



MICROSPONGE DRUG DELIVERY SYSTEM: AN OVERVIEW

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ABSTRACT

The Microsponge Delivery System (MDS) is a patented polymeric system consisting of porous microspheres. They are tiny sponge like spherical particles that consist of a myriad of interconnecting voids within a non-collapsible structure with a large porous surface through which active ingredient are released in a controlled manner. Microsponges are porous microspheres having myriad of interconnected size ranging voids of particle from 5-150 μm . The area of drug delivery technology is evolving rapidly and becoming highly competitive day by day. The developments in the delivery systems are being utilized to optimize the efficacy and the cost effectiveness of the therapy. These microsponges have the capacity to entrap a wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens and anti-infective, etc. are used as a topical carrier system. these porous microspheres with active ingredients can be incorporated in to formulations such as creams, lotions and powders. Microsponges consisting of noncollapsible structures with porous surface through active ingredients are released in a controlled manner. Release of drug into the skin is initiated by a variety of triggers, including rubbing and higher than ambient skin temperature.

KEYWORDS: Microsponge, porous microspheres, Microsponge Delivery System (MDS), Pharmaceutical product.

INTRODUCTION

The microsponges technology was developed by Won in 1987 and the original patent were assigned to advanced polymer system, inc. This company developed a large numbers of variation of the procedures and those are as well as applied to the cosmetic over the counter (OTC) and prescription pharmaceutical product. Microsponges are polymeric drug delivery systems composed of porous microspheres. They are tiny, sponge like spherical particles that consist of a myriad of interconnecting voids within a non-collapsible structure with a large porous surface. Moreover, they enhance stability, reduce side effects and modify drug release. These attributes have been successfully demonstrated in keratoses, respectively. Microsponges are porous microspheres having myriad of interconnected size ranging voids of particle from 5-150 μm .^[2]

The area of drug delivery technology is evolving rapidly and becoming highly competitive day by day. The developments in the delivery systems are being utilized to optimize the efficacy and the cost effectiveness of the therapy. The challenges faced by drug development industry are.

1. sustained release technology for reducing irritation of a wide range and other skin care actives thereby increasing patient/client compliance and results.

2. Enhanced formulation stability ensuring long term product efficacy and extended shelf life.
3. superior skin feel and exceptional product esthetics.

Microsponge delivery systems are uniform, spherical, porous polymeric microspheres having myriad of interconnected voids of particle size range 5-300 μm . These microsponges have the capacity to entrap a wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens and anti-infective, etc. are used as a topical carrier system. Microspheres, averaging 25 μm in diameter and embedded in the vehicle, act like microscopical sponges, storing the active drug until its release is triggered by application to the skin surface. Microspores within the spheres comprise a total pore density of approximately 1ml/g, and pore length 10ft for extensive drug retention. Further these porous microspheres with active ingredients can be incorporated in to formulations such as creams, lotions and powders. Microsponges consisting of noncollapsible structures with porous surface through active ingredients are released in a controlled manner.^[3] Release of drug into the skin is initiated by a variety of triggers, including rubbing and higher than ambient skin temperature. Their high degree of cross-linking results in particles that are insoluble, inert and of sufficient strength to stand up to the high shear commonly used in manufacturing of creams, lotions, and powders. Their characteristic feature

is the capacity to adsorb or “load” a high degree of active materials into the particle and on to its surface. Its large capacity for entrapment of actives, up to three times its

weight, differentiates microsp sponge products from other types of dermatological delivery systems.^[4]

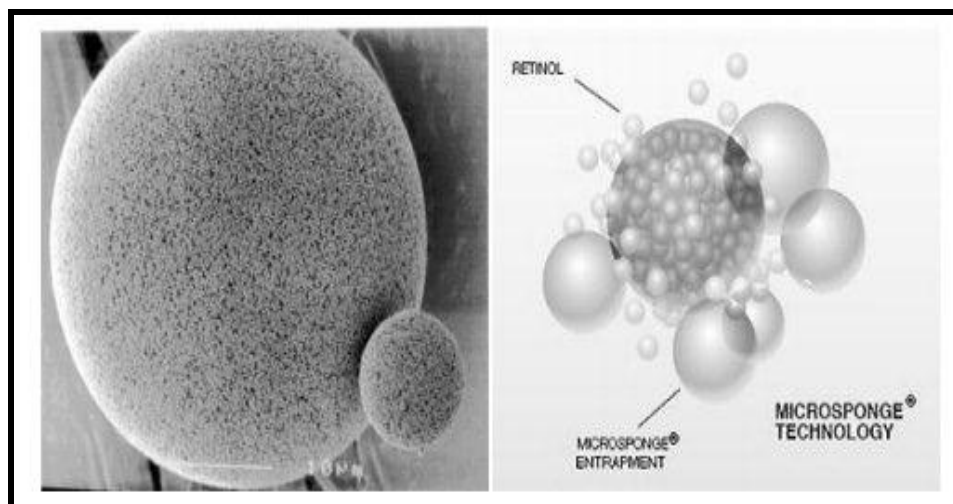


Fig1: Microsponge technology^[5]

Microsponges are microscopic spheres capable of absorbing skin secretions, therefore reducing oiliness and shine from the skin. Spherical particles composed of clusters of even tinier spheres are capable of holding four times their weight in skin secretions. These products are typically presented to the consumer in conventional forms like creams, gels or lotions and they contain a relatively high concentration of active ingredients.^[6]

Definition: The Microsponge Delivery System (MDS) is a patented polymeric system consisting of porous microspheres. They are tiny sponge like spherical particles that consist of a myriad of interconnecting voids within a non-collapsible structure with a large porous surface through which active ingredient are released in a

controlled manner. The size of the microsponge's ranges from 5-300 μ m in diameter and a typical 25 μ m sphere can have up to 250000 pores and an internal pore structure equivalent to 10 feet in length, providing a total pore volume of about 1ml/g for extensive drug retention. The surface can be varied from 20 to 500 m²/g and pore volume range from 0.1 to 0.3cm³/g. This results in a large reservoir within each microsponge, which can be loaded with up to its own weight of active agent.² Microsponges are porous, polymeric microspheres that are mostly used for prolonged topical administration. Microsponges are designed to deliver a pharmaceutically active ingredient efficiently at minimum dose and also to enhance stability, reduce side effects, and modify drug release profiles.^[7]

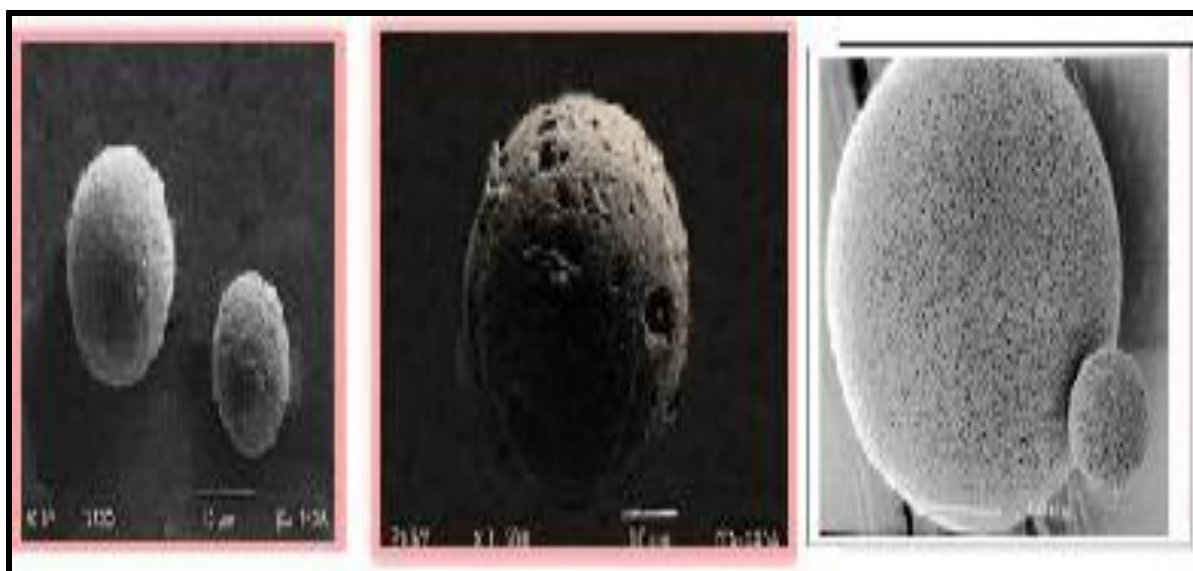


Fig2: view of microsponge^[8]

The Microsponge Delivery System^[9]

The microsponge technology was developed by Won in 1987, and the original patents were assigned to Advanced Polymer Systems. Microsponges are porous microspheres having myriad of interconnected voids of particle size ranging between 5-300 μm (Figure 3). These microsponges have capacity to entrap wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens, and anti-infectives, anti-fungal and anti-inflammatory agents etc. and are used as a topical carrier system. Further these porous microspheres with active ingredients can be incorporated into formulations such as creams, gel, lotions and powders and share a broad package of benefits.

Mechanism

Microsponges consist of non-collapsible structures with porous surface through which active ingredients are released in controlled manner. Depending upon the size, the total pore length may range up to 10 μm and pore volume up to 1 ml/gm. When applied to the skin, the microsponge drug delivery system (MDS) releases its active ingredient on a time mode and also in response to other stimuli (rubbing, temperature, pH, etc). Microsponges have the capacity to adsorb or load a high degree of active materials into the particle or onto its surface. Its large capacity for entrapment of actives up to 3 times its weight differentiates microsponges from other types of dermatological delivery systems. Recently, microsponge delivery system has been successively addressed for the controlled release of drugs onto the epidermis with assurance that the drug remains chiefly localized and does not enter the systemic circulation in major amounts and resulted in a new creation of highly efficacious and well tolerated novel products.

To control the delivery rate of active agents to a predetermined site in human body has been one of the biggest challenges faced by drug industry. Several predictable and reliable systems were developed for systemic drugs under the heading of transdermal delivery system (TDS) using the skin as portal of entry. It improved the efficacy and safety of many drugs that may be better administered through skin. But TDS is not practical for delivery of materials whose final target is skin itself. Most liquid or soluble ingredients can be entrapped in the particles. Actives that can be entrapped in microsponges must meet following requirements.

1. It should be either fully miscible in monomer or capable of being made miscible by addition of small amount of water immiscible solvent.
2. It should be water immiscible or at most only slightly soluble.
3. It should be inert to monomers.
4. It should be stable in contact with polymerization catalyst and conditions of polymerization.^[10]

Materials of Preparation of Microsponge

The microsponges containing drugs were prepared by quasi emulsion solvent diffusion method using different polymer ratio as shown in Table 1. The inner phase, Ethyl cellulose was dissolved in dichloromethane and then added drug to solution under ultrasonication at 35°C and outer phase prepared by dissolving PVA in distilled water at 60°C for 10 min. The inner phase is poured into PVA solution in water. The resultant mixture was stirred by magnetic stirrer for 60 min at 25°C, and filtered to separate the microsponges. The microsponges were dried in an air heated oven at 40 °C for 12 hrs, and weighed to determine the yield. Optimum values for microsponge formulation.

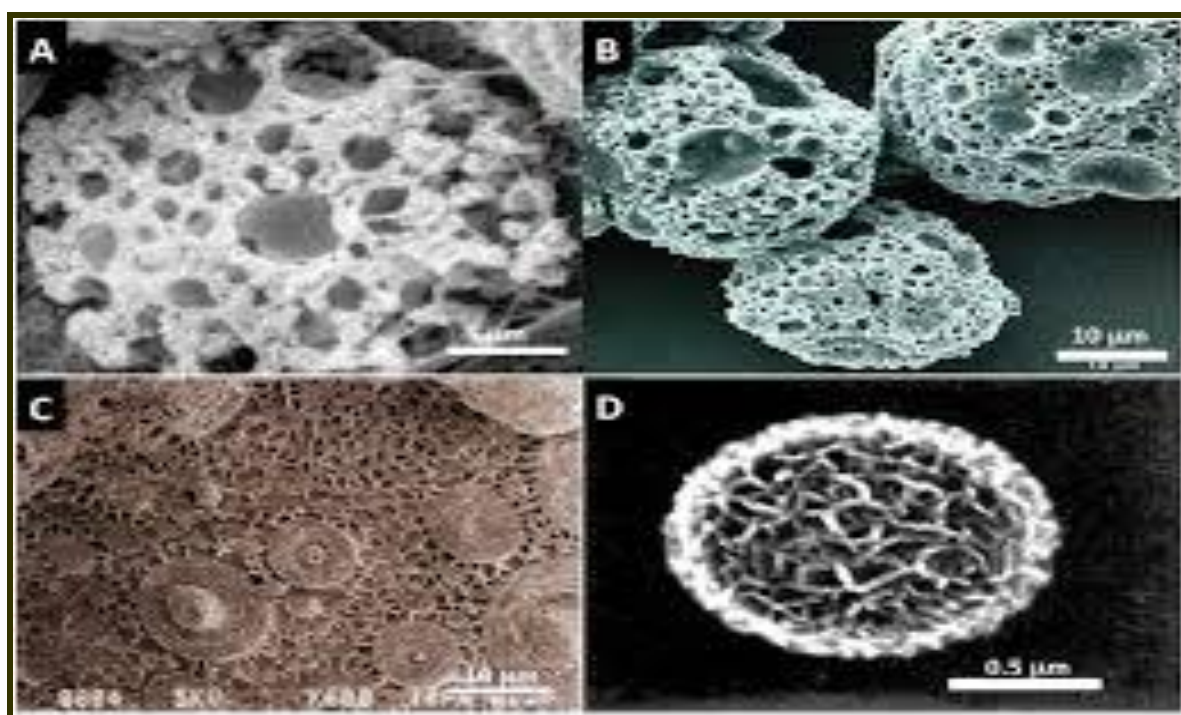


Fig3: Structure Of Microsponge^[11]

Table 1: Optimum Values For Microsponge Formulation^[12]

Sr.no	Specification	Optimum value
1	Drug and polymer ratio	1:1,1:2,1:3, 2:1 & 3:1
2	Amount of drug (mg)	100-300
3	Poly vinyl alcohol (mg)	100
4	Inner phase solvent (ml)	Ethyl alcohol
5	Amount of inner phase solvent	10
6	Amount of water in outer phase (ml)	100
7	Temperature of inner phase	25°C
8	Type of process	Magnetic stirrer and bath sonicator
9	magnetic stirrer speed	1000 rpm

Advantages of MDS^[13]

- 1) Microsponges can times its weight absorb oil up to 6 without drying.
- 2) It provides continuous action up to 12 hours i.e. extended release.
- 3) Improved product elegance. Lessen the irritation and better tolerance leads to improved patient compliance.
- 4) They have better thermal, physical and chemical stability.
- 5) These are non-irritating, nonmutagenic, non allergenic and nontoxic
- 6) MDS allows the incorporation of immiscible products.
- 7) They have superior formulation flexibility.
- 8) In contrast to other technologies like microencapsulation and liposomes
- 9) High drug loading capacity Improve therapy.^[14]
- 10) Compatible with vehicle and ingredients.
- 11) Flexibility to develop novel product forms Stable over the range 1 -11 ph.
- 12) Solution Free flowing and cost effective
- 13) Improve thermal, physical, and chemical stability

Characteristics of Microsponge^[15]

- ❖ Microsponges formulations are stable over range of pH 1-11;

- ❖ Microsponge formulations are stable at temperature up to 130°C;
- ❖ Microsponge formulations are self-sterilizing as their average pore size 0.25 µm where bacteria cannot penetrate;
- ❖ Microsponge formulation have higher payload (50-60%), still free flowing and can be cost effective
- ❖ It should be either fully miscible in monomer or capable of being made miscible by addition of small amount of a water immiscible solvent.^[16]
- ❖ It should be water immiscible or at most only slightly soluble.
- ❖ It should be inert to monomers.
- ❖ The solubility of actives in the vehicle must be limited to avoid cosmetic problems; not more than 10 to 12% w/w microsponges must be incorporated into the vehicle. Otherwise the vehicle will deplete the microsponges before the application.
- ❖ The spherical structure of microsponges should not collapse.
- ❖ Polymer design and payload of the microsponges for the active must be optimized for required release rate for given time period.
- ❖ It should be stable in contact with polymerization catalyst and conditions of polymerization.

Table no: 2 Application^[17]

Sr.no	Active agent	Application
1	Sunscreens	Long lasting product efficacy, with improved protection against sunburns & with reduced irritancy & sensitization.
2	Anti-acne eg. Benzoyl peroxide	Maintained efficacy with decreased skin irritation & sensitization.
3	Anti-inflammatory eg. Hydrocortisone	Long lasting activity with reduction of skin allergic response & dermatoses.
4	Anti-fungal	Sustained release of actives.
5	Anti-dandruffs eg. zinc pyrithione, selenium sulfide	Reduced unpleasant odour with lowered irritation with extended safety & efficacy.
6	Antipruritics	Extended & improved activity.
7	Rubefacients	Prolonged activity with reduced irritancy greasiness & odour.

Factors Affecting Drug Release From Microsponge Delivery System^[18]

- Physical properties of Microsponge system like pore diameter, pore volume, resiliency etc. Properties of vehicle in which the microsponges are finally dispersed.

- Pressure Rubbing/ pressure applied can release active ingredient from microsponges onto skin.
- Temperature change some entrapped actives can be too viscous at room temperature to flow spontaneously from microsponges onto the skin.

Increased in skin temperature can result in an increased flow rate and hence release.

- Solubility Microsponges loaded with water-soluble ingredients like antiperspirants and antiseptics will release the ingredient in the presence of water. The release can also be activated by diffusion taking into consideration the partition coefficient of the ingredient between the microsponges and the outside system.

Potential features of microspunge^[19]

- 1) Shows tolerable stability over pH ranging from 1 to 11 and at high temperatures (up to 130°C).
- 2) Reveal good compatibility with various vehicles and ingredients.
- 3) High entrapment efficiency up to 50 to 60%.
- 4) Are characterized by free flowing properties.
- 5) The average pore size of microsponges is small (0.25 μm) in a way to prevent the penetration of bacteria, thus they do not need sterilization or addition of preservatives.
- 6) Can absorb oil up to 6 times their weight without drying.
- 7) Microsponges are characterized by free flowing properties.
- 8) Microsponges are non-allergenic, non-irritating, nonmutagenic and non-toxic.
- 9) Microsponges can absorb oil up to 6 times their weight without drying.

Limitations^[20]

The preparation methods usually use organic solvents as porogens, which pose an environmental hazard, as some may be highly inflammable, posing a safety hazard. In some cases, the traces of residual monomers have been observed, which may be toxic and hazardous to health.

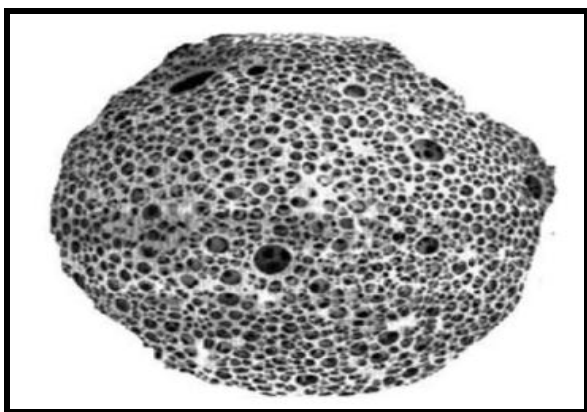


Fig4:-Highly Porous Nature Of A Microspunge^[21]

Benefits Of Microspunge Drug Delivery Systems^[22]

- ❖ Enhanced product performance.
- ❖ Extended release.
- ❖ Diminish irritation and hence enhanced patient Compliance.
- ❖ Improved product elegance.
- ❖ Improved oil control as it can absorb oil up to 6 times it

- ❖ weight without drying.
- ❖ Allows for novel product forms.
- ❖ Improves efficacy in treatment.
- ❖ Cure or control confirm more promptly.
- ❖ Improve control of condition.
- ❖ Improve bioavailability of same drugs.
- ❖ Flexibility to develop novel product forms.
- ❖ Non-irritating, non-mutagenic, non-allergenic and non-toxic.
- ❖ Improves stability, thermal, physical and chemical stability.
- ❖ Allows incorporation of immiscible products.
- ❖ Improves material processing eg. liquid can be converted to Powder.

Methods of preparation of microspunge

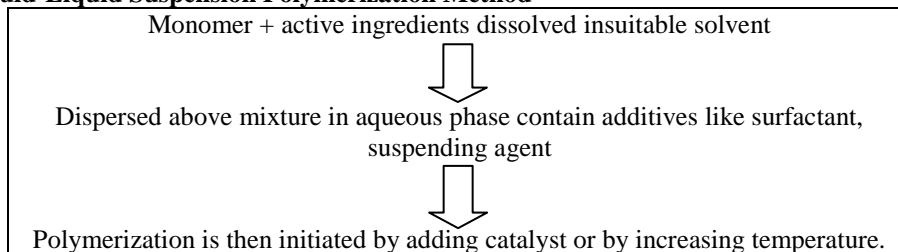
- 1) Liquid-liquid suspension polymerization method.
- 2) Quasi-emulsion solvent diffusion method.

1) Liquid-liquid suspension polymerization method^[23]

The porous micro spheres are prepared by suspension polymerization method in liquid-liquid systems. The polymerization process leads to the formation of a reservoir type of system, which opens at the surface through pores. In some cases an inert liquid immiscible with water but completely miscible with monomer is used during the polymerization to form the pore network. After the polymerization the liquid is removed leaving the porous microspheres, i.e., microsponges. Impregnating them within preformed microsponges then incorporates the functional substances. Sometimes solvent may be used for faster and efficient incorporation of the active substances. The microsponges act as topical carriers for variety of functional substances, e.g. Anti-acne, anti-inflammatory, anti purities, anti fungal, rubefaciants, etc. When the drug is sensitive to the polymerization conditions, two-step process is used. The polymerization is performed using substitute porogen and is replaced by the functional substance under mild experimental condition.

Procedure^[24]

Microsponges are prepared by suspension polymerization process in liquid-liquid systems. Firstly, the monomers are dissolved along with active ingredients (non-polar drug) in an appropriate solvent solution of monomer, which are then dispersed in the aqueous phase with agitation. Aqueous phase typically consist of additives such as surfactants and dispersants (suspending agents) etc in order to facilitate the formation of suspension. Once the suspension is established with distinct droplets of the preferred size then, polymerization is initiated by the addition of catalyst or by increasing temperature as well as irradiation. The polymerization method leads to the development of a reservoir type of system that opens at the surface through pores. During the polymerization, an inert liquid immiscible with water however completely miscible with monomer is used to form the pore network in some cases. Once the polymerization process is completed

Table No: 3 Liquid-Liquid Suspension Polymerization Method^[25]

The various steps involved in the preparation of microsponges are summarized as follows^[26]

Step 1: Selection of monomer as well as combination of monomer.

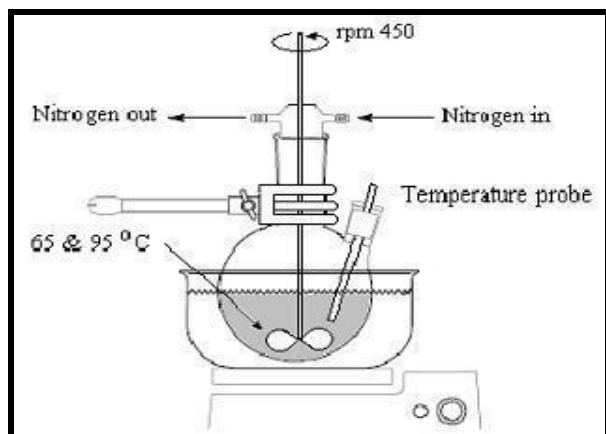
Step 2: Formation of chain monomers as polymerization starts.

Step 3: Formations of ladders as a result of cross-linking between chain monomers.

Step 4: Folding of monomer ladder to form spherical particles.

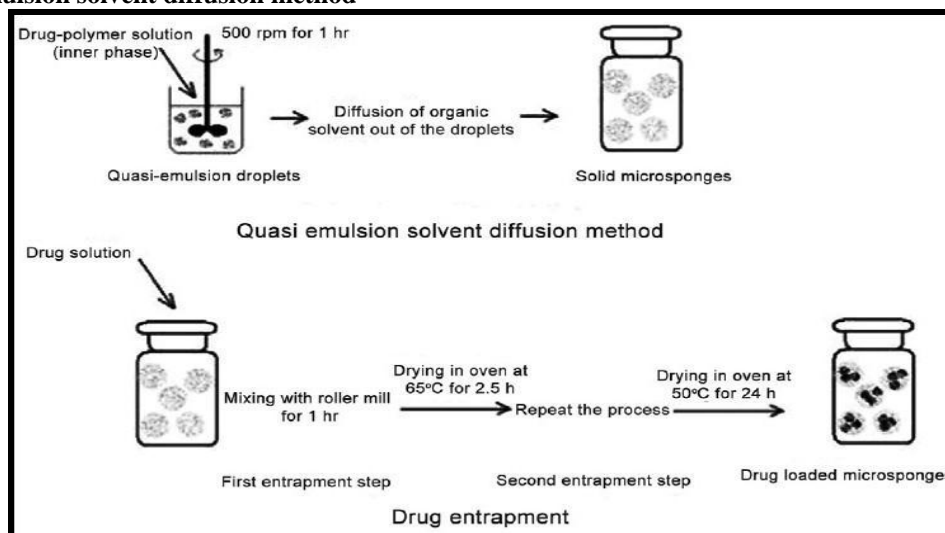
Step 5: Agglomeration of microspheres leads to the production of bunches of microspheres.

Step 6: Binding of bunches to produce microsponges.

**Fig 5: Microsponge preparation of liquid liquid suspension polymerization^[27]**

This is top-down approach starting with preformed polymer. This process involved formation of quasi-emulsion of two different phases' i.e. internal phase and external phase similar to emulsions. The internal phase of drug-polymer solution made in a volatile solvent like ethanol or acetone or dichloromethane was added to external phase comprising the aqueous polyvinyl alcohol (PVA) solution with vigorous stirring. Triethylcitrate (TEC), which was added at an adequate amount in order to facilitate plasticity. Stirring lead to the formation of discrete emulsion globules called quasi-emulsion globules. Solvent was then extracted out from these globules to form insoluble, rigid microparticles i.e. microsponges. Following sufficient stirring, the mixture was then filtered to separate the microsponges. The microsponges were then dried in an air heated oven. Conceptually, the finely dispersed droplets of the polymeric solution of the drug (dispersed phase) get solidified in aqueous phase via counter diffusion of organic solvent and water out of and into the droplets. The diffused aqueous phase within the droplets decreased the drug and polymer solubility resulting in the co-precipitation of both the components and continued diffusion of the organic phase results in further solidification, producing matrix-type porous microspheres. In comparison with liquid-liquid suspension polymerization method, this method offered the advantage of less exposure of the drug to the ambient conditions, low solvent residues in the product because the solvent get extracted out due to its solubility in aqueous media or due to its volatile nature.

3) Quasi-emulsion solvent diffusion method^[28]

**Figure6: Preparation of microsponges by quasi emulsion solvent diffusion^[29]**

Evaluation Test

1. Physiological properties

a) **Particle size and size distribution**^[30]: Particle size and size distribution are evaluated using either an optical microscope or an electron microscope. This is an extremely crucial step, as the size of the particles greatly affects the texture of the formulation and its stability. Free-flowing powders with fine aesthetic attributes are possible to obtain by controlling the size of particles

during polymerization. Particle size analysis of loaded and unloaded Microsponges can be performed by laser light diffractometry or any other suitable method. The values (d50) can be expressed for all formulations as mean size range. Cumulative percentage drug release from Microsponges of different particle size will be plotted against time to study effect of particle size on drug release.(eg.gel)

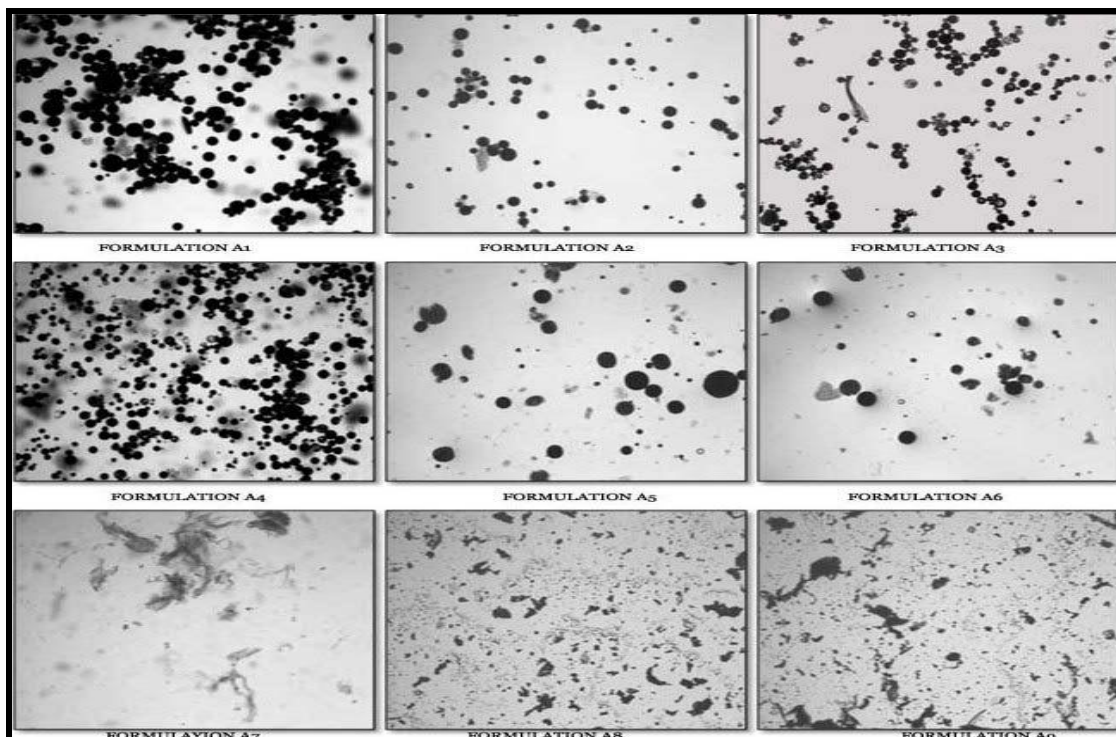


Figure7: Particle Size And Shape Of Microsponge Enriched Gel (Optical Microscopy)^[31]

b) **Determination of pH**^[32]: The pH of the microsponges enriched gel was determined using a calibrated pH meter. The readings were taken for average of 3 samples.

b) **Determination of true Density**^[33]: The true density of microparticles is measured using an ultracycrometer under helium gas and is calculated from a mean of repeated determinations.

c) **Surface topography of Microspong(SPM)**^[34]: For morphology and surface topography, various techniques have been used like photon correlation spectroscopy (PCS), Scanning electron microscopy (SEM),

transmission electron microscopy (TEM) etc. SEM is used widely for which prepared Microsponges are coated with gold-palladium under an argon atmosphere at room temperature and then the surface morphology of the Microsponges is studied.

3) Scanning Electron Microscopy(SEM)^[35]

The morphology and size of microsponges were observed by scanning electron microscopy. Prepared microsponges were coated with gold and studied by scanning electron microscopy (Phenoworld) under vacuum at room temperature.

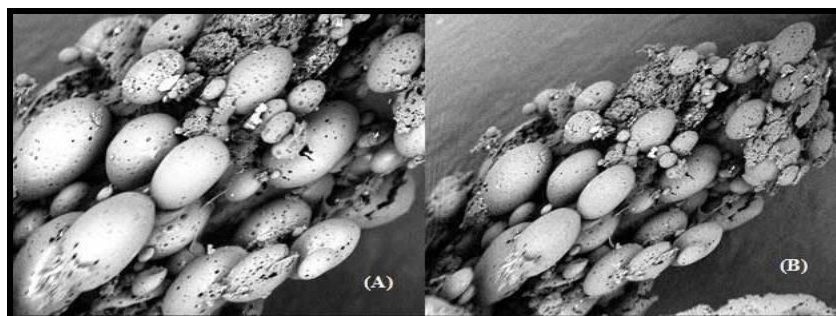


Figure 8: (A and B) SEM photography of microsponges.^[36]

4) Determination of Loading Efficiency^[37]: The drug content in the microsponges was determined by High Performance Liquid Chromatography (HPLC) method. A sample of drug containing microsponges (10 mg) was dissolved in 100 ml of methanol. The drug content was calculated from the calibration curve and expressed as loading efficiency.

$$\text{Loading Efficiency} = \frac{\text{Actual drug content in microsponge}}{\text{Theoretical drug content}} \times 100$$

5) Determination of Production Yield³⁸: The production yield of the microsponges was determined by calculating accurately the initial weight of the raw materials and the last weight of the microsponges obtained.

$$\text{Production Yield (PY)} = \frac{\text{Practical mass of microsponges}}{\text{Theoretical mass (Polymer + drug)}} \times 100$$

6) Dissolution Tests^[39]: Dissolution release rate of microsponges can be studied by use of dissolution apparatus USP XXIII with a modified basket consisted of 5 μm stainless steel mesh. The speed of the rotation is 150 rpm. The dissolution medium is selected while considering solubility of actives to ensure sink conditions. At various intervals the samples from the dissolution medium was analysed by suitable analytical methods.

7) Thermoanalytical Methods^[40]: Thermal analysis using differential scanning calorimetry (DSC) is carried out for the pure drug, polymer and the drug-polymer physical mixture to confirm compatibility. DSC is also performed for the microsponge formulations to ensure that the formulation process does not change the nature of the drug. Samples (approximately 2 mg) are placed in aluminum pans, sealed and operated at a heating rate of 20°C/min over a temperature range 40 to 430°C. The thermograms obtained by DSC for the physical mixtures, as well as microsponges, should be observed for broadening, shifting and appearance of new peaks or disappearance of certain peaks. The peak corresponding to the melting of the drug should be preserved in all thermograms.

8) Resiliency (Viscoelastic Properties)^[41]: Resiliency (viscoelastic properties) of microsponges can be modified to produce beadlets that is softer or firmer according to the needs of the final formulation. Increased cross-linking tends to slow down the rate of release.

9) Compatibility Studies^[42]: Compatibility of drug with reaction adjuncts can be studied by thin layer chromatography (TLC) and Fourier Transform Infra-

red spectroscopy (FT-IR). Effect of polymerization on crystallinity of the drug can be studied by powder X-ray diffraction (XRD) and Differential Scanning Colorimetry (DSC). For DSC approximately 5 mg samples can be accurately weighed into aluminum pans and sealed and can be run at a heating rate of 15°C/min over a temperature range 25–430°C in atmosphere of nitrogen.

Examples of Enhanced Product Performance^[43]

- Oil control: Microsponge can absorb oil up to 6 times its weight without drying.
- Extended release.
- Reduced irritation and hence improved patient compliance.
- Improved product elegance.

Release Mechanisms from Microsponges^[44]

MDS consists of a multitude of porous microspheres that contain a complex network of interconnecting voids with a non-collapsible structure. Depending on several modifiable factors, the rate of release of the active ingredients can be determined before they are entrapped in the microspheres. These modifiable factors include the pore diameter, the extent of cross-linking of the polymers, the difference in concentration of the active ingredient between the microspheres, and the vehicle in which these spheres reside. The topical agent formulation with the MDS can be prepared in many different forms, such as a gel, cream, or lotion. Once the formulation is topically applied to the desired area of the skin, the active ingredients diffuse out of the spheres into the vehicle and then onto the skin. Microsponges can be designed to release given amount of active ingredients over time in response to one or more external trigger.

a) Pressure: Rubbing or pressure applied can release active ingredient from microsponges onto skin.

b) Temperature Change: Some entrapped actives can be too viscous at room temperature to flow spontaneously from microsponges onto the skin. Increase in skin temperature can result in an increased flow rate and hence an increase in release. So it is possible to modulate the release of substances from the microsponge by modulation of temperature. For example, viscous sunscreens were found to show a higher release from microsponge when exposed to higher temperatures; thus a sunscreen would be released from a microsponge only upon exposure to the heat from the sun.

c) pH: Triggering the pH-based release of the active can be achieved by modifying the coating on the microsponge. This has many applications in drug delivery.

d) Solubility: Microsponges loaded with water-soluble ingredients like antiperspirants and antiseptics will release the ingredient in the presence of water. Thus release may be achieved based on the ability of the external medium to dissolve the active ingredient, the concentration gradient varies or the ability to swell the microsponge network. The release can also be activated

by diffusion, taking into consideration the partition coefficient of the ingredient between the microsponges and the outside system. By proper manipulation of the aforementioned programmable parameters, microsponges can be designed to release given amount of active ingredients over time in response to one or more external triggers.

Various Factors Considered During Development Of microsponge^[45]

1. Physical and chemical properties of entrapped actives.
2. Physical properties of microsponge system like pore diameter, pore volume, resiliency etc.
3. Properties of vehicle in which the microsponges are finally dispersed.
4. Particle size, pore characteristics, resiliency and monomer compositions can be considered as programmable
5. parameters and microsponges can be designed to release given amount of actives in response to one or more external triggers like; pressure, temperature and solubility of actives.

Recent Advances In Microsponge Drug Delivery System^[46]

Various advances were made by modifying the methods to form nanosponges, nanoferosponges and porous microbeads.

β -CD nanosponges were also developed that can be used for hydrophobic as well as hydrophilic drugs, in contrast to polymeric micro or nanosponges. These advanced systems were studied for oral administration of dexamethasone, flurbiprofen, doxorubicin hydrochloride, itraconazole and serum albumin as model drug. These nanosponges were developed by cross-linking the β -CD molecule by re-acting the β -CD with diphenyl carbonate.

Some researchers also observed the nanosponges as good carrier for the delivery of gases. Researchers also observed that incorporating a cytotoxic in a nanospunge carrier system can increase the potency of the drug suggesting that these carriers can be potentially used for targeting the cancerous cells.

Nanoferosponge, a novel approach constituted the self-performing carriers having better penetration to the targeted site due to the external magnetic trigger which enforces the carriers to penetrate to the deeper tissue and then causing the removal of magnetic material from the particle leaving a porous system.

Due to the improved characteristics of porous microspheres, process was developed to produce the porous micro beads. This method (High internal phase emulsion, HIPE) consisted of the monomer containing continuous oil phase, cross linking agent and aqueous internal phase. They also observed an improved stability of RNA and the relatively effective encapsulation process of siRNA. The approach could lead to novel therapeutic routes for siRNA delivery.^[47]

Future Prospects^[48]

Microsponge drug delivery system holds a promising opportunity in various pharmaceutical applications in the upcoming future as it has unique properties like enhanced product performance and elegance, extended release, improved drug release profile, reduced irritation, improved physical, chemical and thermal stability which makes it flexible to develop novel product forms. The real challenge in future is the development of the delivery system for the oral peptide delivery by varying ratio of polymers. The use of bioerodible and biodegradable polymers for the drug delivery is enabling it for the safe delivery of the active material. As these porous systems have also been studied for the drug delivery through pulmonary route which shows that these system can show effective drug release even in the scarce of the dissolution fluid thus colon is an effective site for targeting for drug release. These carriers also require to be developed for alternative drug administration routes like parenteral and pulmonary route. These particles can also be used as the cell culture media and thus can also be employed for stem cell culture and cellular regeneration in the body. Due to their elegance, these carrier systems have also found their application in cosmetics. These developments enabled researchers to utilize them variably. These novelties in formulation also open new ways for drug deliver.

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