MICROSPONGES: AN INEVITABLE TOOL IN DRUG DELIVERY SYSTEMS

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ABSTRACT
To meet the objectives of optimised efficacy and cost effectiveness of therapy, numerous advancements are implemented in the drug delivery system. The microsponge drug delivery system, which provides controlled release and site specific administration of active components, is one of the most recent, unique, and rapidly evolving technologies. Microsponge drug delivery devices were first created for topical medication delivery and were then adapted for controlled oral drug delivery. Microsponge drug delivery is a patented polymeric system consisting of porous microspheres that resembles that of sponges and size ranges from 5-300µm. Due to qualities including fewer side effects, more stability, better formulation flexibility, and enhanced product performance, this method is becoming a desirable option for topical medication administration. Wide range of active ingredients can be loaded into the microsponges like emollients, fragrances, anticancer, antifungal etc. Both drugs and cosmetics can entrap into the pores of microsponges. The drug release is aggravated by the change in pH, temperature, solubility and pressure. Microsponges overcome the drawbacks of conventional formulations by release the drug gradually and in controlled manner to the skin. It has a variety of uses in the delivery of oral, topical, ocular and biopharmaceuticals. The current review provides information on microsponge technology, programmable release mechanisms, formulation methodologies, evaluation and applications.

KEYWORDS: Microsponge, Controlled release, Oral delivery, Topical application.

INTRODUCTION
Drug delivery systems describe technology for deliver drugs into or throughout the body. The field of DDS advanced dramatically in the past few decades and even greater innovations are
anticipated in the upcoming years. There has been a considerable shift from conventional drug delivery techniques to new drug delivery systems, such as the use of microparticles, nanoparticles, nanorobots instead of pills, tablets and ointments etc. Carrier technology offers an intelligent approach for drug delivery by coupling the drug to a carrier particle (such as microspheres, nanoparticles, liposomes, etc.) which modulates the release and absorption characteristics of the drug.\[1\]

Microsponge is the most promising and rapidly expanding drug delivery method among the new technologies. Microsponges are porous microsphere based polymeric delivery devices. They are tiny, spherical particles with a porous surface resemble sponges. Additionally they might improve stability, lessen side effects and favourably alter medication release. Numerous medications including antifungal, anti cancer, anti bacterial, anti Parkinson’s and others can be loaded into the microsponge before being finally combined into an appropriate vehicle like gel, cream etc. Microsponges have a size range of 5 to 300 μm, are entrapped in the skin minuscule crevices and release the medicine gradually. While minimising its transdermal entry into the body, the microsponge system maximises the amount of time an active chemical present on the skin surface or within the epidermis. Microsponge are minute spheres that can absorb skin secretions hence lessen skin shine and oiliness. The internal pore structure of a microsponge, which has about 250000 pores and a total pore volume of roughly 1ml/gm for significant drug retention. As a result each microsponge has a sizable reservoir inside of it that can hold as much active agent as the microsponge itself weighs.

The microsponge technology was developed by Won in 1987 and the original patents were assigned to advanced polymer system, Inc. This company developed a large number of variations of the techniques and applied those to the cosmetic as well as OTC and physician prescribed products. Now this interesting technology has been licensed to Cardinal Health, Inc. Or use in topical products.\[2\]

![Figure 1: Structure of microsponge.](image)
Potential features of microsponge drug delivery system\textsuperscript{[3,4]}

- Improved oil control as it can absorb oil up to 6 times its weight.
- Liquid can be converted into powders by improving material processing.
- Release is extended up to 12 hours.
- These are non irritating, non-mutagenic, non-allergenic and nontoxic.
- Self sterilizing as average pore size is 0.25 µm where bacteria cannot penetrate.
- They can entrap a wide variety of drugs either in solid or in liquid form.
- They are stable at high temperatures up to 130 °C and pH range of 1-11.
- Microsponge system compatible with vehicles and active ingredients.

Advantages of microsponge drug delivery system\textsuperscript{[5,6]}

- Microsponge act as a controlled drug delivery system
- Drug directly applied to targeted organ
- It increases stability of drugs
- They are capable of absorbing skin secretions and lessen the oiliness
- It can also improve bioavailability of the drugs
- Reduced irritation and hence improved patient compliance
- Improved product elegance
- Without reducing their efficacy, it can prevent excessive accumulation of ingredients within the skin surface
- MDS are easy to formulate
- Reduce systemic adverse effects

Limitation of microsponge drug delivery system

- During preparation use of organic solvents as porogens, which pose an environmental hazard as some may be highly inflammable, posing a safety hazard.
- In some cases traces of residual monomers have been observed which may be toxic and hazardous to health.
Anil. World Journal of Pharmacy and Pharmaceutical Sciences

Superiority of microsponge over other pharmaceutical formulations\[^{[7]}\]

Table 1: Superiority of microsponge over other pharmaceutical formulations.

<table>
<thead>
<tr>
<th>Conventional pharmaceutical formulations</th>
<th>Microencapsulation and liposomes</th>
<th>Ointments</th>
<th>Microsponge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid releases of the drug</td>
<td>Microcapsules cannot usually control the release rate of actives</td>
<td>Unappealing, greasiness, stickiness</td>
<td>Controlled release of the drug</td>
</tr>
<tr>
<td>Accumulated in the epidermis and dermis layer of the skin</td>
<td>Liposomes have lower payload</td>
<td>Requires high concentrations of active agents</td>
<td>Stable over wide range of pH 1-11 and temperature upto 130°C</td>
</tr>
<tr>
<td>Side effects like irritation, and toxicity</td>
<td>Difficult formulation</td>
<td>Unpleasant odour, potential incompatibility of drug with vehicles.</td>
<td>Compatible with most of the ingredients and vehicles</td>
</tr>
<tr>
<td>Reduced patient compliance due to Repeated application</td>
<td>Limited chemical stability and microbial instability.</td>
<td>Uncontrolled evaporation of active ingredient</td>
<td>Self sterilizing maximum residence time on the skin, low transdermal penetration into body</td>
</tr>
</tbody>
</table>

Characteristics of active moieties that is entrapped into microsponge \[^{[8]}\]

- 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.
- It should be water immiscible or nearly only slightly soluble
- It should be inert to monomers and should not increase the viscosity of the mixture during formulation.
- It should not collapse the spherical structure of microsponges.
- It should be stable in contact with polymerisation catalyst and also in conditions of polymerisation
- The solubility of active in vehicles must be limited. If not, the vehicle will deplete the microsponge before the application.
- Payload and polymer design of microsponge or the actives must be optimized for required release rate for given period of time.
- Not more than 10-12% w/w microsponges must be incorporated into the vehicle in order to avoid cosmetic problems.
Formulation\textsuperscript{[9,10]}

MDS contain drug, polymer, vehicle and other additives like plasticizers that help to stabilize the structure.

- **Various drugs used in MDS**: Paracetamol, Ketoprofen, Acetonide, Benzoyl peroxide, Mupirocin, Avobenzone, Diclofenac Na Various polymers were reported to form microsponge ‘cage’.

- **Polymers used**: Ethyl cellulose, Eudragit RS 100, Eudragit RL 100, PHEMA, Poly lactic acid, Polystyrene, Acrylic polymer

- **Vehicle used**: Ethanol, Dichloromethane, Acetone

- **Plasticizers**: Triethyl citrate, Dibutyl phthalate

**Preparation of microsponge**

The drug loading in microsponge drug delivery system is done in two ways, based upon the physicochemical properties of the drug that is loaded to be

**A) Liquid-Liquid suspension polymerization:**

- One-step process or liquid-liquid suspension polymerization

The porous microsphere based microsponges are prepared by the suspension polymerization method. The immiscible monomers are first dissolved with active ingredient in a suitable solvent and are then dispersed in the aqueous phases which consist of surfactant or suspending agents that are used for the formation of suspension. The polymerization is then activated by increasing the temperature or addition of catalyst. The polymerization process continues until the reservoir type of system with spherical structure is formed. After the polymerization process the solvent is removed, leaving the microsponges.

![Reaction vessel for microsponge preparation by liquid-liquid suspension method](image)

**Figure 2**: Reaction vessel for microsponge preparation by liquid-liquid suspension method.
B) Quasi-Emulsion solvent diffusion

- Two step process or Quasi emulsion solvent diffusion method

This method is generally used for the preparation of oral and topical microsponges. It is simple, reproducible, fast and free of solvent related toxicity issues. The emulsion formed is stabilised by high viscosity of external phase other than interfacial phenomenon that’s why this method is known as quasi emulsion diffusion method.

In the inner organic phase polymer like ethyl cellulose or Eudragit is dissolved in ethyl alcohol/isopropyl alcohol/dichloromethane and drug is dissolved in this solution by ultrasonication at room temperature. The outer aqueous phase consists of PVA solution in water. The solution is stirred and filtered for further use. The inner phase mixed in outer phase on mechanical stirrer drop wise. On the stirring the Quasi emulsion droplet was formed which may further evaporation of organic solvent produces the solid microsponge cages. The prepared microsponges are filtered and dried in oven for 12 h.

![Figure 3: Preparation of microsponge by quasi–emulsion solvent diffusion method.](image)

C) Multiple-Emulsion solvent diffusion

Water in oil in water (w/o/w) emulsion solvent diffusion - This innovative method was devised to create biodegradable porous microspheres. This process involved dispersing an internal aqueous phase in an organic polymeric solution that contained an emulsifier such as span, polyethyleneimine and stearylamine. After then, this was once again disseminated in PVA- containing external aqueous phase forming a double emulsion.
D) Addition of porogen
In this method, the water in oil in water (w/o/w) emulsion’s internal aqueous phase was swapped out for a porogen-like substance hydrogen peroxide or sodium bicarbonate. This was accomplished by first dispersing the porogen in the polymeric solution to create a consistent dispersion system, which was then redispersed in an aqueous phase containing PVA. Then, an initiator was added, and the organic solvent was allowed to evaporate, leaving the microparticles in the w/o/w emulsion.

E) Oil in oil emulsion solvent diffusion
The internal phase of the oil in oil (o/o) emulsion was created using volatile organic liquid, which was then allowed to slowly evaporate at a controlled rate while being continuously stirred. The internal phase’s solvent is dichloromethane the polymer is polylactide glycolic acid and the exterior phase is a mixture of fixed oil (corn or mineral) and dichloromethane containing span 85. To create microsponges, the internal phase was gradually introduced to the dispersion medium while being continuously stirred.

F) Lyophilization
The microspheres created using the gelation procedure were transformed into porous microspheres using the lyophilisation technique. This approach involved lyophilising the microspheres after they had been cultured in a chitosan hydrochloride solution. The microspheres developed pores as a result of the solvent being removed quickly.

G) Ultrasound-assisted production
This technique was created by adapting liquid--liquid suspension polymerization, to use beta-cyclodextrin (β-CD) as the monomer and diphenyl carbonate as the cross-linking agent to create the nanosponges. The reaction mixture was heated and sonicated in order to control the size of the microparticles. The reaction mixture was allowed to cool and the resulting material was milled to produce rough particles that were first cleaned with distilled water and then with ethanol .Drug can be efficiently loaded into the porous microparticles of cross-linked β-CD.

Table 2: Advantages and Disadvantages of various methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid--liquid suspension polymerization</td>
<td>Can be suitably modified to one step or two step methods for drug loading</td>
<td>Probable entrapment of unreacted monomers and solvent traces. Non-uniform</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Notes</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>Quasi-emulsion solvent diffusion</td>
<td>No monomer entrapment. Low solvent traces. High drug loading. No exposure of drug to ambient condition. Size of microsponges can be easily controlled by controlling the stirring. Spherical particles</td>
<td>Cannot be used for the loading of water-soluble drugs. Requires long time for the reaction of monomers. Drug should be soluble in a volatile water-soluble solvent.</td>
</tr>
<tr>
<td>w/o/w emulsion solvent diffusion</td>
<td>Efficient for loading water-soluble drugs. Can be used to entrap proteins and peptides</td>
<td>Uses water-insoluble surfactants that can be present as residues in the resultant microsponges.</td>
</tr>
<tr>
<td>Addition of porogen</td>
<td>Highly porous structure with nicely distributed and interconnected pores</td>
<td>May cause disruption in structure.</td>
</tr>
<tr>
<td>o/o emulsion solvent diffusion</td>
<td>No presence of surfactant traces in microsponges</td>
<td>Requires vigorous washing to remove the traces of organic solvents.</td>
</tr>
<tr>
<td>Lyophilization</td>
<td>Easy quick reproducible results</td>
<td>May lead to cracking or shrinkage of microparticle.</td>
</tr>
<tr>
<td>Ultrasound-assisted production</td>
<td>No traces of solvents. Quick reproducible results</td>
<td>Irregular structure. Require cross-linking agents that may be potentially toxic.</td>
</tr>
</tbody>
</table>

Effects of formulation Parameters and Process variables on microsponge characteristics\(^{11}\)

Microsponges are characterized for particle size, shape, encapsulation efficiency, production yield, drug loading, porosity, surface morphology and drug release. The essential characteristics that significantly affect the effectiveness of microsponges are

- **Size**
- **Entrapment efficiency**
- **Production yield**
- **Drug release**
Table 3: Effects of formulation Parameters and Process variables on microsponge characteristics.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Process variables</th>
<th>Effect of process variables on parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>• Drug: polymer ratio</td>
<td>With increase in drug polymer ratio, increase in particle size of microporous structures.</td>
</tr>
<tr>
<td></td>
<td>• Volume of internal phase</td>
<td>Particle size of microsponges is directly proportional to apparent viscosity of the internal phase.</td>
</tr>
<tr>
<td></td>
<td>• Amount of emulsifying agent</td>
<td>With increase in the amount of emulsifying agent, particle size has been found to increase.</td>
</tr>
<tr>
<td></td>
<td>• Stirring speed</td>
<td>Size of microsponge can be reduced by increasing stirring speed up to a limit.</td>
</tr>
<tr>
<td>Product yield</td>
<td>• Drug polymer ratio</td>
<td>Increase in the drug-polymer ratio may result in higher production yield.</td>
</tr>
<tr>
<td></td>
<td>• Amount and nature of emulsifying agent</td>
<td>Increase in emulsifying agent leads to reduction in production yield.</td>
</tr>
<tr>
<td></td>
<td>• Stirring speed</td>
<td>When the speed of stirrer is increased, a decrease in production yield.</td>
</tr>
<tr>
<td>Entrapment efficiency</td>
<td>• Drug polymer ratio</td>
<td>Increase in the drug-polymer ratio may lead to increase in the ee with increase in pore inducer concentration</td>
</tr>
<tr>
<td>Drug release</td>
<td>• Drug: polymer ratio</td>
<td>Drug: polymer ratio was found to have a negative effect on drug release.</td>
</tr>
<tr>
<td></td>
<td>• Dcm concentration</td>
<td>Dcm concentration was also found to have a positive impact on the drug release.</td>
</tr>
<tr>
<td></td>
<td>• Amount of pva</td>
<td>With increase in amount of pva, slight decrease in drug release has been noticed.</td>
</tr>
<tr>
<td></td>
<td>• Pore inducers</td>
<td></td>
</tr>
</tbody>
</table>

Release mechanism of microsponge\textsuperscript{[12]}

Microsponge can be designed to release given amount of active ingredients over time in response to one or more external triggers.
A) **Pressure triggered release mechanism**

The entrapped drug is released from microsponge when they are pressurized or rubbed. The amount released depends upon the size and number of pore available on the sponge.

B) **Temperature triggered release mechanism**

The active ingredients loaded in microsponges are viscous at storage temperature. On the application onto the skin by the means of rubbing or increase in temperature reduces the viscosity the active drug may flow out vigorously the skin. Sometimes by increasing the temperature of the skin may enhance the fluidity of drug. The release of the drug is easily modulated by changing the temperature.

C) **pH Triggered release mechanism**

In this mechanism microsponge is coated with the pH dependent polymers. On the specific pH these polymers either swelled or leached out from the microsponges. After leaching of pH-dependent polymer the drug released from the microsponges. Coating of the microsponge increases the application of drug delivery to site-specific delivery.

D) **Solubility triggered release mechanism**

When water-soluble drug loaded in microsponge it release only in presence of water. The rate of drug release from microsponge can be triggered by the amount of aqueous medium.
Characterisation of microsponge\textsuperscript{[13]}

Table 4: Characterization of microsponge.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Characterisation methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>Optical microscope or electron microscope</td>
</tr>
<tr>
<td>Loading efficiency</td>
<td>Loading efficiency= practical drug loading/theoretical drug loading × 100</td>
</tr>
<tr>
<td>Production yield</td>
<td>Production yield= practical quantity/theoretical quantity × 100</td>
</tr>
<tr>
<td>True density</td>
<td>Ultra pycnometer</td>
</tr>
<tr>
<td>Compatibility studies</td>
<td>Tlc, ftir,dsc,pxrd</td>
</tr>
<tr>
<td>Surface topography</td>
<td>Sem (scanning electron microscopy)</td>
</tr>
<tr>
<td></td>
<td>Tem (transmission electron microscopy)</td>
</tr>
<tr>
<td>In-vitro release studies</td>
<td>Usp xxiii basket type dissolution apparatus</td>
</tr>
</tbody>
</table>

Currently marketed products

Table 5: Some examples of MDS currently marketed as cosmetic products.

<table>
<thead>
<tr>
<th>Name of product</th>
<th>Active moiety</th>
<th>Indications</th>
<th>Manufactures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retin-A-Micro</td>
<td>Tretinoin</td>
<td>Acne vulgaris</td>
<td>Ortho –MCNell Pharmaceutical,Inc. USA</td>
</tr>
<tr>
<td>Carac Cream</td>
<td>Fluorouracil</td>
<td>Actinic keratoses</td>
<td>Dermik Laboratories,Inc.US A</td>
</tr>
<tr>
<td>Retinol Cream</td>
<td>Retinol</td>
<td>Skin supplement</td>
<td>Biomedical IMPORIUM,South Africa</td>
</tr>
<tr>
<td>Salicylic peel 20 and 30</td>
<td>Salicylic acid</td>
<td>Excellent exfoliation</td>
<td>Biohora Medical skin care,Canada</td>
</tr>
<tr>
<td>Acne peel</td>
<td>Salicylic acid</td>
<td>Acne vulgaris</td>
<td>Biomedical IMPORIUM,South Africa</td>
</tr>
<tr>
<td>Retinol night cream</td>
<td>Retinol</td>
<td>Antiwrinkle</td>
<td>Biomedical IMPORIUM,South Africa</td>
</tr>
<tr>
<td>Ultra guard</td>
<td>Dimethicone</td>
<td>Protective for babies</td>
<td>Scott paper company,USA</td>
</tr>
<tr>
<td>Aramis fragrances</td>
<td>Antiperspirant</td>
<td></td>
<td>Aramis ,Inc.USA</td>
</tr>
</tbody>
</table>

Applications

- **Acne**

Acne is one of the most prevalent skin conditions affecting teenagers. Benzoyl peroxide is widely used for the treatment of acne vulgaris but has many side effects like skin irritation, dryness etc. Nihal atabay et al formulated benzoyl peroxide as microsponge by using quasi
emulsion solvent diffusion method and finally incorporated to the plaster contain 100% woven cotton fabric by dip-coating method. It provides sustained drug release, and high water vapour permeability. This study exhibit the novel approach for acne treatment based on textile containing microspone.[14]

➢ **Obesity**

Orlistat have short half life and poor water solublility. Rahul vishvakarma *et al* developed microsponges as a delivery method to increase Orlistats absorption and bioavailability because they do so more effectively than other orlistat dosage forms. Microsponges disperse freely in GIT, they can improve maximize drug absorption, increase bioavailability and minimize potential side effects. Quasi emulsion solvent diffusion method was used because to avoid dust during preparation and yield high purity microsponges. Orlistatat microsponge prepared with eudragit RS 100 show good particle size, entrapment efficiency, % drug release.[15]

➢ **Inflammatory bowel disease**

Naproxen is a non-steroidal anti inflammatory drug. Naproxen loaded microsponges were prepared by quasi emulsion solvent diffusion method. Optimization was done by box-
The evaluation studies include particle size, entrapment efficiency, and product yield. Naproxen microsponge further formulated as tablet formulation for colon delivery, drug release from tablet follows sustained release. Tablets were evaluated by angle of repose, hardness, friability, thickness, dissolution, kinetic release data and weight variation studies.\[16]\n

> **Arthritis**

Lornoxicam is potent NSAIDs commonly used in rheumatoid arthritis, osteoarthritis, and post operative surgical pain. It is a BCS class II drug with low aqueous solubility, due to this it will not dissolve efficiently and result into poor absorption within the body. Due to the short half life frequent oral administration needed, leads to side effects such as gastrointestinal disorders, headache and skin irritation. Yeteng He et al demonstrated lornoxicam loaded microsponge which eliminates all these problems by establishes a sustained release of drug, reduction in inflammation, and timely relief of symptoms.\[17]\n
> **Glaucoma**

Glaucoma is a chronic progressive eye disease. Acetazolamide a carbonic anhydrase inhibitor used for the treatment of glaucoma. Large oral doses of this drug can cause severe side effects like diuresis, gastrointestinal symptoms include cramping, nausea, diarrhea etc. There is no topical formulation of this drug exist because of low permeability. The major drawback of ophthalmic systems like rapid and extensive precorneal loss can be overcome by
formulating microsponge loaded in-situ gel. Tahani H Elfaham et al demonstrated microsponge loaded in-situ gel of acetazolamide, which enhances the contact time between the drug and corneal surface and also reduces the systemic side effects of the drug and increase patient acceptance.[18]

➢ **Psoriasis**
A long lasting, non-contagious, auto immune disease. Topical application of clobetasol propionate produces side effects like steroid acne, skin atrophy, allergic contact dermatitis, and systemic absorption. In order to diminish all these side effects microsponges is a good carrier for topical delivery of CP. Quasi emulsion solvent diffusion method using eudragit RS 100 as the polymer. The formulation shows the zero order drug release with absence of initial burst release.[19]

➢ **Colon cancer**
5-FU has wide range of anticancer activity but its oral administration shows poor bioavailability and IV administration causes cytotoxicity to normal human healthy cells. These problems can be overcome by the microsponge system; the microsponges are easily taken up by the macrophages in the colon and produce more effective drug action. Microsponges are prepared by o/o emulsion solvent diffusion method using eudragit RS 100 as the polymer. The MTT assay on HCT16 &CACO2 cell line shows cytotoxicity of microsponge and shows sustained release; act as a substitution for 5 FU oral deliveries.[20]
**Burn**

Silver sulfadiazine is an antibacterial agent and honey is a natural healing agent. Priya patel *et al*, formulated honey based silver sulfadiazine micosponge loaded hydrogel. The release rate was found to be 85% within 12 hour. This formulation show the advantages like increase drug retention ability in skin, no irritation, low toxicity, reduce application time and improve wound contraction. It is an alternative to the marketed product.\(^{[21]}\)

**Antiungal**

Topical fluconazole cause systemic absorption, skin irritation & fail to accomplish mycological destruction. By converting to microspone by quasi emulsion, it produces more advantages like continual topical delivery for extended period; reduce application frequency, increase bioavailability, and safety. Microsponges were evaluated for drug content, encapsulation efficiency, product yield, drug release, morphology, surface topography. Drug release from microspone follow zero order & extended drug release with respect to conventional. This formulation was promising to eradicate face fungus, candidiasis, and fungal infections.\(^{[22]}\)

### Table 6: Applications of microsponges drug delivery systems.\(^{[23]}\)

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Drug candidates</th>
<th>Formulation type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fluconazole</td>
<td>Gel</td>
<td>Anti fungal</td>
</tr>
<tr>
<td>2</td>
<td>Oxybenzone</td>
<td>Gel</td>
<td>Sun screen agent</td>
</tr>
<tr>
<td>3</td>
<td>Benzoyl peroxide</td>
<td>Cream, gel, lotion</td>
<td>Anti acne</td>
</tr>
</tbody>
</table>
4. Indomethacin Tablets Inflammation
5. Paracetamol Tablets Anti – pyretic
6. Poly(dl-lactic-co-glycolic acid) Implants Skin tissue engineering
7. Poly(lactic-co-glycolic acid) Grafts Cardiovascular surgery
8. Basic fibroblast growth factor Injection Growth factor
9. Babchi oil Gel Antibacterial
10. Mupirocin Emulgel Primary and secondary skin infections
11. Ketoconazole Gel Anti fungal
12. Voriconazole Gel Anti fungal
13. Itraconazole Gel Anti fungal
14. Tea tree oil Gel Antibacterial
15. Terbinfine Gel Anti fungal
16. Sertaconazole nitrate Gel Anti fungal
17. Ketoprofen Tablets Musculoskeletal pain

CONCLUSION
Due to the demand for innovative and highly efficient pharmaceutical and cosmetic products, microsponge technology and the versatility it offers have a lot of potential in the market. The highly controlled release of an active chemical that has been placed into MDS is made possible by the promising technology known as MDS, which also results in a reduction in pharmacological side effects while retaining therapeutic efficacy. Along with greater formulation elegance and flexibility, it also showed noticeably better formulation stability. Numerous investigations led to the conclusion that they are non-toxic, non-allergic and non-mutagenic in nature.

REFERENCE


