REVIEW ON MICROSPONGE DRUG DELIVERY SYSTEM

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Abstract: **Microsponges are at the forefront of the rapidly developing field of novel drug delivery technology. Microsponge drug delivery technology holds a great promise for reaching the goal of controlled and site-specific drug delivery and hence, has attracted wide attention of researchers. A Microsponges delivery system is a highly cross-linked, porous, polymeric microsphere, polymeric system consisting of porous microspheres that can entrap and release them into the skin over a long period of time. This delivery system provides extended release with reduced irrit ation, better tolerance, improved thermal, physical and chemical stability. The main goal of any drug delivery system is to achieve desired concentration of the drug in blood or tissue, which is therapeutically effective and non-toxic for a prolonged period. Microsponge technology offers entrapment of ingredients and is believed to contribute towards 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, on-allergenic, and non-toxic. Microsponge drug delivery system technology is being used currently in cosmetics, over-the-counter (OTC) skin care, sunscreens and prescription products. They are mostly used for topical use and have recently been used for oral administration. This article presents a broad review of Microsponges delivery system discussing the principles and preparation methods. Appropriate analytical techniques for characterization of Microsponges like Particle size and its distribution, surface morphology, porosity, density are covered. Advantages, limitations and their possible remedies of the microsponge drug delivery are also mentioned.**

***Keywords*: Microsponges, Controlled release, Target release, topical formulation, oral administration**

INTRODUCTION

The drug delivery technology landscape has become highly competitive and rapidly evolving. More and more developments in delivery systems are being integrated to optimize the efficacy and cost-effectiveness of the therapy. Peptides, proteins and DNA-based therapeutics cannot be effectively delivered by conventional means. New classes of pharmaceuticals, biopharmaceuticals (peptides, proteins and DNA-based therapeutics) are fuelling the rapid evolution of drug delivery technology. These new drugs typically cannot be effectively delivered by conventional mean. Drug delivery systems (DDS) that can precisely control the release rates or target drugs to a specific body site have had an enormous impact on the health care system. In the current years the development of new drugs is not sufficient for the drug treatment. But it also involves the development of suitable drug delivery system at site of action. The in-vivo fate of the drug is not only determined by the properties of the drug, but it is also determined by the carrier system, which permits a controlled and localized release of the active drug according to the specific need of the therapy. The biggest challenge up to date is to control the delivery rate of the medicaments by various modern technologies met by extensive research.[1, 2]

The microsponge technology was developed by Won in 1987, and the original patents were assigned to Advanced Polymer Systems, Inc. This company developed a large number of variations of the procedures and those are applied to the cosmetic as well as over-the- counter (OTC) and prescription pharmaceutical products. At the current time, this interesting technology has been licensed to Cardinal Health, Inc., for use in topical products. The scanning electron microscopy of the microsponge particle reveals that its internal structure as the "bag of marbles". The porosity is due to the interstitial spaces between the marbles. The interstitial pores can entrap many wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens, anti-infective and anti-inflammatory agents. [3,4]

Defining microsponges

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 5-300µm in diameter and a typical 25µm 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.[5,6]

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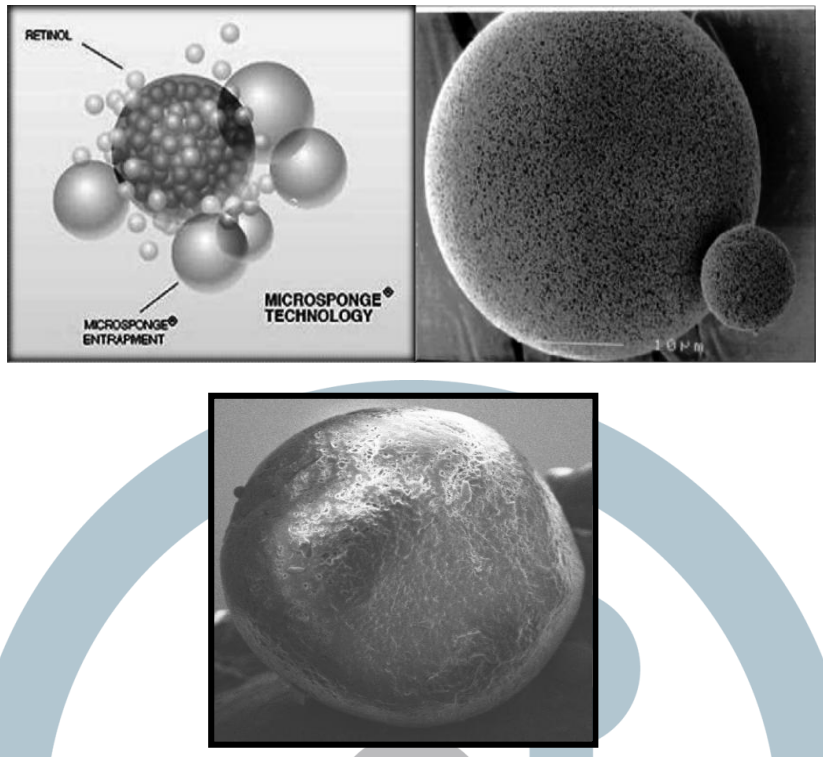

Figure 1: A typical diagram of Microsponge

The scanning electron microscopy of the microsponge particle reveals that its internal structure as the "bag of marbles". The porosity is due to the interstitial spaces between the marbles. The interstitial pores can entrap many wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens, anti-infective and anti-inflammatory agents. These entrapped microsponges may then integrated or formulated into product forms, such as creams, lotions, powders, soaps, capsules and tablets. When these products are applied the entrapped material gets delivered to the skin in a controlled time release pattern or a pre-programmed manner through the use of several different „triggers", rubbing or pressing the Microsponge after it has been applied to the skin, elevates skin surface temperature introducing solvents for the entrapped materials such as water, alcohol or even perspiration and controlling the rate of evaporation. Active ingredients entrapped in the porous polymeric structure display altered behavior, with respect to their release, which is restricted and prolonged.[8]

Characteristics of microsponges

When these are applied to the skin, the microsponge releases its active ingredient gradually to the skin on a time mode and also in response to stimuli such as rubbing, temperature and pH effect etc. with excellent efficacy and minimal irritation. Characteristics of microsponges are as follows: [7,9-11]

1. Microsponge formulations are stable over range of pH 1 to 11.
2. Microsponge formulations are stable at the temperature up to 130^0C.
3. Microsponge formulations are compatible with most vehicles and ingredients.
4. Microsponge formulations are self- sterilizing as their average pore size is about 0.25µm where the bacteria cannot penetrate the pores.
5. Microsponge formulations have high entrapment upto 50 to 60%.
6. Microsponge formulations are free flowing and can be cost effective.
7. Microsponge particles themselves are too large so they are difficult to be absorbed into the skin and this adds a measure of safety to these microsponge materials by avoiding the side effects of the microsponge adjutants.
8. Microsponges formulations can be cost effective even for the cosmetic mass market use where the cost of the materials is important.
9. Microsponges can absorb oil up to 6 times its weight without drying.

10. It provides continuous action up to 12 hours i.e. extended release.
11. They have superior formulation flexibility.

Benefits of microsponge drug delivery systems: [12,13,14]

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

Characteristics of actives moieties that is entrapped into Microsponges

1. Active ingredients that are entrapped in microsponge can then be incorporated into many products such as creams, gels, powders, lotions and soaps.
2. Certain considerations are taken into account while, formulating the vehicle in order to achieve desired product characteristics.
3. It should be either fully miscible in monomer as well as capable of being made miscible by addition of small amount of a water immiscible solvent.
4. It should be inert to monomers and should not increase the viscosity of the mixture during formulation.
5. It should be water immiscible or nearly only slightly soluble.[15]
6. It should not collapse spherical structure of the microsponges.
7. It should be stable in contact with polymerization catalyst and also in conditions of polymerization.
8. The solubility of actives in the vehicle must be limited.
9. If not, the vehicles will deplete the microsponges before the application.
10. Not more than 10 to 12% w/w microsponges must be incorporated into the vehicle in order to avoid cosmetic problems.
11. Payload and polymer design of the microsponges for the active must be optimized for required release rate for given. period of time.[16]

Limitations

1. The preparation methods usually use organic solvents as porogens
2. An environmental hazard
3. Highly inflammable
4. Posing a safety hazard.
5. In some cases, the traces of residual monomers have been observed, which may be toxic and hazardous to health.

METHOD OF PREPARATION OF MICROSPONGE DRUG DELIVERY SYSTEM:

A Porogen drug neither hinders the polymerization process nor become activated by it and also it is stable to free radicals is entrapped with one-step process (liquid- liquid suspension polymerization). Microsponges are suitably prepared by the following methods:

1. Liquid-liquid suspension polymerization: [17,18,19]

The porous microspheres are prepared by suspension polymerization method in liquid-liquid systems. In this method the monomers which are immiscible are first dissolved along with active ingredients in a suitable solvent monomer and are then dispersed in the aqueous phases which consist of additives like surfactant, suspending agents to facilitate formation of suspension. The polymerization is then activated by increasing temperature or irradiation or by addition of catalyst. The polymerization process continues the formation of a reservoir type of system with spherical structure. After the polymerization process the solvent is removed leaving the spherical structured porous microspheres, i.e., microsponges

The various steps involved in the preparation of microsponges are summarized as follows:

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

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.

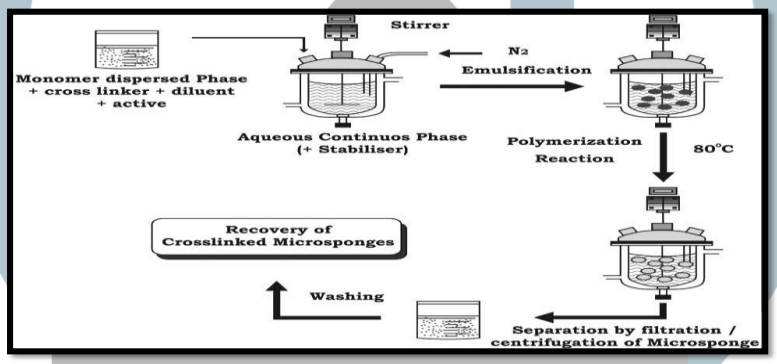

Figure 2: Liquid-liquid suspension polymerization

2. Quasi-Emulsion Solvent Diffusion Method: [20, 21,22]

Porous microspheres (microsponges) were also prepared by a quasi-emulsion solvent diffusion method (two-step process) using an internal phase containing polymer such as Eudragit RS 100 which is dissolved in ethyl alcohol. Then, the drug is slowly added to the polymer solution and dissolved under ultrasonication at 35ºC and plasticizer such as triethylcitrate (TEC) was added in order to aid the plasticity. The inner phase is then poured into external phase containing polyvinyl alcohol and distilled water with continuous stirring for 2 hours11. Then, the mixture was filtered to separate the microsponges. The product (microsponges) was washed and dried in an air heated oven at 40°C for 12 hrs.

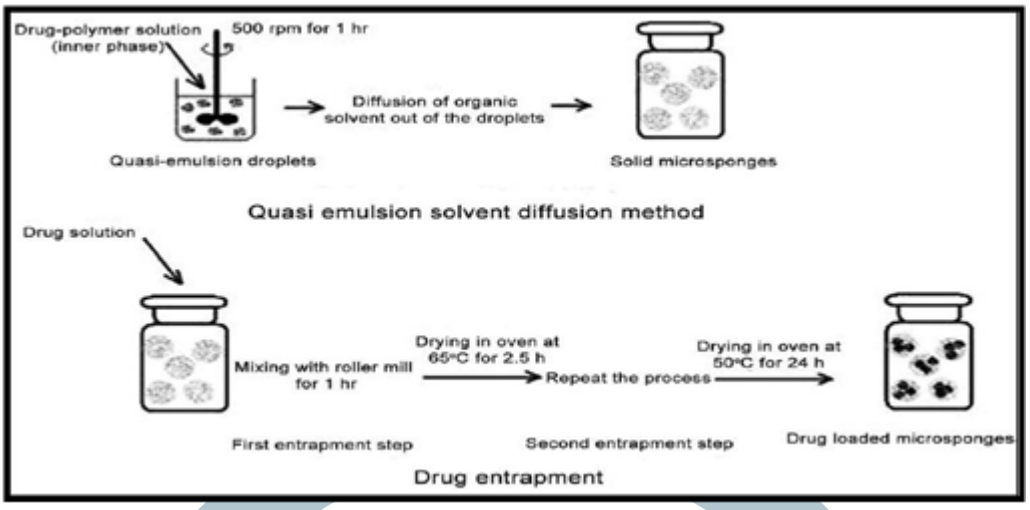

Figure 3: Preparation of microsponges by quasi emulsion solvent diffusion

RELEASE MECHANISMS

The mentioned programmable parameters can be effectively manipulated to design Microsponge delivery system for the release of functional substance over a period of time in response to one or more external stimuli. The release mechanism of this system is mainly:-

A. Sustained or Time Release

In the development of a sustained release Microsponge, different physical and chemical parameters of the entrapped active substance such as volatility, viscosity and solubility will be studied while in case of polymeric microsponge pore diameter, volume, and resiliency of the polymeric microsponge are evaluated to give necessary sustained release effects.[23]

B. Release on Command

Microsponges can be designed to release the given amounts of active ingredients over time in response to one or more external triggers.

Accelerated or Triggered by following mechanism:

- Pressure triggered systems
- Temperature triggered systems
- pH triggered systems
- Solubility triggered system

- ***Pressure Release***

Microsponge system releases fluid or active ingredient when it is pressed or squeezed, thereby replenishing the level of entrapped active ingredient onto the skin. The amount released may also depend upon the release of the sponge and the resiliency of the Microsponges.[24]

- ***Temperature Release***

The release of active ingredients from microsponges can be activated by temperature.At room temperature, few entrapped active ingredients can be too viscous to flow suddenly from microsponges onto the skin. With increase in skin temperature, flow rate is also increased and therefore release is also enhanced.[25]

- ***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.[24]

- ***Solubility***

Microsponges loaded with water miscible ingredients like antiseptics and antiperspirants will release the ingredient in the presence of water. The release can also be activated by diffusion but taking into consideration, the partition coefficient of the ingredient between the microsponges and the external system.[26]

CHARACTERIZATION OF MICROSPONGES

1. Particle size and size distribution

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.[27]

2. Morphology and Surface topography of SPM

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.[28]

3. Determination of loading efficiency and production yield

The loading efficiency (%) of the Microsponges can be calculated according to the following equation:

$$\%\text{loading efficiency} = \frac{\text{actual drug content in microsponges}}{\text{Theoretical drug content}} \times 100$$

The production yield of the microparticles can be determined by calculating accurately the initial weight of the raw materials and last weight of the SPM obtained.

$$\%\text{Production yield} = \frac{\text{Production yield}}{\text{Theoretical mass (polymer + drug)}} \times 100$$

4. Determination of true density

The true density of Microsponges can be measured using an ultra-pycnometer under helium gas and is calculated from a mean of repeated determinations.[29]

5. Characterization of pore structure

Pore volume and diameter are vital in controlling the intensity and duration of effectiveness of the active ingredient. Pore diameter also affects the migration of active ingredients from Microsponges into the vehicle in which the material is dispersed. Mercury intrusion porosimetry can be employed to study effect of pore diameter and volume with rate of drug release from Microsponges. Porosity parameters of Microsponges include intrusion– extrusion isotherms. Pore size distribution, total pore surface area, average pore diameters, shape and morphology of the pores, bulk and apparent density can be determined by using mercury intrusion porosimetry. Incremental intrusion volume scan be plotted against pore diameters that represented pore size distributions. The pore diameter of Microsponges can be calculated by using Washburn equation:

$$D = \frac{-4\gamma\cos\Theta}{P}$$

Where D is the pore diameter (μm); γ the surface tension of mercury (485 dyn cm^{-1}); θ he contact angle (130°); and P is the pressure (psia).

Total pore area (Atot) was calculated by using equation,

$$A_{tot} = \frac{1}{\gamma\cos\theta} \int \frac{V_{tot}}{P.\,dV}$$

Where P is the pressure (psia); V volume (mL g^{-1}); V_{tot} is the total specific intrusion volume (mL g^{-1}).The average pore diameter (Dm) was calculated by using equation,

$$Dm = \frac{4 V_{tot}}{A_{tot}}$$

Envelope (bulk) density (ρse) of the Microsponges was calculated by using equation,

$$\rho_{se} = \frac{W_s}{V_p - V_{Hg}}$$

Where Ws is the weight of the SPM sample (g); Vp the empty penetrometer (mL); V_{Hg} is the volume of mercury (mL).

Absolute (skeletal) density (ñsa) of Microsponges was calculated by using equation

$$\rho_{se} = \frac{W_s}{v_{se} - v_{tot}}$$

Where Vse is the volume of the penetrometer minus the volume of the mercury (mL).Finally, the % porosity of the sample was found from equation,

$$\text{Porosity } \% = (1 - \frac{}{P_{sa}}) \times 100$$

Pore morphology can be characterized from the intrusion– extrusion profiles of mercury in the Microsponges.[30,31]

Compatibility studies

The drug-excipients compatibility studies are carried out in order to ensure that there is no inadvertent reaction between the two when formulated into a dosage form. These studies are commonly carried out by recording the differential scanning Calorimetry (DSC) of the chemicals viz., API and excipients individually and also together and checking for any addition or deletion of any peaks or troughs. For DSC approximately 5 mg samples can be accurately weighed into aluminium pans and sealed and can be run at a heating rate of 15oC/min over a temperature range 25–430oC in atmosphere of nitrogen.[32,33] Infrared (IR) spectroscopy can also reveal the incompatibilities between the chemical moieties. Compatibility of drug with reaction adjuncts can also be studied by thin layer chromatography (TLC) and FT-IR.[35] Effect of polymerization on crystallinity of the drug can be studied by powder X-ray diffraction (XRD) and Differential Scanning Colorimetry (DSC).[34]

Polymer/ Monomer composition

Factors such as particle size, drug loading, and polymer composition govern the drug release from Microsponges. Polymer composition of the Microsponges Drug Delivery system can affect partition coefficient of the entrapped drug between the vehicle and the Microsponges system and hence have direct influence on the release rate of entrapped drug. Release of drug from Microsponge systems of different polymer compositions can be studied by plotting cumulative % drug release against time. Release rate and total amount of drug released from the system composed of methyl methacrylate/ ethylene glycol dimethacrylate is slower than styrene/divinyl benzene system. Selection of monomer is dictated both by characteristics of active ingredient ultimately to be entrapped and by the vehicle into which it will be dispersed. Polymers with varying electrical charges or degrees of hydrophobicity or lipophilicity may be prepared to provide flexibility in the release of active ingredients. Various monomer combinations will be screened for their suitability with the drugs by studying their drug release profile.[35]

Resiliency

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. Hence resiliency of Microsponges is studied and optimized as per the requirement by considering release as a function of cross linking with time.[36]

Drug Release

Dissolution profile of Microsponges can be studied by use of dissolution apparatus USP XXIII with a modified basket consisted of 5µm 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. Samples from the dissolution medium can be analyzed by suitable analytical method at various intervals.[37]

Kinetics of release

To determine the drug release mechanism and to compare the release profile differences among microsponges, the drug released amount versus time was used. The release data were analyzed with the following mathematical models:

$$Q = k1t^n \quad \text{or} \quad \log Q = \log k1 + n \log t \text{.....Equation (1)}$$

Where Q is the amount of the released at time (h), n is a diffusion exponent which indicates the release mechanism, and k1 is a constant characteristic of the drug–polymer interaction. From the slope and intercept of the plot of log Q versus log t, kinetic parameters n and k1 were calculated

For comparison purposes, the data was also subjected to Equation (2), which may be considered a simple, Higuchi type equation.

$$Q = k2t0{:}5 + C \text{ .....Equation (2)}$$

Equation (2), for release data dependent on the square root of time, would give a straight line release profile, with k2 presented as a root time dissolution rate constant and C as a constant.[38]

APPLICATIONS OF MICROSPONGES

Microsponge delivery systems are used to enhance the safety, effectiveness and aesthetic quality of topical prescription, over-the-counter and personal care products. Microsponges can be used in variety of applications. It is used mostly for topical and recently for oral administration. Several patents have reported that it can be used as excipients due to its high loading capacity and sustained release ability. It offers the formulator a range of alternatives to develop drug and cosmetic products. Microsponges are designed to deliver a pharmaceutical active ingredient efficiently at the minimum dose and also to enhance stability, reduce side effects and modify drug release. Over-the-counter products that incorporate microsponge drug delivery system include numerous moisturizers, specialized rejuvenative products, and sunscreens.

Applications of microsponges with respect to their advantages

Table 1: Applications of microsponges with respect to their advantages

S. No.	Application	Advantages
1	Sunscreens	Long lasting product efficacy, with improved protection against sunburns and sun related injuries even at elevated concentration and with reduced irritancy and sensitization
2	Anti-acne e.g. Benzoyl peroxide	Maintained efficacy with decreased skin irritation and sensitization.
3	Anti-inflammatory e.g. hydrocortisone	Long lasting activity with reduction of skin allergic response and dermatoses.
4	Anti-dandruffs e.g. zinc pyrithione, selenium sulfide	Reduced unpleasant odour with lowered irritation with extended safety and efficacy.
5	Antipruritics	Extended and improved activity.
6	Skin depigmenting agents e.g. hydroquinone	Improved stabilization against oxidation with improved efficacy and aesthetic appeal.

PHARMACEUTICAL UTILIZATION OF MICROSPONGES:

Microsponge delivery systems are used to enhance the safety, effectiveness and aesthetic quality of topical prescription, over-the-counter and personal care products. Microsponges can be used in variety of applications. It is used mostly for topical and recently for oral administration. Several patents have reported that it can be used as an excipients due to its high loading capacity and sustained release ability.

Long lasting Coloured Cosmetics: [39,40]

Colours entrapped in microsponges may be used in a variety of coloured cosmetic products such as rouge or lipsticks to make

them long lasting. As stated above, microsponges help in uniform spreading and improving covering power. Thus, colored cosmetics formulated with microsponges would be highly elegant.

For topical administration: [41, 42]

A single microsponge is as tiny as a particle of talcum powder, measuring less than one-thousandth of an inch in diameter. Like a true sponge, each microsphere consists of a myriad of interconnecting voids within a non-collapsible structure that can accept a wide variety of substances. The outer surface is typically porous, allowing the controlled flow of substances into and out of the sphere. Several primary characteristics, or parameters, of the microsponge system can be defined during the production phase to obtain spheres that are tailored to specific product applications and vehicle compatibility. Microsponge systems are made of biologically inert polymers. Extensive safety studies have demonstrated that the polymers are non-irritating, non- mutagenic, non-allergenic, non-toxic and non- biodegradable. As a result, the human body cannot convert them into other substances or break them down. Although they are microscopic in size, these systems are too large to pass through the stratum corneum when incorporated into topical products. Benzoyl peroxide is commonly used in topical formulations for the treatment of acne, with skin irritation as a common side effect.

For oral administration: [43]

In oral applications, the microsponge system has been shown to increase the rate of solubilisation of poorly water soluble drugs by entrapping such drugs in the microsponge system's pores. As these pores are very small, the drug is in effect reduced to microscopic particles and the significant increase in the surface area thus greatly increases the rate of solubilisation. Controlled oral delivery of ibuprofen microsponges is achieved with an acrylic polymer, Eudragit RS, by changing their intraparticle density. Sustained release formulation of chlorpheniramine maleate, using powder- coated microsponges, is prepared by the dry impact blending method, for oral drug delivery.

For Bone and Tissue Engineering: [44, 45]

Compounds were obtained by mixing pre polymerized powders of polymethyl methacrylate and liquid methyl methacrylate monomer with two aqueous dispersions of tricalcium phosphate grains and calcium deficient hydroxyapatite powders. The final composites appeared to be porous and acted as microsponges. Basic fibroblast growth factor (bFGF) incorporated in a collagen sponge sheet was sustained released in the mouse sub-cutis according to the biodegradation of the sponge matrix, and exhibited local angiogenic activity in a dose- dependent manner.

Examples of microsponge drug delivery with their formulations[46-56, 57]

Table 2: Examples of microsponge drug delivery with their formulations

Microsponge Delivery Systems	Drug	Disease
Gels	Benzoyl peroxide	Anti-Acne Treatment
	Fluconazole	Inflammation
	Mupirocin	Antibacterial activity
	Diclofenac sodium	Inflammation
	Acyclovir	Viral infections
	Hydroxyzine HCl	Urticaria and atopic dermatitis
	Terbinafine HCl	Anti-fungal
Lotions	Benzoyl peroxide	Anti-Acne Treatment
Creams	Hydroquinone and Retinol	Melanoma
Tablets	Indomethacin	Inflammation
	Paracetamol	Anti-pyretic
	Chlorpheniramine maleate	Hay Fever
	Ketoprofen	Musculoskeletal pain
	Fenofibrate	Gout
	Flurbiprofen	Metabolic ratio
	Dicyclomine	Anticholinergic
	Meloxicam	Arthritis
	Paracetamol	Colon targeting
Implants	Poly (DL-lactic-co-glycolic acid)	Skin tissue engineering
Grafts	Poly (lactic-co glycolic acid)	Cardiovascular surgery
Injection	Basic fibroblast growth facto	Growth factor
Others	Benzoylperoxide	Anti-Acne Treatment
	Mefenamic acid	Rheumatoid arthritis
	Ibuprofen	NSAID

List of Marketed Products based on Microsponges[23,48,49]

Table 3: List of Marketed Products based on Microsponges

Product Name	Pharmaceutical Uses	Manufacturer
Glycolic Acid Moisturizer w/SPF 15	Anti-Wrinkles, soothing	AMCOL Health & Beauty Solution
Retin A Micro	Acne vulgaris	Ortho-McNeil Pharmaceutical, Inc.
Carac Cream, 0.5%	Actinic keratoses	Dermik Laboratories, Inc.
Line Eliminator Dual Retinol Facial Treatment	Anti-wrinkle	Avon
Retinol 15 Night cream	Anti-wrinkles	Sothys
Retinol cream	Helps maintain healthy skin	Biomedic
EpiQuin Micro	Hyper pigmentation	SkinMedica Inc
Sports cream RS and XS	Anti-inflammatory	Embil Pharmaceutical Co. Ltd.
Salicylic Peel 20	Excellent exfoliation	Biophora
Oil free matte block SPF 20	Sunscreen	Dermalogica
Lactrex™ 12% Moisturizing Cream	Moisturizer	SDR Pharmaceuticals, Inc
Dermalogica Oil Control Lotion	Skin protectant	John and Ginger Dermalogica Skin Care Products
Ultra Guard	Protects baby‟s skin	Scott Paper Company

RECENT ADVANCES IN MICROSPONGE DRUG DELIVERY SYSTEM

Various advances were made by modifying the methods to form nanosponges, nanoferrosponges 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 nanosponge carrier system can increase the potency of the drug suggesting that these carriers can be potentially used for targeting the cancerous cells.[58]

Nanoferrosponge, 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.[59]

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.[60] 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.[61]

FUTURE PROSPECTS

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 elegancy, 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.[49]

CONCLUSION

The microsponge delivery technology of controlled release system in which active pharmaceutical ingredient is loaded in the macro porous beads and initiates reduction in side effects with improved therapeutic efficacy. Microsponge can be effectively incorporated into topical drug delivery system for retention of dosage form on skin, and also use for oral delivery of drugs using bio erodible polymers, especially for colon specific delivery and controlled release drug delivery system thus improving patient compliance by providing site specific drug delivery system and prolonging dosage intervals. With demand for innovative and highly efficient Pharmaceutical as well as Cosmetic products, the market holds considerable potential for Microsponge technology and the versatility they offer. As formulators consider new and creative ways to deliver actives, they can realize the full capabilities of these unique materials providing enhanced safety, improved stability, reduced side effects from actives, enhanced multifuntionality and improved ingredient compatibility. Complemented by novel development approaches and creative formulation techniques, Microsponge delivery system can be a winning strategy for a new generation of Pharmaceutical and Cosmetic industry. Ease manufacturing, simple ingredients and wide range actives can be entrapped along with a programmable release make microsponges extremely attractive. It is originally developed for topical delivery of drugs like anti-acne, anti-inflammatory, anti-fungal, anti-dandruffs, antipruritics, rubefacients etc. Microsponge Delivery System holds a promising future in various pharmaceutical applications in the coming years as they have unique properties like enhanced product performance and elegancy, extended release, reduced irritation, improved thermal, physical, and chemical stability so flexible to develop novel product forms. Microsponges have a distinct advantage over the existing conventional topical dosage forms for the treatment of tropical diseases; it is a unique technology for the controlled release of topical agents also use for oral as well as biopharmaceutical drug delivery. This shows advantageous over other products by non mutagenic, non toxic, non irritant. So microsponge drug delivery system has got a lot of potential and is a very emerging field which is needed to be explored in the future with most research study.

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