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Review Article

Microsponges: The Drug Delivery System

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ABSTRACT

Microsponge technology has been developed for topical drug products in order to promote controlled release of the drug's active ingredient into the skin, thereby reducing systemic exposure and minimizing local cutaneous reactions to active drugs. Microsponge is made up of macroporous beads that are normally 10-25 micron in diameter and loaded with an active agent. When applied to the skin, the microsponge releases its active ingredients on a timer as well as in response to other signals. Microsponge drug delivery technology holds great promise for achieving the goal of controlled and site-specific drug delivery, and thus has sparked the curiosity of many investigators. This article provides a comprehensive overview of the Microsponges delivery system, including principles and preparation methods. Particle size and distribution, surface morphology, porosity, and density are all covered using appropriate approaches for characterization of microsponges. These microsponges are used in sunscreens, creams, ointments, as well as over-the-counter skin care preparations for topical application. Microsponge drug delivery can provide greater efficacy for topically active agents while also improving safety, product stability, and aesthetic properties in an efficient and novel way. They are mostly used topically, but have recently been used for oral administration.

INTRODUCTION

A microsponge the delivery system consists of unusual, highly cross-linked, porous, polymeric microspheres that can entrap a broader spectrum of activities and then release them at a controlled rate. This system is useful for improving the performance of relevant applicable drugs. It is a novel method for the controlled release of relevant agents that consists of micro porosity beads, typically 10 to 25 microns in diameter and filled with active agent. Because of the high degree of crosslinking, the particles are insoluble, inert, and strong enough to withstand the high shear commonly used in the manufacture of creams, gels, lotions, and powder.(1) Microsponges are small spheres capable of absorbing skin secretions and thus reducing skin oiliness and shine. Spherical particles made out of clusters of even

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smaller spheres can hold four times their weight in skin secretions. Microsponge particles are incredibly small inert spheres that do not pass through the skin. Rather, they accumulate in the skin's small nooks and gently release the entrapped drugs as the skin requires it. The microsponge system can prevent excessive part accumulation in the epidermis and dermis. The microsponge technology has the potential to dramatically minimize the irritation of effective medications while maintaining their potency. During subsequent cleaning, the empty spheres are washed away. The microsponge delivery system combines these characteristics, resulting in a new kind of unique, well-tolerated, and highly effective products. These products are usually delivered to the consumer in standard ways such as creams, gels, or lotions, and they have an appropriately high concentration of active ingredients.(2) Microsponges technology is utilized in cosmetics, OTC skin care, sunscreens, and prescription medications. The delivery system consisted of a polymeric bead with a network of pores containing an active component was designed to offer regulated release of active substances and the final target is skin.(3) The major challenge for the pharmaceutical industry currently is to control the rate of delivery of active pharmaceutical ingredients to a predetermined site in the human body. As a result, researchers concentrated on developing various controlled release drug delivery systems in order to improve efficacy and patient compliance.(4) For both local and systemic treatment, topical formulations are the most effective drug delivery systems. Controlled drug release onto the epidermis with assurance that the drug remains primarily localized and does not enter the systemic circulation in significant amounts is a relatively new area research that has achieved success. There are no efficient vehicles during controlled and localized drug delivery into the stratum corneum and underlying skin layers, not beyond the epidermis. (5) The application of topical drugs has many issues, such as ointments that are often aesthetically unappealing, greasiness, stickiness, and so on, which frequently leads to a lack of patient compliance. Due to their low delivery system efficiency, these vehicles require high concentrations of active agents for effective therapy, resulting in irritation and allergic reactions in significant users. Other disadvantages of topical formulations include uncontrolled evaporation of the active ingredient, unpleasant odour, and the possibility of drug incompatibility with the vehicles. Conventional topical drug formulations are intended to work on the skin's outer layers. While the implementation, such products typically release their active ingredients, resulting in a highly concentrated layer of active ingredient that is rapidly absorbed. As a result, there is a need for a system that maximizes the amount of time that an active ingredient is present on the skin surface or within the epidermis while minimizing transdermal penetration into the body. (6)

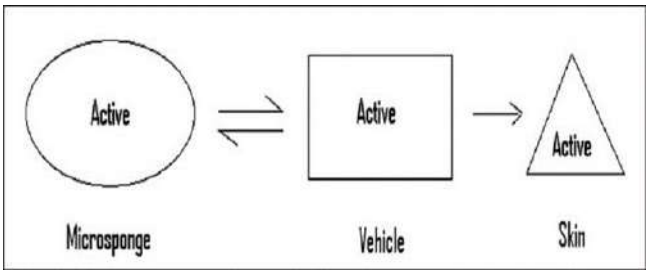

Fig 1. Schematic representation of the distribution of the loaded material (active) on skin

History

The micro sponge technology was developed by Won in 1987 and the original patents were assigned to Advanced Polymer Systems, Inc. (Redwood City, California, US). This company invented numerous variations of the procedures, and they are used for both prescription and over-the-counter (OTC) pharmaceutical products in along with cosmetics. At the recent time, this novel technology has been licensed to Cardinal Health, Inc., for use in topical products to facilitate

the controlled release of active ingredient into the skin in order to reduce systemic exposure and minimize local cutaneous reactions to active drugs. (7)

Characteristics of Microsponges: (8)

1. Microsponge formulations are pH 1 to 11 stable;
2. Microsponge formulations are temperature stable up to 130oC;
3. Microsponge formulations are compatible with most vehicles and ingredients.
4. Microsponge formulations are self-sterilizing due to having an average pore size of 0.25m, through which bacteria cannot penetrate;
5. Microsponge formulations have a higher payload (50 to 60%), are free flowing, and can be affordable.

Benefit of Microsponge Drug Delivery System: (9)

When Microsponges are applied to the skin, drug release can be controlled through diffusion. Microsponges deliver active ingredients to the target site of the skin in a controlled manner, resulting in improved product efficacy and reduced irritation often associated with potent therapeutic agents such as benzoyl peroxide. Several advantages of microsponge are based on drug delivery.

Characteristics of actives that is entrapped into microsponges: (10)

Entrapped active ingredients in microsponges can then be incorporated into a variety of products, including creams, gels, powders, lotions, and soaps. In order to achieve the desired product characteristics, certain considerations are taken into account when developing the vehicle:

1. It should be fully miscible in monomer or capable of being made miscible by adding a small amount of a water immiscible solvent.
2. It should be monomer-inert and should not to increase the viscosity of the mixture during formulation.
3. It should be water insoluble or only slightly soluble in water.
4. It should not collapse the spherical structure of the microsponges.
5. It should be stable in contact with the polymerization catalyst as well as under polymerization conditions.
6. The actives' solubility in the vehicle must be limited. Otherwise, the vehicle will deplete the microsponges prior to application.
7. To avoid cosmetic issues, the vehicle must not contain more than 10 to 12% w/w microsponges.
8. The payload and polymer design of the microsponges for the active must be optimized for the required release rate during a given time period.

VARIOUS DRUGS USED IN MICROSPONGE TECHNOLOGY: (11 ,12)

Ketoprofen (NSAID)
Benzoyl peroxide (Anti-acne)
Fluconazole (Anti-fungal)
Ibuprofen (NSAID)
Tretinoin (Vitamin-A)
Trolamine (Analgesic)
Paracetamol (NSAID)
Tioconazole (Anti-fungal)
Acyclovir sodium (Anti-viral)
Miconazole (Anti-fungal)
Fluocinolone acetonide (Corticosteroid)
Prednisolone (Corticosteroid)
Erythromycin (Anti-biotic)
Mupirocin (Anti-bacterial)
Indomethacin (NSAID)
Lornoxicam (NSAID)
Curcumin (Anti-inflammatory).

POLYMERS FOR FORMULATION OF MDS: (13)

Eudragit RS 100
Eudragit RL 100
Ethyl cellulose
Cellulose acetate

Polyvinyl acetate
Carbopol 934
Carbopol 940
Polymethacrylates
Polystyrene

ADVANTAGES: (14)

1. Advanced oil control, absorbs up to six times its own weight without drying.
2. Enhanced product elegancy.
3. It permits the use of immiscible products.
4. Better product aesthetics.
5. Improves thermal, physical, and chemical stability
6. Develops material processing, e.g , liquid can be converted to powder.
7. Longer release, continuous action for up to 12 hours.
8. Reduced irritability and increased tolerance show greater consumer acceptance.

Advantages over conventional formulation: (15, 16)

Conventional topical drug formulations are designed to work on the skin's outer layers. When such products are applied, their active ingredients are released, resulting in a highly concentrated layer of active ingredient that is quickly absorbed. When compared to the Microsponge system, it can prevent excessive ingredient development within the epidermis and dermis. The Microsponge technique has the potential to significantly reduce the irritation of effective drugs while maintaining their efficacy. MDS Benzoyl peroxide formulations, for example, have excellent efficacy with minimal irritation by gradually providing the active ingredient to the skin.

Advantages over microencapsulation and liposomes:(17,18)

MDS has advantages over other technologies such as microencapsulation and liposomes. Microcapsules cannot usually control the rate of active release. When the wall is ruptured, the actives contained within the microcapsules are released. Liposomes have a lower payload, difficult formulation, limited chemical stability, and microbial instability. While the microsponge systems are stable over a pH range of 1 to 11, the microsponge system is stable over a temperature range of 1300C; suitable with most vehicles and ingredients; self-sterilizing as the average pore size is 0.25m where bacteria cannot penetrate; higher weight (50 to 60%), still free flowing, and cost effective.

Advantages over ointments: (18, 19)

Ointments are frequently unsightly due to greasiness, stickiness, and other factors. This frequently leads to a lack of patient compliance. Due to their low delivery system efficiency, these vehicles require high concentrations of active agents for effective therapy, resulting in irritation and allergic reactions in significant users. Other disadvantages of topical formulations include uncontrolled evaporation of active ingredients, unpleasant smell, and potential drug incompatibility with the vehicles, when the microsponge system maximizes the amount of time an active ingredient is present on the skin's surface or within the epidermis while minimizing its transdermal penetration into the body.

METHODS OF PREPARATION OF MICROSPONGES : (20)

A specific encapsulation method is selected based on the drug's and polymer's solubility properties. It has been reported that the preparation of micro sponge drug delivery systems can be carried out using two methods: the first is liquid-liquid suspension polymerization, and the second is quasi emulsion solvent diffusion techniques. These methods are based on the physical and chemical properties of the loaded drug. If the loaded drug is an inert non-polar material, the previous structure will be formed known as "porogen" . Other than the above methods, lyophilization, water in oil in water (w/o/w) emulsion solvent diffusion, and oil in oil (o/o) emulsion solvent diffusion have been

discovered that prevent polymerization and become it activated.

A. Liquid-Liquid Suspension Polymerization:

1. Micro sponges are made by using the suspension polymerization method, which is based on the free radical suspension polymerization technique shown in Figure 1.
2. In this method, the process is carried out in three naked round bottom flasks with stirrers connected to a water condenser and a thermometer to determine the temperature.

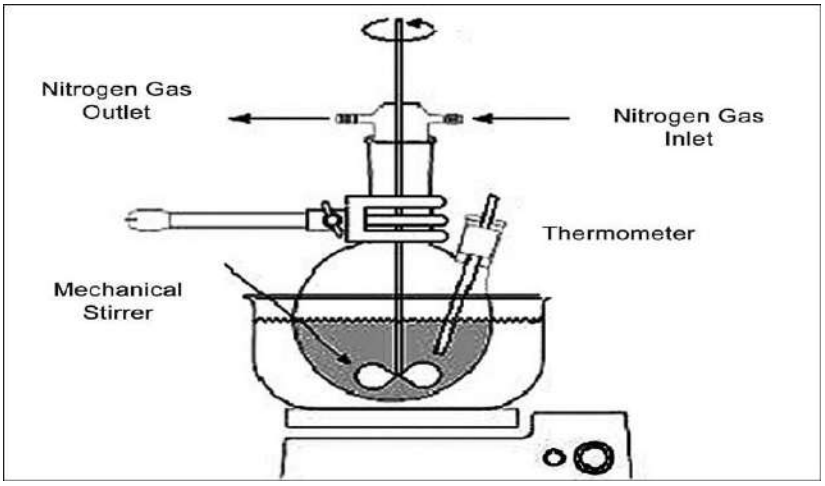

Fig. 2. Reaction vessel for microsponge preparation by liquid–liquid suspension polymerization.

B. Quasi-Emulsion Solvent Diffusion

1. This is the most commonly used micro sponge preparation technique.
2. Micro sponge was also created using the second technique, i.e; Quasi-emulsion solvent diffusion technique.
3. In this method , the inner phase containing Eudragit polymer, i.e., Eudragit RS 100, was dissolved in ethanol.
4. After preparing the internal phase, the drug is slowly added to the solution and dissolved using ultrasonication at 35oC.

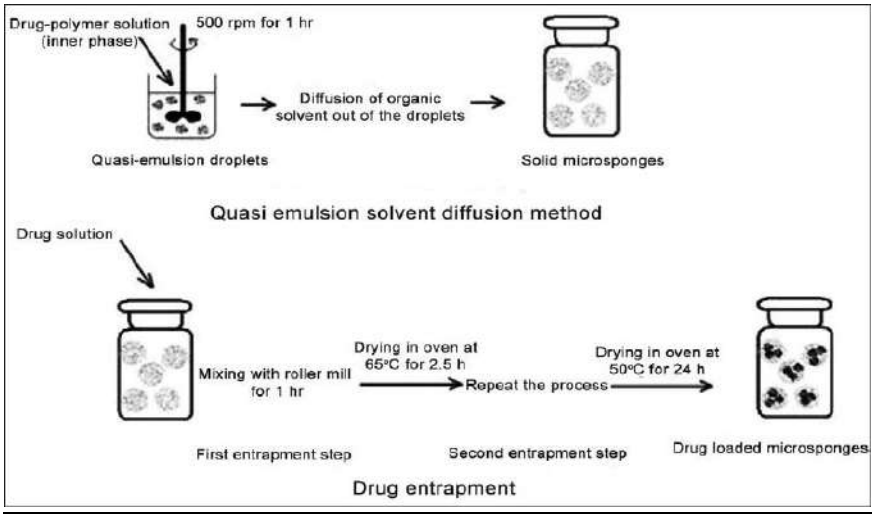

Fig 3. Preparation of microsponges by the quasi-emulsion solvent diffusion method

C. Lyophilization:

Lyophilization is a novel technique that was created by using the gelation technique to convert microspheres to porous microspheres. The microparticles were lyophilized after being incubated in Chitosan HCl solution. The rapid elimination of the solvent causes the formation of pores in the microspheres. This method is quick

and easy. However, due to the rapid elimination of the solvent, broken or shrunken microparticles are formed. This is the disadvantage of the lyophilization method.

D. Water in oil in water (w/o/w) emulsion solvent diffusion:

Another novel technique, w/o/w emulsion solvent diffusion, was developed to create biodegradable porous microparticles. In this method, an internal water phase was dispersed in an organic polymeric solution. The internal phase contains an emulsifying agent such as span, stearyl amine, and polyethyleneimine. After that, the w/o emulsion was dispersed in an external aqueous phase containing PVA to form a double emulsion. The advantage of this method is that it can entrap both water soluble and water insoluble drugs.

RELEASE MECHANISM: (21)

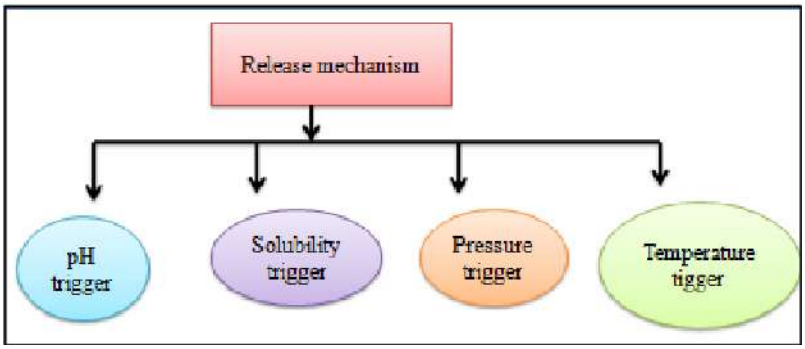

Fig 3: Programmable release from microsponges

pH - Triggered Systems:

The pH-based release of the active can be triggered by modifying the coating on the micro sponge. This has many applications in drug delivery.

Solubility Triggered System:

A micro sponge loaded with water-soluble ingredients will release the ingredient when exposed to water. In the presence of an aqueous medium, the release rate of active ingredients can be accelerated. The ability of the external medium to dissolve the active, the concentration gradient, or the ability to swell the microspore network can all contribute to this release.

Pressure Triggered Systems:

When pressurized/rubbed, the micro sponge system releases the entrapped material; the amount released is determined by the sponge's unique properties. The micro sponge which is best suited for a given application can be optimized by modifying the type of material and different process variables.

Temperature Triggered Systems

Some active ingredients in micro sponges may be too viscous at room temperature to flow freely into the skin. The flow rate can be increased by increasing the skin temperature and thus the release. As a result, temperature can be used to control the release of substances from the micro sponge.

Characterization of microsponges:

A. Particle size analysis: (22)

Particle size determination of loaded and blank microsponges can be accomplished using laser light diffractometry or any other appropriate method. All formulations have values that can be expressed in terms of mean size range. To investigate the effect of particle size on drug release, plot the cumulative % drug release from microsponges of various particle sizes against time. Particles larger than 30 µm in size can impart grittiness, so particles sized between 10 and 25 µm are preferred for use in final topical formulation.

B. Determination of entrapment efficiency and production yield: (23)

The entrapment efficiency (%) of the microsponges can be calculated according to the following equation: Entrapment efficiency (%) = [Actual drug content/Theoretical drug content] X 100 The production yield of the microsponges can be obtained by calculating accurately the initial weight of the raw materials and the last weight of the microsponge obtained. Production yield = [Practical mass of microsponges /Theoretical mass (polymer + drug)] X 100.

C. Morphology and surface topography of microsponges:(24)

Scanning electron microscopy (SEM) can be used to investigate internal and external morphology as well as surface topography. Prepared microsponges were coated with gold-palladium under an argon atmosphere at room temperature, and SEM images of the microsponges at the required magnification were captured. A SEM image of a fractured microsponge particle can also be used to show its ultrastructure.

D. Characterization of pore structure: (24)

Pore volume and diameter are critical in controlling the intensity and duration of the active ingredient's effectiveness. Pore diameter can also influence the passage of active ingredients from microsponges into the vehicle in which the material is dispersed. Mercury intrusion porosimetry can be used to investigate the relationship between pore diameter as well as volume on the rate of drug release from microsponges. Mercury intrusion Porosimetry31 can be used to determine microsponge porosity parameters such as intrusion-extrusion isotherms, total pore surface area, pore size distribution, average pore diameters, pore shape and morphology, bulk and apparent density.

E. Determination of true density: (25)

The true density of microsponges was measured by an ultra-pycnometer under helium gas and was calculated from a mean of repeated determinations.

F. Polymer/ Monomer composition: (25)

The drug release from microspheres is governed by several factors, including microsphere size, polymer composition, and drug loading. Polymer composition can also influence the partition coefficient of the entrapped drug between the microsponge system as well as the vehicle, thereby influencing the rate of entrapped drug release. Plotting cumulative % drug release against time from microsponge systems with different polymer compositions can be used to study drug release. The monomer specified is determined by both the vehicle through which it will be dispersed along with the properties of the active ingredient to be entrapped. Polymers with varying degrees of hydrophobicity, lipophilicity, or electrical charge can be prepared to provide flexibility in active ingredient release. A variety of possible monomer combinations will be evaluated for drug compatibility by examining their drug release profiles.

G. Compatibility studies: (26)

Fourier Transformation to investigate drug compatibility with reaction adjuncts, infrared spectroscopy (FT-IR) and thin layer chromatography (TLC) were used. Powder X-ray diffraction (XRD) and differential scanning colorimetry (DSC) can be used to investigate the effect of polymerization on drug crystallinity. For DSC, approximately 5mg samples can be accurately weighed into aluminium pans, sealed, and run at a heating rate of 15°C/min over a temperature range 25–430°C in atmosphere of nitrogen.

H. Resiliency (viscoelastic properties): (27,28)

The resiliency (viscoelastic properties) of microsponges can be altered to produce beadlets that are softer or firmer depending on the final formulation's requirements. Increased cross-linking slows the rate of release.

In-vitro release studies: (29)

In-vitro release studies were conducted using a dissolution apparatus USP XXIII equipped with an improved basket made of 5 µm stainless steel mesh. Dissolution rates were measured at 37°C via a rotor speed of 150 rpm. To ensure sink conditions, the dissolution medium is chosen with active ingredient solubility in mind. At regular time intervals, sample aliquots were removed from the dissolution medium and analysed using a suitable analytical method (UV spectrophotometer).

I. Stability studies: (30,31)

In the pharmaceutical industry, stability is defined as a formulation's ability to remain within its physical, chemical, microbiological, therapeutic, and toxicological specifications in a specific container or closure system. A product's durability can be defined as the ability of a specific formulation in a specific container to maintain physical, chemical, microbiological, therapeutic, and toxicological specifications. The storage stability of Microsponge gel formulation is a major concern because it is the major resistance in the development of marketed preparations. The prepared formulation was tested for stability after being stored at 4 ± 1ºC, 25 ± 2ºC and 37 ± 5ºC & RH (Relative Humidity) 75 %. They were evaluated after one month and three months for the following parameters: appearance, pH, drug content analysis, drug release profiles, rheological properties, etc.

Safety considerations: (32,33)

Safety studies of microsponges can be confirmed by;

1. Allergenicity in guinea pigs
2. Eye irritation studies in rabbits
3. Mutagenicity in bacteria
4. Oral toxicity studies in rats.
5. Skin irritation studies in rabbits.

Applications: (32,33,34)

Microsponge delivery systems are used to improve the safety, efficacy, and aesthetic quality of topical prescription, OTC, and personal care products. This technology is intended to allow for a slower rate of release of the active ingredients, potentially reducing side effects while maintaining therapeutic efficacy. The Topical Microsponge systems are used in three ways by products in development or in the market:

1. As reservoirs that release active ingredients over time,
2. As receptacles for absorbing undesirable substances, such as excess skin oils, or
3. As closed containers that keep ingredients away from the skin for superficial action.

Microsponge for oral delivery:

The microsponge system has been demonstrated shown in oral applications to increase the rate of solubilisation of poorly water-soluble drugs by entrapping such drugs in the microsponge system's pores. Since pores are so small, the drug is effectively reduced to microscopic particles, and the significant increase in surface area increases the rate of solubilisation significantly. For example, changing the intraparticle density of ibuprofen microsponges allows for controlled oral delivery using an acrylic polymer, Eudragit RS. Sustained release chlorpheniramine maleate formulation for oral drug delivery using powder-coated microsponges produced by the dry impact blending method.

Microsponge for Bone and Tissue Engineering:

Mixing pre polymerized powders of poly methyl methacrylate and liquid methyl methacrylate monomer with two aqueous dispersions of tri calcium phosphate grains and calcium deficient hydroxyapatite powders yielded bone-substitute compounds. The final composites appeared porous and functioned as microsponges. Basic fibroblast growth factor (bFGF) incorporated in a collagen sponge sheet was sustained released in the mouse subcutis due to sponge matrix biodegradation and

exhibited local angiogenic activity in a dose dependent manner. Microsponges are primarily used for topical administration, but have recently been used for oral administration as well as biopharmaceutical delivery. Table 1 show various applications as well as the marketed product.

Microsponge for topical delivery:

The Microsponge systems are formed microscopic polymer-based microspheres that can bind, suspend, or entrap a wide range of substances before being incorporated into a formulated product such as a gel, cream, liquid, or powder. A single Microsponge is as small as a talcum powder particle, measuring less than one thousandth of an inch in diameter. Each microsphere, like a true sponge, is made up of a network of interconnected voids within a non-collapsible structure that can accept a wide range of substances. The outer surface tend to be porous, allowing controlled flow of substances into and out of the sphere. Microsponge systems are made of biodegradable polymers. Extensive safety research has revealed that the polymers are non-irritating, non-mutagenic, non-allergenic, non-toxic, and non-biodegradable. As a result, the human body cannot convert or break them down. Microsponges had a wide range of applications. It is mostly used topically, but it has recently been used orally. Because of its high loading capacity and sustained release ability, it has been reported in several patents that it can be used as an excipient. It provides the formulator with a variety of options for developing pharmaceutical and cosmetic products. Microsponges are intended to deliver a pharmaceutical active ingredient efficiently at the lowest possible dose while also improving stability, reducing side effects, and modifying drug release. Several moisturizers, specialized rejuvenative products, and sunscreens are among the over-the-counter products that rely on the microsponge drug delivery system.

Applications of microsponges with respect to their advantages

Table 1: Applications of microsponges with respect to their advantages (32,33,44)

Sr. 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.	Antipruritic	Extended and improved activity.
6.	Skin depigmenting agents e.g. hydroquinone	Improved stabilization against oxidation with improved efficacy and aesthetic appeal.

Examples of microsponge drug delivery with their formulations: (35,36,37)

Table 2: Examples of microsponge drug delivery with their formulations

Sr no	Microsponge Delivery Systems	Drug	Disease
1.	Gels	Benzoyl peroxide Fluconazole Mupirocin	Benzoyl peroxide Inflammation Antibacterial activity

		Diclofenac sodium Acyclovir Hydroxyzine HCl Terbinafine HCl	Inflammation Viral infections Urticaria and atopic dermatitis Anti-fungal
2.	Lotions	Benzoyl Peroxide	Anti-Acne Treatment
3.	Creams	Hydroquinone and Retinol	Melanoma
4.	Tablets	Indomethacin Paracetamol Chlorpheniramine maleate Ketoprofen Fenofibrate Meloxicam	Inflammation Anti-pyretic Hay Fever Musculoskeletal Pain Gout Arthritis
5.	Implants	Poly(DL-lactic-co-glycolic acid)	Skin tissue engineering
6.	Grafts	Poly (lactic-co glycolic acid)	Cardiovascular surgery
7.	Injection	Basic fibroblast growth factor	Growth factor

List of Marketed Products based on Microsponges 39,40,41,42

Table 3: List of Marketed Products based on Microsponges

Sr no	Product Name	Pharmaceutical Uses	Manufacturer
1.	Glycolic Acid Moisturizer w/SPF 15	Anti-Wrinkles, soothing	AMCOL Health & Beauty Solution
2.	Retin A Micro	Acne vulgaris	Ortho-McNeil Pharmaceutical, Inc.
3.	Line Eliminator Dual Retinol Facial Treatment	Anti-wrinkle	Avon
4.	EpiQuin Micro	Hyper pigmentation	Skin Medical . Inc
5.	Sports cream RS and XS	Anti-inflammatory	Embil Pharmaceutical Co. Ltd.
6.	Salicylic Peel 20	Excellent exfoliation	Biophora
7.	Ultra Guard	Protects baby's skin	Scott Paper Company
8.	Dermalogica Oil Control Lotion	Skin protectant	John and Ginger Dermalogica Skin Care Products

Patents Filed Related to Microsponges: (43)

Table 4: Patents Filed Related to Microsponges

Sr no	Patent no	Inventors	Publication Date
1	US4690825	Won, Richard	1987
2	US4863856	Dean RC Jr et al.	1989
3	US5292512	Schaefer et al	1989

4	US5135740	Katz et al	1992
5	US5679374	Fanchon; Chantal et al	1994
6	US5316774	Eury, Robert P et al.	1994
7	US5725869	Lo; Ray J. R	1996
8	US6395300	Straub et al.	1999
9	US6211250	Tomlinson et al	2001
10	US20030232091	Shefer et al	2005
11	US20040247632	Cattaneo, Maurizio	2004
12	US20050271702	Wright, Steven G et al	2005

FUTURE OUTCOMES:

Microsponge drug delivery system has a promising future in various pharmaceutical applications due to its unique properties such as enhanced product performance and elegancy, extended release, improved drug release profile, minimized irritation, improved physical, chemical, and thermal stability, which makes it possible for the development of novel product forms. The true future challenge will be the development of an oral peptide delivery system. This delivery system utilizes bioerodible and biodegradable polymers, resulting in the safe and effective delivery of the active ingredient. These porous systems have also been investigated both parenteral and pulmonary drug delivery. Microsponge particles can be used as cell culture media, which is beneficial for stem cell culture and cellular regeneration in the body. In future years, microsponge carrier systems might come into the applications in cosmetics. The flexibility in formulation benefits those in various fields yet additionally opening up new avenues for drug delivery systems.

CONCLUSION:

Microsponge drug delivery has become an extremely competitive and rapidly developing technology, with increasing research are being conducted to optimize both cost effectiveness and therapy efficacy. The market holds significant promise for Microsponge technology and the variety of applications it provides, with demand for innovative and extremely effective Pharmaceutical and Cosmetic products. Formulators can realize the full capabilities of these unique materials by considering new and creative ways of delivering actions, which provide enhanced safety, improved stability, reduced side effects from activities, expanded multifunctionality, and improved ingredient compatibility with other protocols. Microsponge delivery system, when teamed with novel development approaches and creative formulation techniques, can be a winning strategy for the forthcoming generations of Pharmaceutical and Cosmetic industry. Microsponges have an added benefit over current conventional topical dosage forms for the treatment of tropical diseases; it is a novel technology for the controlled release of topical agents that can also be used for oral and biopharmaceutical drug delivery. This product is superior compared to other products because it is non-mutagenic, non-toxic, and non-irritant. So, the microsponge drug delivery system has a lot of potential and is an emerging field that needs to be explored further down the road with more research.

REFERENCE

1. Shailesh Sharma, Anu Sharma and Chamanpreet Kaur, MICROSPONGES: AS A TOPICAL DRUG DELIVERY SYSTEM, IJPSR, 2020; Vol. 11(2): 524-534. E-ISSN:0975-8232; P-ISSN: 2320-5148.
2. Santanu Katy, Sabyasachi Maity Ashok Kumar Ghosh, Shubham Banerjee; Microsponge: A novel strategy for drug

delivery system, Journal of practical technology and research, (2011).
3. Won R: Method for delivering an active ingredients by controlled time release utilizing a novel delivery vechicle which can be prepared by a process utilizing the active ingredients as a porogen 1987,US Patent No. 4690825.
4. Vyas, S. and Khar, R.K., Controlled Drug Delivery- Concept and Advances, Vallabh Prakashan, 418422 (2002).
5. Storm, J.E. Collier, S.W. Stewart, S., Mtabolism of Xenobiotics During Percutaneous Penetration: Role of Absorption Rate and Cutaneous Enzyme Activity. Fundam. Appl. Toxicol. 132–41 (1990).
6. Nacht, S. Kantz, M., The Microsponge: A Novel Topical Programmable Delivery System. In Topical Drug Delivery Systems. New york: 42: 299-325 (1992).
7. Saripilli Rajeshwari, Vanapalli Swapna Microsponges as a Neoteric Cornucopia for Drug Delivery System, Int. J. Curr. Pharm. Research Vol 11, Issue 3, 4-12.
8. Aritoni, H. Yamasaki, Y. Yamada, K. Honda, H. Koshi, M., Development of sustained release formulation of chlorphenaramine maleate using powder coated microsponges prepared by dry impact method, J Pharm Sci Tech 56: 49-56 (1996).
9. Kumari P, Mishra SK, A Comprehensive review on novel microsponge drug delivery approach, Asian Journal of Pharmaceutical and Clinical Research, 9, 2016, 25-30.
10. Kawashima, Y. Niwa, T. Takeuchi, H. Hino, T. Ito, Y., Control of Prolonged Drug Release and Compression Properties of Ibuprofen Microsponges with Acrylic Polymer, Eudragit RS, byChanging Their Intraparticle Porosity. Chemical & pharmaceutical bulletin, 40(1): 196-201 (1992) .
11. Charde MS, Ghanawat PB, Welankiwar AS, Kumar J, Chakole RD, Microsponge a novel new drug delivery system: a review, International Journal of Advances in Pharmaceutics, 2013; 2(6):63-70.
12. 12. Mishra SK, Kumari P, A comprehensive review on novel microsponge drug delivery approach, Asian Journal of Pharmaceutical and Clinical Research, 2016; 9(1):25-30.
13. Gandhi KJ, Deshmane SV, Biyani KR, Polymers in pharmaceutical drug delivery system: a review, International Journal of Pharmaceutical Sciences Review and Research, 2012; 14(2):57-66.
14. Rahul Shivaji patil, Vishnu Uddhav Kemkar, S.S patil; Microsponge drug delivery system: A novel dosage form, American Journal of pharmatech research, 2(4): 230 (2012).
15. Parthiban, K.G. Manivannan, R. Krishnarajan, D. Chandra, S. Nidhin, Raj. Microsponge role in novel drug delivery system. International journal of pharmaceutical research and development, 3(4): 117125 (2011).
16. Panwar, A.S. Yadav, C.S. Yadav, P. Darwhekar, G.N. Jain, D.K. Panwar, M.S. Agarwal, A., Microsponge a novel carrier for cosmetics. J Global Pharma Technology, 3(7): 15-24 (2011)
17. Parthiban, K.G. Manivannan, R. Krishnarajan, D. Chandra, S. Nidhin, Raj. Microsponge role in novel drug delivery system. International journal of pharmaceutical research and development, 3(4): 117125 (2011).
18. Viral Shaha et al. Microsponge drug delivery system: A review. Int. J. Res. Pharm. Sci. 1: 121-218 (2010).
19. Kawashima, Y. Niwa, T. Takeuchi, H. Hino, T. Ito, Y., Control of Prolonged Drug Release and Compression Properties of Ibuprofen

Microsponges with Acrylic Polymer, Eudragit RS, by Changing Their Intraparticle Porosity. Chemical & pharmaceutical bulletin, 40(1): 196-201 (1992).

20. Microsponges : An Innovative and Novel Strategy for Drug Delivery System Buddhabhushan V. Bansol et.al. International Journal of ChemTech Research Vol-2, 299-321, 2019.
21. Jyoti and Kumar Sandeep, Innovative and Novel Strategy: Micro sponges for Topical Drug Delivery, Journal of Drug Delivery and Therapeutics, 2018: 28-34.
22. Martin, A. Swarbrick, J. Cammarrata, A., In: Physical Pharmacy- Physical Chemical Principles in Pharmaceutical Sciences 3: 527 (1991).
23. Kilicarslan, M. Baykara, T., The effect of drug polymer ratio on the properties of verapamil HCl loaded microspheres, Int J. Pharm, 252: 99-109 (2003).
24. Emanuele, A.D. Dinarvand, R. Preparation, Characterization and Drug Release from Thermo responsive Microspheres. Int J Pharma, 237-42 (1995).
25. Barkai, A. Pathak, Y.V. Benita, S., Polyacrylate (Eudragit retard) microspheres for oral controlled release of nifedipine. Formulation design and process optimization, Drug Dev Ind Pharm, 16: 20572075 (1990).
26. D'souza, J.I., The microsponge drug delivery system: For delivering an active ingredient by controlled time release, Pharmainfo.net, 6: 62 (2008).
27. Rawlins, E.A., Bentlys Text book of pharmaceutics by, 8th edition, page no-131.
28. Shobha rani, R Hiremath Text book of industrial pharmacy, published by universities press private limited page no-44-45.
29. D'souza,. J.I. In-vitro antibacterial and skin irritation studies of microsponges of benzoyl peroxide, Indian Drugs, 38: 361-362 (2001).
30. Netal Amrutiya Amrita Bajaj and Madhu Madam, Development of microsponges for topical delivery of Mupirocin, AAPS Pharm Sci Tech, 10(2): 402-409 (2009).
31. Jain, V. Singh, R. Dicyclomine loaded eudragit based microsponge with potential for colonic delivery: Preparation and characterization, Trop J Pharm Res, 9: 67-72 (2010).
32. Joshi G, Kaur R, Kaur H, Microsponge: A Novel New Drug Delivery System, International Journal of Pharmaceutics and Bio-science, 3(1), 2016, 01-11.
33. Pandey P, Jain V, Mahajain SC, A Review: Microsponge drug delivery system. International Journal of Biopharmaceutics, 4, 2013, 225-230.
34. 34. Hussain H, Juyal D, Dhyani A, Microsponge: An Overview, Indian Journal of Novel drug delivery, 6, 2014, 198-207.
35. Peppas, N.A., Analysis of Fickian and non-Fickian drug release from polymers. Pharm. Acta Helv. 60: 110–111 (1985).
36. Guyot, M. and Fawaz, F., "Microspheres-Preparation and physical characteristics". Int. J. Pharmaceutics, 175: 61-74 (1998).
37. Gangadharappa, H.V. Gupta, V. Sarat, C.P.M. Shivakumar, H.G., Current Trends in Microsponge Drug Delivery System. Current Drug Delivery. 10: 453-465 (2013).
38. Kaity, S. Maiti, S.Ghosh, A. Pal, D. Banerjee, A., Microsponges: A novel strategy for drug delivery system. J Adv Pharm Technol Res. 1(3): 283-90 (2010).
39. Shyam, S.M. Vedavathi, T., Novel approach: microsponge drug delivery system. Int. J. Pharm. Sci.Res. 3(4): 967-980 (2012).
40. Kaity, S. Maiti, S.Ghosh, A. Pal, D. Banerjee, A., Microsponges: A novel strategy for drug delivery system. J Adv Pharm Technol Res. 1(3): 283-90 (2010).

41. Shyam, S.M. Vedavathi, T., Novel approach: microsponge drug delivery system. Int. J. Pharm. Sci.Res. 3(4): 967-980 (2012).
42. Srivastava, R. Pathak, K., Microsponges: a futuristic approach for oral drug delivery. Expert Opin. Drug Deliv., 9(7): 863-878 (2012).
43. Namrata jadhav et al, Microsponge Delivery system: An updated review, current status and prospects, Journal of scientific and innovative research, 2(6): 1907-1110 (2013).
44. Namrata J, Patel V, Mungekar S, Karpe M, Kadam V, Microsponge delivery system: An updated review current status and future prospects, World Journal of Pharmacy and Pharmaceutical Sciences, 2(6), 2007; 6463-6485

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