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REVIEW ON OVERVIEW OF TRANSDERMAL DRUG DELIVERY SYSTEM

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ABSTRACT

In put of conventional needle infusions, a number of non-invasive medications have recently gotten to be accessible. Among them, a transdermal sedate conveyance framework (TDDS) is the most engaging due to its tall understanding compliance, and it's remarkable ease of organization. The drawbacks of elective organization strategies, such as verbal and parenteral, can be relieved by utilizing these frameworks. An cement fix that has been sedated and connected to the skin to convey a indicated dose of pharmaceutical through the skin and into the circulation system is called a transdermal patch.

KEYWORDS: TDDS, Transdermal Fix, Components of TDDS, Sorts of Transdermal Fix, Variables Influencing TDDS.

INTRODUCTION

The final a few a long time have seen a resurgence of intrigued in the creation of imaginative medicate conveyance strategies for already-approved pharmaceutical compounds. The creation of a novel conveyance strategy for already-approved medicine particles essentially increments persistent compliance and the add up to restorative impact of the medicine in expansion to improving its viability and safety.[1] Another way to regulate medicine through the skin is with transdermal sedate conveyance frameworks (TDDS), now and then known as patches. These gadgets are made to viably regulate helpful doses of drugs into the circulatory system, getting levels that are reasonable for both the anticipation and treatment of disease.[2] It overcomes the downsides of conventional verbal or injectable adaptations and offers more viable treatment with less unfavorable occasion dangers and steady medicate levels. Transdermal medicine organization is particularly valuable for

conditions that require visit, long-term dosage.[3] The FDA approved Transderm SCOP, the to begin with transdermal gadget, in 1979 to decrease travel-related sickness and spewing. The lion's share of transdermal patches are made to discharge the dynamic substance into the skin at a zero arrange rate for a few hours to numerous days after application. This is especially advantageous for preventative treatment of long-term illnesses.[4] Definition of transdermal patch: A transdermal fix, moreover called a skin fix, is a sedated cement fix, which is connected to the surface of the skin to non-invasively convey a particular dosage of medicate through the skin layers and into the systemic circulation over a period of a few hours to days after the application.

Figure 1: Transdermal patch the medicate affirmed by FDA For TDDS.[12,13,14,15,16]

Sr. no.	Approved year	Drug item	Indications
1.	1979	Scopolamine	Motion affliction
2.	1982	Nitroglycerin	Angina pectoris
3.	1984	Clonidine	hypertension
4.	1986	Estradiol	Menopausal indications
5.	1990	Fentanyl	Chronic torment
6.	1991	Nicotine	Smoking cessation
7.	1993	Testosterone	Testosterone insufficiency
8.	1995	Lidocaine	Local pain relieving
9.	1999	Lidocaine	Post hepatic torment
10.	2001	Ethinyl estradiol	contraceptive
11.	2003	Oxybutynin	Overactive bladder
12.	2006	Fentanyl	Acute postoperative torment
13.	2007	Rotigotine	Parkinson’s infection
14.	2008	Granisetron	Chemo actuated emesis
15.	2010	Buprenorphine	Chronic torment
16.	2022	Donepezil	Alzheimer’s malady

Advantages of transdermal sedate conveyance

- It gives a persistent and consistent mixture of pharmaceutical over an expanded period, decreasing the chance of antagonistic impacts and helpful disappointments related with irregular dosing.[5]
- Patients can self-administer medicine utilizing these frameworks.[5]
- Transdermal conveyance dodges the fluctuating medicate levels seen with top and trough designs, permitting for longer and less visit dosing intervals.[6]
- It offers a speedier and more helpful organization method.[7]
- The retention rate can be controlled through a multilayered structure.[7]

- Patients are more likely to follow to their treatment plans as they no longer require to take numerous doses.[8]
- This approach enables patients to oversee their medicine independently.[8]
- It diminishes systemic medicate intelligent
- It offers longer length of action
- They can halt issues with gastrointestinal medication retention brought on by enzymatic action, stomach pH, and medicate intelligent with nourishment, refreshments, and other verbal medications.
- Lower medicate side impacts due to diminished pharmaceutical plasma concentration levels.
- Patient compliance
- The organization is painless
- Avoid a drug's first-pass metabolism.
- Zero potential for toxicity

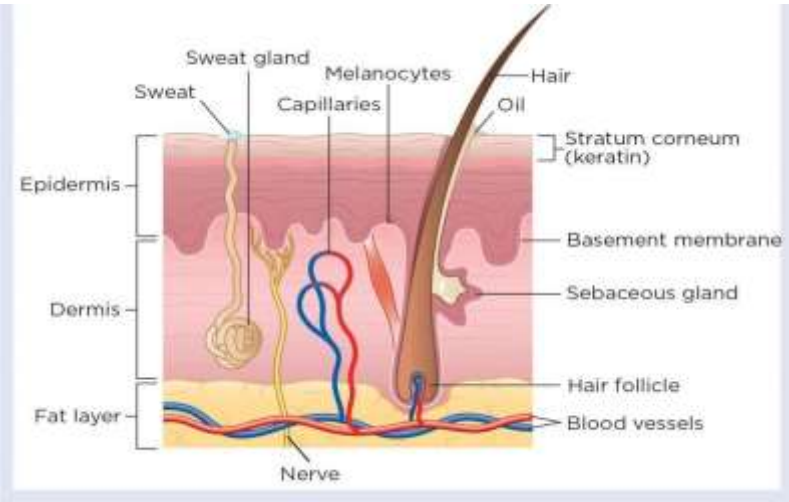
Disadvantages of transdermal sedate conveyance

- Only a modest lipophilic pharmaceutical is presently endorsed for utilize in TDDS.
- A medicine with a enormous atomic estimate is not suitable.
- Unsuitable for medicines with expansive dosages
- Water and sweat can kill a skin fix.
- Skin inconvenience and touchiness may occur
- Long-term utilize may cause inconvenience
- Long-term grip is challenging
- Ionic pharmaceutical conveyance is not possible
- Not continuously conservative
- Dosage dumping may happen if the medicine ties to the skin.

Limitations

- Ionic drugs cannot be conveyed by means of TDDS.
- If a pharmaceutical or definition aggravates the skin, TDDS cannot form.
- It is not competent of creating for huge atomic weight medications (over 500 Daltons).
- High sedate levels in blood and plasma are accomplished with TDDS.
- Restricted penetrability of the skin.
- The patch's adherence to the skin.

- A pharmaceutical may corrupt in the skin.
- This strategy cannot be utilized to regulate profoundly softening drugs since of their destitute solvency in fat and wate



Anatomy of skin

In order to protect the body from the outside world, the skin is the main barrier.[9] The epidermis of the human body covers an estimated 2 square meters. Given that it gets around one-third of all the blood that circulates in the body, it is essential to our general health. Put another way, our skin operates as a big canvas that interacts with a substantial amount of our blood supply to facilitate vital processes and preserve the overall health of our body.[10] Human skin is divided into two main types: non-hairy skin and skin that bears hair. The skin is made up of several layers of cells. Sebaceous glands and hair follicles are both included in hair-bearing skin.[11]

Layers of skin

Human skin consists of three distinct layers:-

- Epidermis
- Dermis
- Hypodermis

Epidermis: The skin's outermost layer, the epidermis, functions as an essential tissue barrier. It is made up of basally differentiated stratified epithelium and proliferating keratinocytes in the suprabasal area. The thickness of the epidermis varies; the soles of the feet and the palms of the hands usually have a thickness of about 0.8 mm. The majority of the cells in the epidermis are keratinocytes.[17] These cells give rise to the basal layer of skin cells, which are

found inside the skin. The outermost layer of the epidermis is made up of dead cells. This layer serves as a barrier; many medications cannot pass through the stratum corneum, while lipotropic medications can pass through more readily than hydrophilic medications.[21]

This layer is made up of living cells that are arranged into five layers according to the degree of keratinisation of the cells[22]

- The stratum corneum (SC or horny layer),
- Stratum lucidum (Clear layer),
- Stratum granulosum (Granular layer),
- Stratum spinosum (Spinous or prickle layer),
- Stratum germinativum (Basal layer).

Stratum corneum: This layer, also known as the Horny layer, is the outermost layer of skin. It is roughly 10 μm thick when dehydrated, but when completely hydrated, it swells to many times this thickness. The dead, keratinised cells known as corneocytes are arranged in 10–30 layers on it. Drug molecules have three possible routes of penetration into the stratum corneum. Numerous methods exist for the drug to be absorbed through the skin, contingent upon its physicochemical properties.

Different mechanisms are involved in the absorption of lipophilic and hydrophilic drugs

- Transcellular route
- Intercellular route
- Transfollicular route

Viable epidermis: This is found underneath the outermost layer and ranges in thickness from 0.8 mm on the palms to 0.06 mm on the soles of the eyelids. It is made up of several layers that go inward, including the stratum lucidum, stratum spinosum, stratum granulosum, and the stratum basal. The epidermis is continuously reproduced by basal layer cells through mitotic divisions, which counteracts the loss of dead Horny cells from the skin's surface.

Dermis: The skin's middle layer is called the dermis.[18] The skin's dermis, a complex fibro-elastic structure, gives it mechanical strength. There is a vast network of blood vessels and nerves within this layer. Parenteral medication delivery-related pain may result from possible injury to the dermal nerve endings.[19] The layers of dermis are 3 to 5 mm thick. Also

removes pollutants and waste items from the skin while supplying it with nourishment and oxygen.

Hypodermis: The subcutaneous adipose tissue, or hypodermis, is essential for maintaining the dermis and epidermis. It provides mechanical protection, nutritional support, and fat storage in addition to helping to regulate body temperature. Major blood arteries, nerves that reach the skin, and possibly sensory pressure organs are all found in this stratum. When a medicine is delivered transdermally, it must pass through the epidermis, dermis, and hypodermis in order to enter the systemic circulation. On the other hand, drug retention in the skin layers is the intended result of topical drug delivery, where penetration through the stratum corneum is the main prerequisite.[20]

Essential components of TDDS

- Drug
- Polymer matrix
- Penetration enhancers
- Adhesives
- Backing membrane
- Discharge Linear[23]

Drug: Drugs must have specific physicochemical characteristics in arrange to permit for retention through the skin. These comprise of brief half-lives, moo dissolving temperatures, non-irritating qualities, moo atomic weights [up to 1000 Daltons], adequacy, and affinities for both hydrophilic and lipophilic molecules.[24] To accomplish viable advancement, the medicines utilized for a transdermal sedate conveyance framework must be carefully considered.[25]

Polymer network: Transdermal sedate conveyance frameworks, or TDDS, depend intensely on polymers since they oversee the system's controlled medicate discharge. The pharmaceutical can be included in a fluid or strong state to get ready the polymer framework. The utilize of a biodegradable polymer, whether characteristic or engineered, is fundamental for intramuscular medicate conveyance frameworks. The pharmaceutical is scattered all through this polymer network to deliver it. The chosen polymer needs to appear solid steadiness and compatibility with the sedate and other framework components in arrange to

be utilized for focused on medicate organization by injectable methods. It require to viably discharge the medicine in a secure and directed way.

Many sorts of polymers are utilized in transdermal sedate conveyance frameworks, including

- Synthetic elastomers incorporate silicone elastic, butyl elastic, hydrin elastic, polybutadiene, and polyisobutylene.
- Polyvinyl liquor, polyvinyl chloride, polyethylene, polypropylene, polyacrylate, polyamide, polyurea, and polyvinylpyrrolidone are illustrations of engineered polymers.
- Natural polymers incorporate waxes, gums, glycol, polyethylene, eudragits, and subordinates of cellulose.[25]

Permeation enhancer: These compounds has the capacity to adjust the stratum corneum's structure in a reversible way, thus improving the infiltration of medicines from the skin into the bloodstream.[26] They fulfill this by either expelling lipids or presenting amphiphilic atoms into the stratum corneum's profoundly requested intercellular lipid layers. By bringing down boundary resistance, this reversible instrument progresses co-administered pharmaceutical absorption.

A idealize enhancer ought to satisfy certain necessities: it ought to be non-irritating, non-toxic, non-allergic, and inactive. It ought to too work unidirectionally and be congruous with the solutions and excipients included in the detailing. Depending on the specific pharmaceutical, the skin's properties, and the concentration used, these enhancers' adequacy can change.[34] One device utilized to degree the sum of pharmaceutical that saturates the skin is a dissemination cell.[27] By expanding the stratum corneum's penetrability, these chemical compounds offer assistance the medicine candidate reach helpful concentrations. Through their intelligent with the stratum corneum, they increment permeability.[28]

Adhesives: Not at all like single-layer and multi-layer drug-in-adhesive frameworks, the store transdermal framework has a unmistakable sedate layer. This medicine capacity holder is totally contained inside a shallow zone composed of a metallic plastic cover that is impenetrable to drugs. It moreover has a rate-regulating film with one surface made of a polymer taking after vinyl acetic acid derivation. A one of a kind cement layer, such as silicone subsidiaries, polyacrylates, and polyisobutylenes, is utilized to ensure division.[26]

Backing film: In a transdermal fix, the backing layer acts as a boundary against the exterior world. It must be impenetrable to infiltration enhancers and drugs alike. It too secures the medicate store from the environment and serves as auxiliary back for the in general framework. Polyesters, siliconised polyethylene terephthalate, and aluminised polyethylene terephthalate are frequently used backing materials.[29] Transdermal patches depend intensely on backing covers as back structures.[30] These backing films offer a strong association to the medicine supply and are malleable. They empower printing on the fix and halt the pharmaceutical from getting away the measurement shape through the best surface.[31]

Release direct: Amid capacity, the transdermal fix is ordinarily ensured by a liner that is expelled and disposed of fair some time recently applying the fix to the skin. This liner is considered a component of the essential bundling fabric or maybe than an necessarily portion of the sedate conveyance framework itself.[32] Other materials commonly utilized for discharge liners in Transdermal Sedate Conveyance Frameworks [TDDS] incorporate polyester thwart and metalized laminate.[33]

Types of transdermal patches

- Single-layer drug-in-adhesive.
- Multi-layer drug-in-adhesive
- Supply.
- Matrix.
- Vapor fix.

Single-layer Drug-in-Adhesive: The reality that the pharmaceutical is coordinates specifically into the skin-contacting cement sets it separated. This transdermal framework plan employments an cement that serves as both the establishment for the definition and a instrument of skin connection, keeping the medicine and all excipients contained in a single backing film. The speed at which the sedate diffuses through the skin influences the medication discharge rate of this kind of device.[35,36]

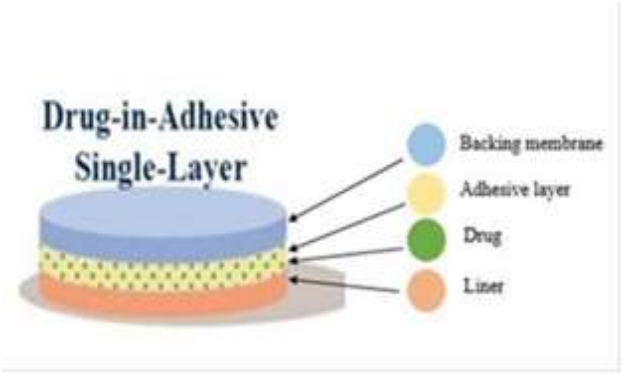


Fig: Single layer patch.

The Multi-layer Drug-in-Adhesive: Since the medicine is blended right into the cement, it is comparable to the Single-layer Drug-in-Adhesive. The term "multi-layer" portrays the addition of different drug-in-adhesive layers or a film between two particular drug-in-adhesive layers that are situated underneath a single backing film.[35,36]

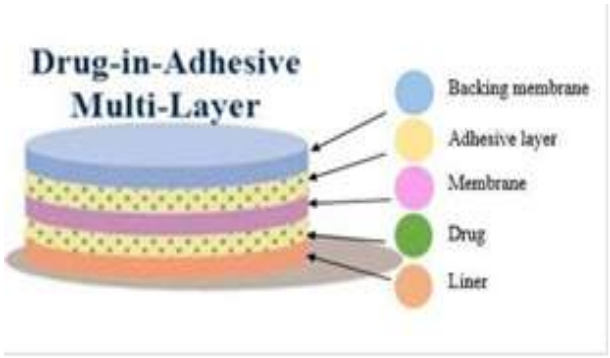


Fig: Multilayer fix.

Drug Reservoir-in-Adhesive: It is recognized by the nearness of a fluid compartment with a pharmaceutical arrangement or suspension that is kept separated from the discharge liner by an cement and semi-permeable layer. The cement component of the item that is in charge of skin connection can be included in either a concentric plan encompassing the film or a nonstop layer between the layer and the discharge liner.[35,36]

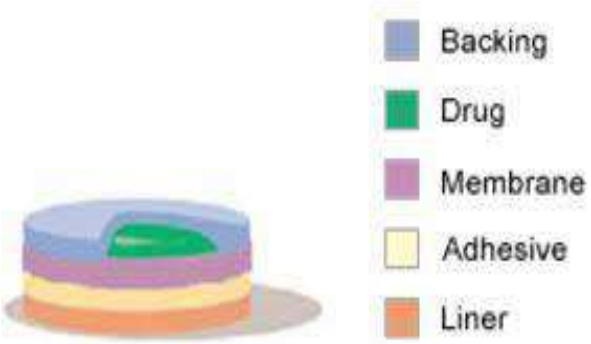


Fig: Store patch.

Drug Matrix-in-Adhesive: The component in charge of skin adherence is included in an overlay and shapes a concentric arrangement around the semisolid lattice. It is recognized by the incorporation of a semisolid lattice holding a sedate arrangement or suspension that is in coordinate contact with the discharge liner.[35,36]

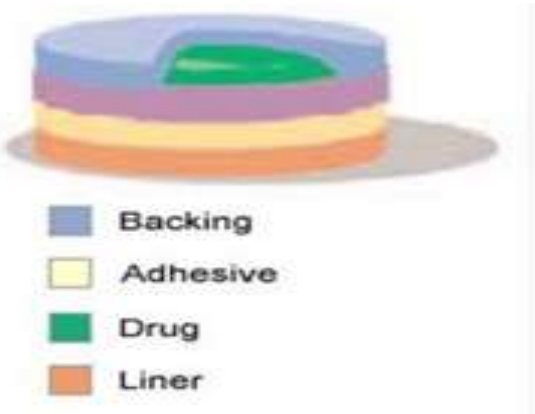


Fig: Framework patch.

Vapour patch: This type of patch has an adhesive layer that not only holds the layers together but also releases vapour. Vapour patches, which release essential oils for up to six hours, are relatively new to the market. They are primarily used to treat decongestion cases. Controller vapour patches, which improve sleep quality, are available as alternatives. Vapour patches that can reduce the number of cigarettes a person smokes each month are also available.[37]

Factors affecting transdermal drug delivery system

Physicochemical properties affecting the penetration of molecules

Partition coefficient: An ideal partition coefficient (K) is essential for efficient action, and it can be chemically changed without changing the drug's pharmacological effectiveness. Generally speaking, a lipid/water partition coefficient of 1 or above is required.[38,40]

pH condition: Acidic and basic medications' rates of absorption are largely influenced by pH, with the drug's unaltered form showing superior penetration.[42] The pH of skin normally falls between 4 and 6.[40] There is a noticeable pH dependence in the movement of ionisable species from aqueous solutions.[43]

Penetrant concentration: When the concentration of dissolved drug increases, the flux increases proportionately, assuming membrane-related transport. Concentrations surpassing solubility levels allow excess solid drug to act as a reservoir, maintaining a constant drug constitution for an extended period.[38,44]

Molecular Weight & Size: Drugs with a higher molecular weight have less penetration. The permeability of smaller particles is higher than that of larger ones. Percutaneous transport may be hampered by drug molecules larger than 500 daltons; generally speaking, higher molecular weight results in less absorption.[40,41]

Solubility: Drugs are either hydrophilic or lipophilic, and the partition coefficient determines whether the drug is soluble or diffuses in lipid and aqueous systems. Drugs that are both soluble in lipid and water can be absorbed through the skin because the skin is a lipid bilayer, which requires some lipid solubility for absorption and hydrophilicity for diffusion in the aqueous environment.[41]

Physicochemical property of drug delivery system

Release characteristics: The release time is determined by the drug's solubility in the dosage form; the drug's interfacial partitioning from the formulation to the skin, the carrier's affinity for the drug, and the drug's solubility in the solvent all affect the drug's release rate.[40,41]

Composition of drug delivery system: Through hydration and interactions with skin lipids, this influences not just the rate of medication release but also the permeability of the skin.[40]

Presence of permeation enhancers: Different types of permeation enhancers temporarily alter the integrity of the skin, allowing absorption through the pores. These enhancers may be physical agents that interact physically with the skin or chemical chemicals that act chemically.[41]

Physiological and Pathological conditions of the skin

Hydration of skin: Increased hydration improves permeant solubility and partitioning, which facilitates drug molecule penetration. Hydration causes the stratum corneum to thicken, giving the skin fluidity.[41]

Skin temperature: By fluidizing lipids and dilatation of blood arteries, elevated skin temperature improves medication absorption by percutaneous absorption.[41,45]

Skin age: Younger and older people are thought to have higher skin permeability than middle-aged people. Because they lack a stratum corneum, premature babies are more vulnerable to the skin-based effects of drugs.[41]

Blood flow: Peripheral circulation changes impact transdermal absorption; higher blood flow modifies the concentration gradient across the skin, lowering the duration of drug molecules' residence in the dermis.[46]

Pathology of the skin: Skin disorders and traumas can change the integrity of the skin by rupturing the stratum corneum's lipid layers, which in turn changes skin penetration.[41]

Regional site of skin: Different percutaneous absorption rates are caused by variations in anatomical characteristics such as sweat gland density per unit area, hair follicles, and stratum corneum thickness.[41]

Skin Flora and Enzymes: Drugs that pass through the skin are broken down by the microorganisms and metabolising enzymes found in the skin. Before entering the bloodstream, the majority of medications go through various stages of metabolism in the skin. For instance, the skin metabolises over 95% of the testosterone that is absorbed.

REFERENCES

1. Jalwal P, Jangra A, Dhaiya L, Sangwan Y, Saroha R. A review on transdermal patches. Pharm Res. J, 2010; 3: 139-149.

2. Duan Y, Chen Y, Li YR, et al. Research progress on the application of microneedle transdermal drug delivery system in dermatology. Life Res, 2022; 5[2]: 15. doi: 10.53388/2022-1203-303
3. Lakunde Sathish Kumar Jyothika, Hindustan Abdul Ahad, Chinthaginjala Haranath, Shaik Kousar, Hothur Dharani pal Gowd, Sampathikota Halima Sadiya. Research Journal of Pharmaceutical Dosage Forms and Technology, 2022; 14[2]: 157-2. doi: 10.52711/0975-4377.2022.00025
4. Mehta R. Topical and transdermal drug delivery: what a pharmacist needs to know. InetCE. Arizona, 2004; 1: 1-10.
5. Arunachalam, A., Karthikeyan, M., Vinay Kumar, D., Prathap, M., Sethuraman, S., Ashutoshkumar, S., & Manidipa, S. Transdermal Drug Delivery System: A Review. Current Pharma Research, 2010; 1[1]: 70.
6. Rastogi, V., & Yadav, P. Transdermal drug delivery system: An overview. Asian Journal of Pharmacy, 2012; 6: 161-170. 10.4103/0973-8398.104828
7. Jeong, W.Y., Kwon, M., Choi, H.E., et al. Recent advances in transdermal drug delivery systems: a review. Biomaterials Research, 2021; 25[1]: 24. https://doi.org/10.1186/s40824-021-00226-6
8. Jain S, Kirar M, Bindeliya M, Sen L, Soni M, Shan M, Purohit A, Jain PK, Novel Drug Delivery Systems: An Overview, Asian Journal of Dental and Health Sciences, 2022; 2[1]: 33-39. D http://dx.doi.org/10.22270/ajdhs.v2i1.14
9. Ramadon, D., McCrudden, M.T.C., Courtenay, A.J. et al. Enhancement strategies for transdermal drug delivery systems: current trends and applications. Drug Deliv. and Transl. Res, 2022; 12: 758–791. https://doi.org/10.1007/s13346-021-00909-6
10. Aundumbar Digambar Mali, Ritesh Bathe and Manojkumar Patil, "An Updated Review of Transdermal Drug Delivery Systems", International Journal of Advances in Scientific Research, 2015; 1(06): 244-254.
11. Anurag Mishra*, Mohd. Aqil Siddiqui, A Overview of the Transdermal Drug Delivery System, Int. J. in Pharm. Sci, 2023; 1[9]: 391-396. https://doi.org/10.5281/zenodo.8363004
12. Zohar Nachum, Avi Shupak, and Carlos Gordon, "Transdermal Scopolamine for Prevention of Motion Sickness", Journal of Clinical Pharmacokinet, 2006; 45(6): 544-566.
13. Mark R. Prausnitz1 & Robert Langer, "Transdermal drug delivery", Nature Biotechnology, 2018; 26(11): 1261-1268.

14. Delly Ramadon et al., "Enhancement Strategies for Transdermal Drug Delivery Systems. Current Trend & Application", Drug Delivery and Translational Research, 2022; 12: 759-791.
15. Hanumanaik et al. "Design, Evaluation and Recent Trends in Transdermal Drug Delivery Systems: A Review", CNS Drugs, 2021; 3(8): 2393-2406. UPSR.
16. Michael N. Pastore, Yogeshvar N. Kalia, Michael Horstmann, and Michael S. Robert, "Transdermal Patches: History, Development, and Pharmacology", British Journal of Pharmacology, 2015; 172: 2179-2209.
17. Bajpai, S., Butola, K., & Bisht, V. Recent Advancement on TDDS [Transdermal Drug Delivery System]. Journal for Research in Applied Sciences and Biotechnology, 2022; 1[5]: 59–67. https://doi.org/10.55544/jrasb.1.5.6
18. Bariya, S. H., Gohel, M. C., Mehta, T. A., & Sharma, O. P. Microneedles: an emerging transdermal drug delivery system. The Journal of pharmacy and pharmacology, 2012; 64[1]: 11–29. doi: 10.1111/j.2042-7158.2011.01369.x
19. Umesh D. Jirole, Dhanashree U. Jirole, Sohel M. Shaikh, Yuvraj P. Shelake, Shreya S. Kadam, Shweta S. Hajare, Abhijeet S. Kulkarni, " Microneedles: A Smart Approach for Transdermal Drug Delivery System", International Journal of Scientific Research in Science and Technology [IJSRST], 2023; 10[1]: 612-623, doi: https://doi.org/10.32628/IJSRST2310165
20. Chavhan, P. G., Patil, A. N., & Patil, S. G. A Review on Transdermal Drug Delivery System. International Journal of Progressive Research in Engineering Management and Science [IJPREMS], 2023; 03[04]: 1077-1087. www.ijprems.com
21. Deependra Singh et al., "Recent Advancesof Transdermal Drug Delivery Systems", Journal of Pharmaceutical Negative Results, 2022; 13: 4452-4459.
22. Khater Ahmed Saeed AL-apairaia, Syed Mahmooda,b, Samah Hamed AlmurisicJayarama Reddy Venugopald, Ayah Rebhi Hillese, Motia Azmanaa, Subashini Ramana. Current trends in polymer microneedle for transdermal drug delivery. International Journal of Pharmaceutics, 2020; 587: 1-14.
23. Patel, Gayatri & Narkhede, Kantilal & Prajapati, Anuradha & Narkhede, Sachin. A Comprehensive Review Article on Transdermal Patch. International Journal of Pharmaceutical Sciences and Medicine, 2023; 8: 77-81. DOI: 10.47760/ijpsm.2023.v08i03.006
24. Ayesha T, Kishore Bandarapalle, Rajasekhar K K, Tholla Bhagyamma, Mohit Ragavendra M R, Pathakota Bhuvan Kumar Reddy, Sindhu P. Transdermal Drug

Delivery System – A Review. Future J. Pharm. Health. Sci, 2023; 3[1]: 52-64. https://doi.org/10.26452/6jphs.v3i1.340

25. Lee H., Song C., Biak S., Kim D., Hyeon T., & Kim D. H. Device-assisted transdermal drug delivery. Advanced drug delivery reviews, 2018; 127: 35-45.
26. Dubey R, Pothuvan U, Transdermal patches: an emerging mode of drug delivery system in pulmonary arterial hypertension, Journal of Drug Delivery and Therapeutics, 2021; 11[4-S]: 176-186. http://dx.doi.org/10.22270/jddt.v11i4-S.4925
27. Butola, K. A Review Article on Transdermal Drug Delivery System Based On-Microneedles. Journal for Research in Applied Sciences and Biotechnology, 2022; 1[3]: 65–76. https://doi.org/10.55544/jrasb.1.3.9
28. Shukla, M.K., Shukla, K., & Srivastava, H. Title of the Article. World Journal of Pharmacy and Pharmaceutical Sciences, 2023; 12[9]: 1250-1261.DOI: 10.20959/wjpps20239-25734
29. Gohil, d., panchal, d., saggu, v., sajan, c., joshi, k., patel, k., & maheshwari, r. "transdermal drug delivery system [tdds]: an overview." in research trends in science and technology, 2023; 1. [ISBN: 978-93-88901-64-2]
30. Kumar, C. A., Ashwini, J., G. L. A., Laxmi, S. V., Garige, A. K., Chandupatla, V., Haque, M. A., & Khan, S. L. Transdermal Patches for the Treatment of Angina Pectoris: An Effective Drug Delivery System - A Review. International Journal of Applied Pharmaceutics, 2022; 14[4]: 115–125. https://doi.org/10.22159/ijap.2022v14i4.44623.
31. Prabhakar, D., Sreekanth, J., & Jayaveera, K. N. Transdermal Drug Delivery Patches: A Review. Journal of Drug Delivery & Therapeutics, 2013; 3[4]: 213-221. http://jddtonline.info
32. Chaithanya, N., Amaravathi, V., Venkatesh, P., Kalarini, D. H., & Prema, R. A Review Article of Transdermal Drug Delivery System [TDDS]. International Journal of Research in Engineering, Science and Management, 2019; 2[11]. www.ijresm.com
33. Lal, N. Transdermal Drug Delivery: Prerequisites and Current Strategies. Stechnolock Pharmacol Ther, 2022; 1: 1-11. www.stechnolock.com
34. Ghadge, R. S. Transdermal Drug Delivery System. Journal of Research in Agriculture and Animal Science, 2022; 9[6]: 31-48. www.questjournals.org
35. Jain.N.K, Controlled and novel drug delivery, first edition, CBS publishers and distributors, New Delhi, 1997.
36. Mathiowitz.Z. E, Chickering, Lehr.C.M, Bio adhesive drug delivery systems; fundamentals, novel approaches and development, Marcel Dekker, Inc. New York. Basel

37. Sharma N, Parashar B, Sharma S, Mahajan U. Blooming Pharma Industry with Transdermal Drug Delivery System. Indo Global J Pharm. Sci, 2012; 2(3): 262-278.
38. Kharat Rekha Sudam, Bathe Ritesh Suresh. A Comprehensive Review on: Transdermal drug delivery systems. International Journal of Biomedical and Advance Research, 2016; 7(4): 147-159.
39. Mohammed Jahid Halder, Dr. Mohammad Wais, Mohammad Anas Khan. Overview of Transdermal Drug Delivery System. International Journal of Scientific Research and Engineering Development, 10(10): 1-7.
40. Jawale N. R., Bhangale C. D., Chaudhari M. A., Dr Deshmukh T. A. Physical Approach to Transdermal Drug Delivery: A Review. Journal of Drug Delivery & Therapeutics, 2017; 7(3): 28-35.
41. Dimpy Jaiswal, Dr. Pushpendra Jain. Recent Updates and Advancement of Transdermal Drug Delivery System. International Journal of Scientific Research in Science, Engineering and Technology, 2023; 10(3): 634-642.
42. Preetam Bala, Sonali Jathar, Sangeeta Kale, Kavita Pal. Transdermal Drug Delivery System (TDDS) - A Multifaceted Approach For Drug Delivery. Journal of Pharmacy Research, 2014; 8(12): 1805-1835.
43. Patel, D. S., Patel, M. V., Patel, K. N., Patel, B. A., Patel, P. A. Transdermal Patches: A Complete Review on Transdermal Drug Delivery System. International Journal for Pharmaceutical Research Scholars, 2012; 1(1).
44. Harneet Marwah, Tarun Garg, Amit K. Goyal, and Goutam Rath. Permeation enhancer strategies in transdermal drug delivery. Drug Delivery, 2016; 23(2): 564–578.
45. Neha Mishra, Pushpendra Jain. A comprehensive review on transdermal patch of ciprofloxacin hydrochloride. International Journal of Advances in Pharmacy Medicine and Bioallied Sciences, 2022; 10(2): 82-87.