.
4. Spherical particles will be formed by folding the ladder.
5. Bunches of microspheres will be formed due to microsphere aggregation.
6. Bunches will further give rise to the formation of Microsponges [39-42].

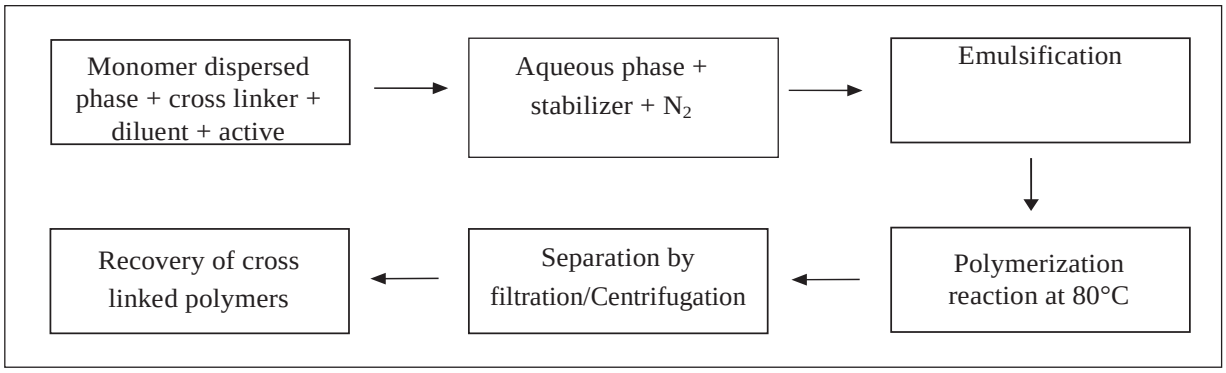

Figure 2: Suspension Polymerization Technique

Quasi-emulsion solvent diffusion

This technique involves two phases - internal organic phase and external aqueous phase. Internal phase generally consists of volatile solvents like ethanol, acetone or dichloromethane, while the external phase consists of aqueous PVA (polyvinyl alcohol) solution or water. Dichloromethane (20%) or TEC (Triethyl citrate) offers plasticity to the formulation. First, the internal organic phase polymer is dissolved in ethyl alcohol and drug is dissolved in this solution by ultrasonication at room temperature while the external phase consists of PVA solution in water. The solution is stirred and filtered for further use. The internal phase is mixed in external phase on mechanical stirrer dropwise. On continuous stirring, the Quasi emulsion droplets are formed which on further evaporation of organic solvent produces the solid microsponge cages. The obtained microsponge mixture is filtered to separate the microsponges and washing is done to obtain microsponges. Separated and washed microsponge is dried in a vacuum oven for 12hr at 40°C (Figure 3).

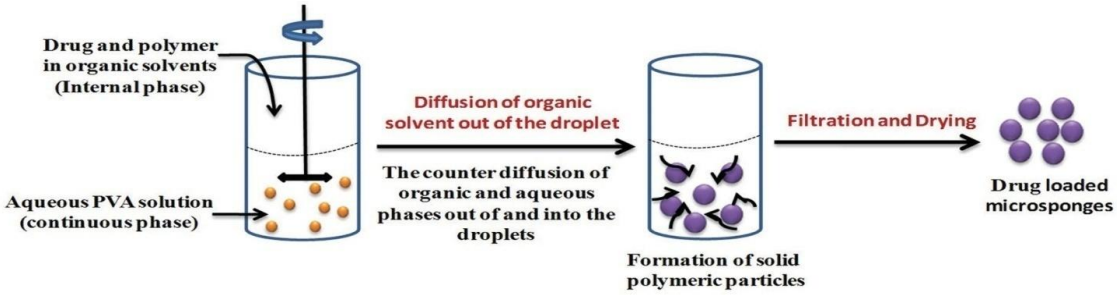

Figure 3: Quasi-emulsion solvent diffusion method

MECHANISMS OF DRUG RELEASE FORM MICROSPONGES

Several drug release mechanism apply to the microsponges as drug delivery systems (Table 1) for programmable release of actives from Microsponges [43].

Table 1: Mechanisms of drug release form microsponges

S. No.	Release system	Mechanism
1.	**Pressure triggered release**	The device extracts the fluid by rubbing or gripping the microsponges. The volume of release is dependent on microsponge tolerance.
2.	**Temperature-triggered release**	Temperature may also influence microsponges release of the active ingredients. At room temperature, certain compressed substance becomes very viscous to move naturally from the microsponge to the surface. For examples, the viscous sunscreens can not fully disperse out of the microsphere. A flow rate decreases rising due to decreased viscosity as the sun or skin temperature warms them up.
3.	**pH-triggered release**	This may be done by changing the surface on the microsponges, so the release of active compounds may vary depending on pH. Conventional microsponges are enteric- with a polymer (which imparts pH response) to produce pH-microsponges. USP spindle dissolution tool is used to conduct studies relevant to pH. Release increases from zero to 80% if the pH falls from 3 to 8. Therefore, pH may be changed to increase the drug's release time.
4.	**Solubility triggered release**	Microsponges loaded with water miscible elements such as antiseptics, deodorants and antiperspirants can activate the API in the presence of an aqueous medium, which is based on the external medium's capacity to absorb the API and its concentration gradients. Additionally, diffusion will trigger the liberation, by changing the partition coefficient of the elements between microsponge and external media.

EVALUATION METHODOLOGY OF MICROSPONGES [44-53]

1. Particle size and shape: The measurement of the particle size of loaded and unloaded microsponges can be carried out using laser light diffractometry or any other appropriate method. Light microscopy (LM) and scanning electron microscopy (SEM) are the most commonly used methods for visualizing microsponges to determine the structure and outer shape of these microparticulates [54-56].

2. Morphology and surface topography of microsponges: Research on morphology of Microsponges has proven that pores occur in the floor of the carrier. The remaining prepared microsponges can be coated at room temperature with gold-palladium, i.e. 37±0.5ºC underneath the argon surrounding. For determining the structure and surface topography of microsponges, these are gold-palladium-coated and then examined with SEM (scanning electron microscopy) approach for surface morphology [57].

3. Loading efficiency and production yield: Passive loading and active loading are the two methods which are completely based on the physical and chemical properties of the drug to be loaded. The passive charging method is one step whereas the active charging method is second step. Passive loading method or Passive charging is faster, more efficient and less complicated than active loading, so it is possible to choose passive drug loading [58-60]. The effectiveness of the drug loading and the yield of product can be calculated using the following:

$$\text{Loading efficacy} = \frac{\text{Actual drug content in microsponges}}{\text{Theoretical drug content}} \times 100 \qquad \text{Eqn. (1)}$$

$$\text{Production yield} = \frac{\text{Practical mass of microsponges}}{\text{Theoretical mass (Polymer + Drug)}} \times 100 \qquad \text{Eqn. (2)}$$

4. Characterization of Pore structure: The volume and diameter of the pores are critical in regulating the intensity and duration of the effectiveness of the active ingredient. The diameter of the pore also affects the flow

of the active ingredients from the microsponges into the vehicle which disperses material. The porosity parameters of microsponges such as intrusion–extrusion isotherms, total surface area of the pores, pore size distribution, interstitial volume, average pore diameters, percent porosity filled, percent porosity, bulk and apparent porous density, pores shape and morphology can be measured using mercury intrusion.

5. Determination of True density: The true density of microsponges is determined using an ultra pycnometer under helium gas and determined from an average of repeated determinations.

6. Drug-Polymer Compatibility Studies: The sample of drug, excipients, and mixture of drug with excipients (binary (1:1) powder mixtures prepared by triturating drug with the individual excipients) is sealed in vials and kept at room temperature for not less than one month and then samples are analyzed by DSC, XRD and FTIR [61, 62].

7. In-vitro Dissolution studies: Study of in vitro dissolution is carried out using USP XXIII dissolution apparatus with a modified basket consisting of 5µm chrome steel mesh, and rotation speed is 150 rpm. Mehta et al found that the drug release of clotrimazole gel of microsponge formulation is 88.89 %, 98.1 %, 99.4 % in 12 hours. The mechanism of dissolution (formal methods) is selected, and the solubility of drugs is assumed to establish sink conditions. The appropriate analytical methods are used in the evaluation of samples from the dissolution medium at different intervals [63].

8. Stability Studies: Stability of Microsponge formulation on storage is of great concern as it is the major resistance in the development of marketed preparations. The prepared formulation are tested for stability at 4 ± 1ºC, 25 ± 2ºC and 37 ± 5ºC & RH (Relative Humidity) 75 %. After three months, formulations are evaluated at regular intervals for the following parameters-appearance, pH, drug content analysis, Drug release profiles, Rheological properties etc [64, 65].

APPLICATIONS OF MICROSPONGES AS DRUG DELIVERY SYSTEMS

Microsponges are often used for topical delivery as anti-fungal, anti-inflammatory, antizits, anti-ulcer, in the therapy of Acitinic keratoses and may be included in a variety of products such as creams, gel, lotion. The microsponge technique is also used in the engineering of bone as well as cardiac tissue. Microsponge technique is used to minimize skin irritation or inflammation and sensitization in the sunscreen [66, 67]. The detailed applications of microsponges are listed as under and some are listed in (Figure 4).

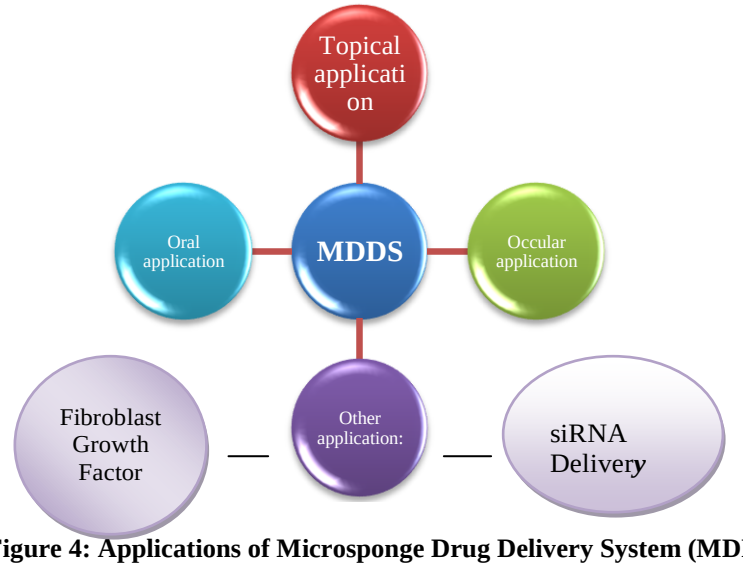

Figure 4: Applications of Microsponge Drug Delivery System (MDDS)

A. Topical Application

Microsponges have been researched for delivery of dental, topical, and biopharmaceutical products (Figure 5). The formulator is accessible with a broad variety of alternatives for medication and cosmetic product production. Besides supplying active ingredients at small concentrations to the target site, microsponges exhibits improved efficacy, decreased side effects and adjusted product release. For example, Paeonol microsponges provides a safer solution to managing skin diseases than plain paeonol cream due to improved bioavailability, leading to decreased residence time of the product on the face. Furthermore, adverse effects are minimized as fewer formulation passes into bloodstream circulation. Similarly, Microsponges for acne therapy are effective in managing acne lesions and oiliness in patients receiving acne vulgaris treatment [68].

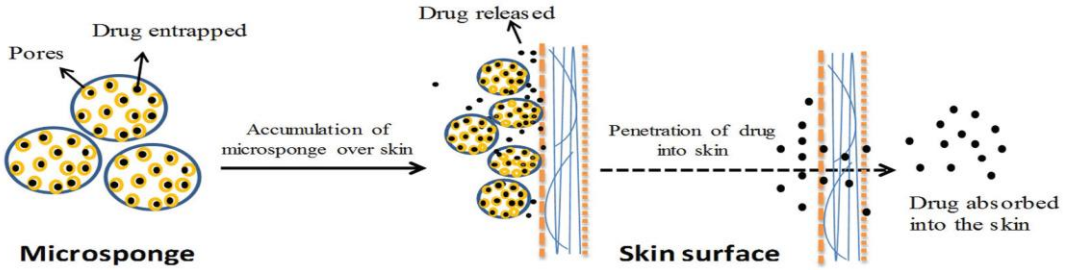

Figure 5: Drug release from topical application

B. Oral appilcation

The Microsponges compression property is remarkable since it varies from traditional microcapsules or solid powder mixtures owing to its matrix or sponge-like composition. The compressibility properties of microsponges are better than those of a physical drug mixture because of their sponge-like structure. A microsponge's spongy feature contributes to plastic particle deformation; creating mechanically solid tablets.

The rate of solubilization of bioactive compounds that are poorly water-soluble rises after being trapped in microsponges pores. In addition, the microsponges offer a safe environment and regulated medication release. It can be taken up by colonic macrophages due to its smaller size (< 200 µm), and localized drug action occurs at the desired site; therefore, microsponges is used for colon targeting. Similarly, Curcumin Microsponges with a gastro-retentive as floating microsponges offer improved site-specific absorption to combat gastric cancer. In vitro permeation of this curcumin microsponge across the matrix of gastric mucin gel shows the significant potential to transmit the medication through mucin and enter the intended site of gastric cancer as illustrated in (Figure 6).

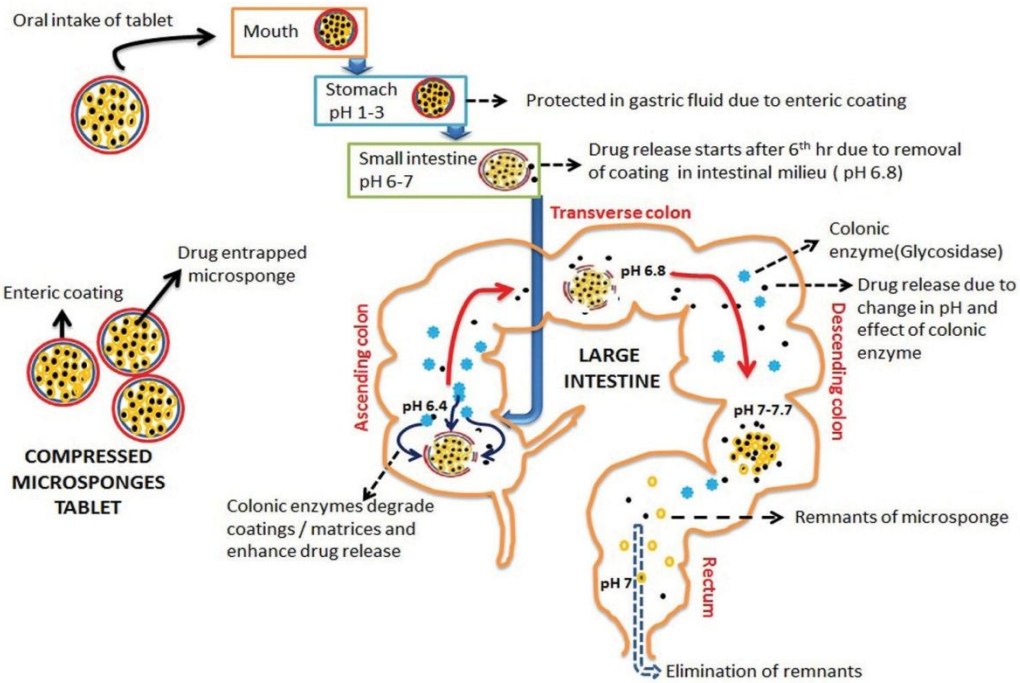

Figure 6: Drug release from oral microsponge application

C. Occular Application

Many forms of anatomical and physiological barriers (e.g. various layers of cornea, retina, and sclera including both blood aqueous and blood retinal barriers and other barriers) that present challenges to the delivery of a drug alone or in dosage form to the posterior of the eye [69]. Topical administration as an aqueous solution helps in the occular delivery of water-soluble drugs, whereas water-insoluble drugs can be administered topically as ointments or aqueous suspensions [70].

An ideal Ocular drug delivery system (OcDDS) should release the drug sustainably and remain intact for prolonged period in the front area of the eye. OcDDS has recently been recognised as a system that combines continuous medication release or bioavailability enhancements with patient satisfaction and user-friendliness. The system must be capable of providing site-specific facilities, increased bioavailability, and

continuous drug release; Microsponges has thus be0en increasingly used in recent research efforts. For example, a microsponge enhanced gel (MEG) has been formulated to administer topical ketotifen to the skin (Figure 7). MEG's viscosity, gel strength, mucoadhesive capacity, and spreadability varied in the range of 1299–1600centipoises, 8.12sec, 32.32 dynes/cm^2, and 22.88gm.cm/sec. The extraction of the drug from standardized formulations took up to 8 hours. Consequently, a MEG formulation has greater potential as a delivery method than an ophthalmic solution because of the stronger regulated release of the drug agent [71].

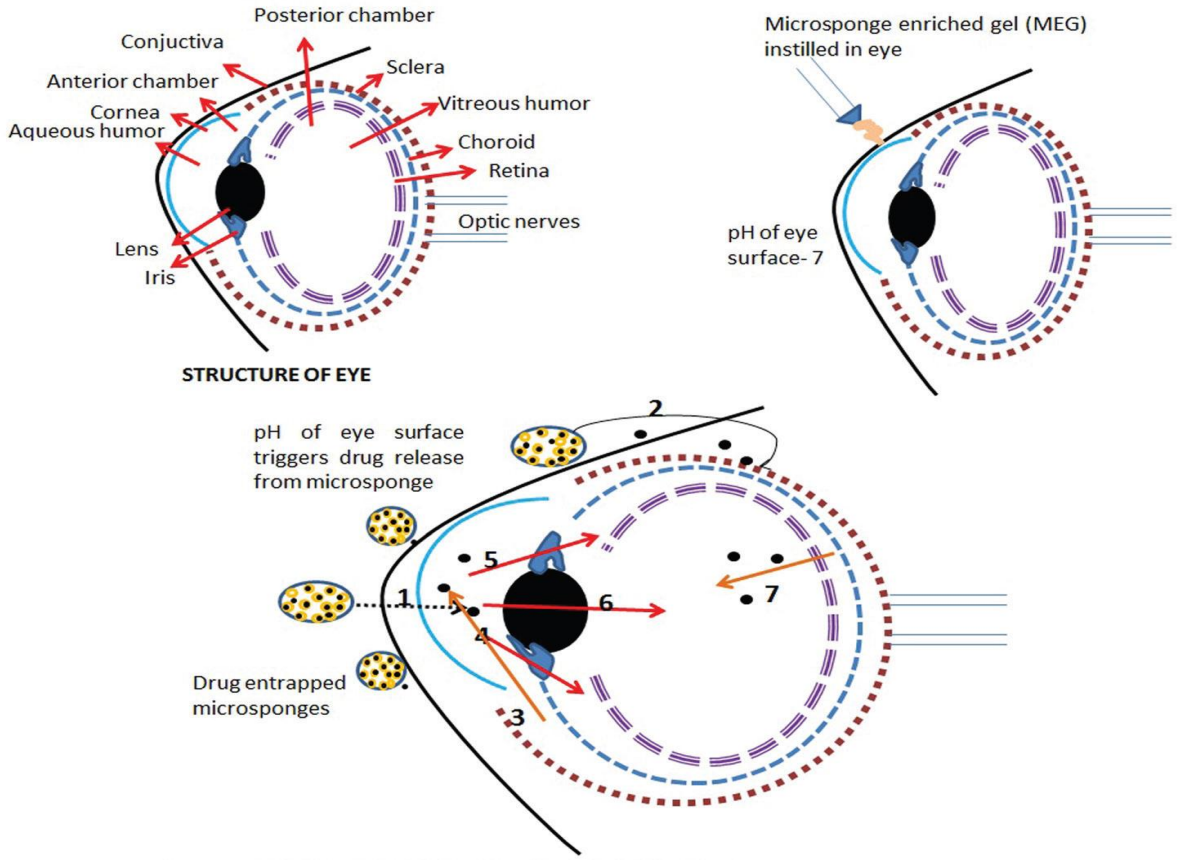

Figure 7: Drug release from ocular application

D. Other Applications

Microsponges have developed as an innovative drug delivery method with applications that involve not only topical and oral distribution, but also production of siRNA and fibroblast growth factors.

i. siRNA Delivery: In the field of modern therapeutics and pharmaceutical science, the delivery of siRNA by such a method can be used as transporting more than half a million copies of siRNA to a cell can be facilitated by taking one single RNAi-Microsponges. The Microsponges shows a high RNA load (15–21 wt %) that provides protection from degradation (Figure 8) [72, 73]

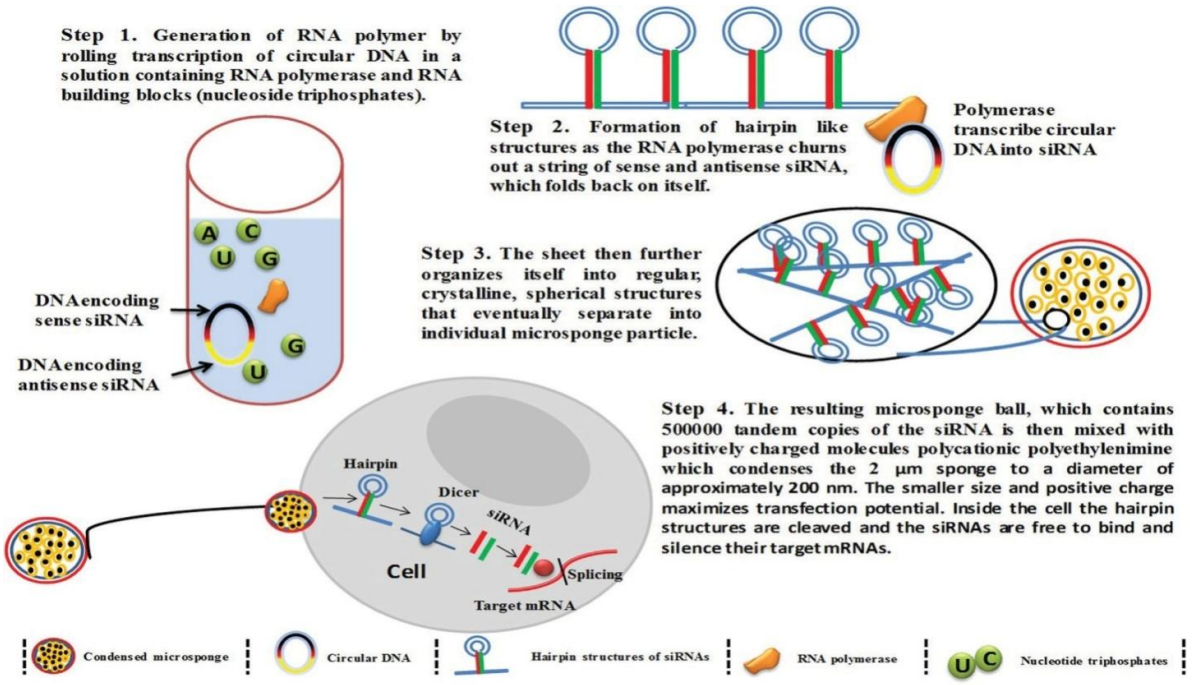

Figure 8: Delivery of siRNA from microsponges

ii. Fibroblast Growth Factor

In processing Poly(DL-lactic-co-glycolic acid), a thin biodegradable hybrid mesh, three-dimensional culture of human skin fibroblasts has been successfully tested. In the opening of a PLGA knitted mesh, the preparation consisted of web-like collagen microsponges [74]. In addition, a type 1 collagen was intended to act as a reservoir of the basic fibroblast growth factor (bFGF). When the microsponge was introduced by intramuscular injection into a mouse model, dose-dependent angiogenic activity occurred via sponge matrix biodegradation. An increase in blood flow in the murine ischemic limb was detected, which was not accomplished by bolus injection of bFGF [75].

RECENT ADVANCEMENTS IN MICROSPONGE DRUG DELIVERY SYSTEM

In Microsponge technologies, pharmaceutical companies are taking a step forward. Some of the marketed preparations and patented technologies (Table 2 and Table 3) [76-82]. Nowadays they are engaged in nanosponges, nanoferrosponges, and porous microbeads by changing the process. Such preparations are better and more durable than the microsponges.

Nanosponges: Nanosponges are the nanoformulations that are used in the delivery of topical drugs, particularly passive targeting of cosmetic agents. These are useful for skin absorption and extended retention within skin layer. These nanosponges have been developed by modifying the method of diffusion of the Solvent through either change in agitation, the amount of polymer and the emulsifier. Some researcher also showed that nanosponges are good carrier for the delivery of active ingredient which is available in gaseous form. These nanosponges carriers are also responsible for targeting cancerous cells.

Nao-ferrosponges: Nano-ferrosponges are nano targeting devices made up of ferric ions that can be triggered with the help of magnets. The magnet enforces the carrier to stimulate the deeper tissues and supply the drug at the specific target location. Such nano-ferrosponges were primed with polymers by co-precipitation of magnetic liquid. The prepared Nano-ferrosponges have high swelling index, excellent elasticity, hydrophilicity, and response to magnetism.

Porous Microbeads: Improved porous microsphere properties generate microbeads that have a wide number of pores. Technologies for polymerisation and cross-linking are used for the production of stable porous microbeads. These microbeads are used for the delivery of drugs to topical, buccal, and oral systems.

Table 2: List of marketed products using microsponge drug delivery system

Product Name	Pharmaceutical Uses	Manufacturer
Aramis fragrances	It soothes and cools the skin surface	Aramis Inc.
Carac Cream, 0.5%	Actinic keratoses	Dermik Laboratories, Inc.
Benzoyl peroxide	Anti-Acne	

Dermalogica Oil Control Lotion	Skin protectant	John and Ginger Dernatol
EpiQuin Micro	Hyper pigmentation	SkinMedica Inc
Glycolic Acid Moisturizer w/SPF 15	Anti-Wrinkles, soothing	AMCOL Health & Beauty Solution
Line Eliminator Dual Retinol Facial Treatment	Anti-wrinkle	Avon
Lactrex™12% Moisturizing Cream	Moisturizer	SDR Pharmaceuticals, Inc
Murad Moisturing Cream	Moisturizer	Murad Inc.
Micro Peel plus/Acne peel	Anti-Wrinkles, softer skin and smoother skin surface	Biomedic
Neutrogena oil free Acne face wash	Anti-Acne	Jhonson and Jhonson
NeoBenz®Micro, Neo®MicroSD NeoBenz®Microwash	absorb natural skin oils and act as antibacterial	Intendis Inc. Morristown
Oil free matte block SPF 20	Sunscreen	Dermalogica
Retin A Micro	Acne vulgaris	Ortho-McNeil Pharmaceutical, Inc
Retinol 15 Night cream	Anti-wrinkles	Sothys
Retinol cream	Helps maintain healthy skin	Biomedic
Salicylic Peel 20 and 30	Excellent exfoliation	Biophora
Sports cream RS and XS	Anti-inflammatory	Embil Pharmaceutical Co. Ltd.
Shine Stopper Oil Control	Control Oil, Minimize pore appearance, Smooth imperfection	Paula's choice skincare
Ultra guard	Protect Baby's skin	Scott Paper Company

Table 3: Patents filed on Microsponges [83]

Patent no.	Inventor	Publication Date	Technique	References
US4690825	Won	1987	Delivery vehicles consisting of a polymeric bead with a network of pores with an active ingredient retained in the network are made available for use in a system to provide controlled release of the active ingredient.	83
US4863856	Dean et al.	1989	Weighted microsponges of collagen with a highly cross linked collagen matrix are defined as suitable for use in motive reactor systems in organisms that cultivate. Also, the microsponges have an average particle size ranging from 100 to 1000 microns and specific gravity of about 1.05	84
US5135740	Katz et al.	1992	Immiscible phases, particularly polar and non-polar liquids, semi-solids or solids, are combined into a composition in which one is finely dispersed over the other without relying on emulsifying agents to either produce or stabilize dispersion. The particles are scattered in the continuous process. The principle applies to dispersions of the oil-in-water and water-in-oil form, and the drawbacks and limitations of emulsifying agents are absolutely avoided.	85
US5292512	Schaefer et al.	1994	The invention relates to a pharmaceutical or cosmetic composition for topical use, comprising microspheres of polymers or fatty substances filled with at least one active ingredient in an effective container, distinguished by a diameter of between 3 μm and 10 μm of at least 80% of the microspheres used.	86
US5316774	Robert et al.	1994	A formulation for the controlled release of an active material requires a matrix of polymeric particles, where each particle determines a network of internal pores. The enteric content remains intact in the stomach but under pH pressures in the intestines it can degrade. For another exemplary example, the formulation of the sustained release employs a blocking agent that remains stable under the anticipated environmental conditions to release the active substance.	87
US5725869	Ray et al.	1998	Microspheres, preferably containing an ingredient to be dispensed by controlled release, are prepared by solvent evaporation of an oil-in-water emulsion created by an organic	88

			solvent containing a polymer and plasticizer, and an aqueous solution containing one or more emulsifiers.	
US5955109A	Won et al.	1999	Retinoic acid compositions intended for topical use are formulated into novel formulations in which they are stored within pores of dense particles or microspheres as impregnants. The pores form a continuous network open to the particle's exterior, allowing the impregnant retinoic acid to be diffused outward at a controlled rate, depending on the size of the pore.	89
US6395300	Straub et al.	2000	Drugs, particularly drugs that are low in aqueous solubility, are supplied in a porous matrix shape, preferably microparticles, which enhances the drug dissolution in aqueous media. Microparticles of the porous drug matrix are reconstituted in a desired embodiment with an aqueous medium and administered parenterally or packaged in tablets or capsules for oral administration using normal techniques.	90
US20040247632	Maurizio et al.	2004	In accordance with this invention, these are equipped with high consistence chitosan-topical formulations for the delivery of water-active agents (such as retinoic acid) during which the chemical agent is either dissolved or stuck within the variety of Suspended Particles in an efficient dispersing agent in a very chitosan matrix beneath Vigorous Stirring conditions.	91
US7426776B2	Franklin et al.	2008	The invention relates to a method of creating a nonwoven fabric with microsponges consisting of obtaining a nonwoven base consisting of fibers having a first side and a second side and having a weight greater than around 2 oz / yd2, stitching the nonwoven base with a stitching yarn in elongated spaced separate rows of stitches, stitching rows with a stitch form factor greater than 0.54 where the stitching yarn is more than 1 gf / denier tenacious.	92
EP2317989A2	Shubhas Balaram Bhowmick et al.	2009	A substantially porous, micro-particle comprising therapeutically effective amounts of tretinoin and ethyl cellulose.	93
US20140102991	Euginea P. et al.	2014	Given substantial progress in the synthesis of nanocomposite materials, the integration of multiple components with different functions remains a major challenge, significantly limiting control over nanocomposite properties. The hybrid degradable systems can be used as novel non-toxic photocatalytic products for polluted waters, such as environmental cleanup.	94

FUTURE PROSPECTS OF MICROSPONGE AS DRUG DELIVERY SYSTEM

Microsponge drug delivery system would soon offer promising opportunities in multiple pharmaceutical implementations as it has distinctive characteristics such as enhanced product quality and elegance, expanded release, enhanced drug release profile, decreased discomfort, enhanced physical, chemical, and thermal stability, making it easy to develop novel product form. It provides a wide range of formulating advantages. Liquids can be transformed into free flowing powders. Formulations can be developed with otherwise incompatible ingredients with prolonged stability without use of preservatives. Safety of the irritating and sensitizing drugs can be increased and programmed release can control the amount of drug release to the targeted site.

The actual role in the future is the design of the delivery system for oral peptide distribution by variable polymer ratio. Newly developed classes of pharmaceuticals, biopharmaceuticals (peptides, proteins and DNA-based therapeutics) are fueling the rapid evolution of drug delivery technology. The use of bioerodible and biodegradable polymers for drug delivery enables it to deliver active content safely. Since these porous structures have additionally been researched for drug delivery through the pulmonary path, that demonstrates that these structures will demonstrate economical drug discharge even within the deficiency of the dissolved fluid; the colon being the associate economical destination location for drug discharge. These carriers additionally got to be established for different methods of drug administration such as parenteral and pulmonic pathways. These carrier systems have also found their application in cosmetics because of their class. These developments enabled researchers to create varying use of them. These novelties within the formulation additionally open up new ways that of delivering drugs.

III. Conclusion

The microsponge delivery system is a unique technology for the controlled release of microporous beads, loaded with an active agent, offering a potential reduction in side effects while maintaining their therapeutic efficacy. The microsponge drug delivery system offers entrapment of its ingredients and is believed to contribute toward reduced side effects, improved stability, increased elegance and enhanced formulation flexibility. In addition, numerous studies have confirmed that microsponge systems are non-irritating, non-mutagenic, non-allergenic, and non-toxic. This technology is being used currently in cosmetics, over-the-counter skincare, sunscreens, and prescription products. This kind of drug delivery technology may lead to a better understanding of the healing of several diseases. Hence, Microsponge-based drug delivery technology is likely to become a valuable drug delivery matrix substance for various therapeutic applications in the future.

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