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A Painless Drug Delivery System / Transedermal Drug Delivery System

Supekar Rohini K.*, Kawade Kartik D.[1], Mapari Akanksha U.[2], Bhor Vaishnavi R.[3]
Sahakar Maharshi Kisanrao Varal Patil College of Pharmacy, Nighoj
Assistant Professor, Sahakar Maharshi Kisanrao Varal Patil College of Pharmacy, Nighoj

Abstract: *Transdermal drug delivery systems (TDDS) represent an innovative and painless approach for administering therapeutic agents through the skin. Unlike conventional oral or injectable routes, transdermal patches bypass first-pass metabolism, provide controlled and sustained drug release, and enhance patient compliance by reducing pain and discomfort. Various designs, including single-layer, multi-layer, reservoir, and matrix patches, have been developed to optimize drug delivery. While TDDS offer advantages such as improved therapeutic outcomes, convenience, and reduced risk of needle-related complications, they also face limitations including restricted drug applicability, variable skin absorption, and possible skin reactions. Emerging technologies such as microneedles and nanoneedles are revolutionizing this field by improving penetration, precision, and multifunctional capabilities, making them suitable for delivering complex molecules, vaccines, and personalized therapies. Overall, transdermal systems hold great promise in advancing painless drug delivery and improving the quality of patient care in the future*

Keywords: Transdermal drug delivery system (TDDS), Painless drug delivery, Skin patches, Microneedles /Nanoneedles, Patient compliance, Matrix patch, Reservoir patch, Drug bioavailability

I. INTRODUCTION

Drug delivery is always changing, and researchers are looking for new ways to deliver medicines that are easy to use, work well, and don't hurt. Old methods like taking pills or getting shots have problems, like the body breaking down the medicine too fast or causing pain and other issues. (4) Skin patches are sometimes a better choice than pills for taking medicine. They help the medicine stay in your system longer and work better because it's not digested in the same way. Plus, they are easy to use and don't cause pain, making them more comfortable. Using patches on the skin for medicine can be better than pills. Patches help the medicine work well and for a longer time because the body doesn't break it down as quickly. They are also easy to use and don't hurt, making them more comfortable for patients. Patches that stick to the skin can deliver medicine more effectively and for longer periods compared to taking pills, as the body processes it differently. Patients often find them easy to use and more comfortable since they are not invasive. (5) Some medicines don't stay in the body long, which can cause side effects. New delivery systems like skin patches can help. They release medicine slowly and steadily, which makes them work better and reduces side effects. These patches can also avoid breaking down in the liver, making them more effective.

I broke it down into simpler words and phrases, focusing on the main ideas:

Medicines with short half-lives can cause problems
New delivery systems like skin patches can help
Patches release medicine slowly and steadily
This makes them more effective and reduces side effects

Skin patches are a safe way to give medicine, especially for people with liver problems. The skin has a tough outer layer that makes it hard for medicine to get through. To solve this, scientists have developed special technologies like tiny needles, electric currents, and special chemicals to help the medicine get through the skin. Only certain medicines can work well in skin patches they need to be small and able to dissolve in oil. Skin patches are a safe way to deliver medicine.

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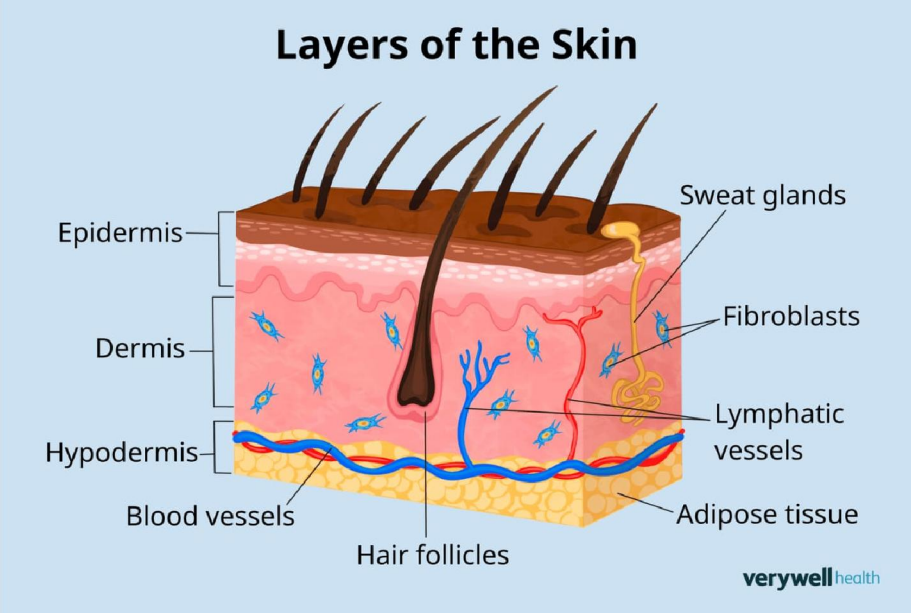
The skin's outer layer is a barrier Special technologies help medicine gets through the skin only certain medicines work well in skin patches. (2)



Transdermal drug delivery (using skin patches) is a popular way to give medicine without using needles. It's helpful for managing pain, hormones, and some diseases. Since the medicine goes through the skin, it doesn't get broken down like it would in the stomach. This means the medicine works better and lasts longer. Plus, it's a painless way to take medicine, making it easier for patients.

Skin patches are a popular way to deliver medicine
They help with pain, hormones, and some diseases
Medicine goes through the skin, avoiding breakdown
It works better and lasts longer
It's a painless way to take medicine (3)

skin and help medicine get in. They're painless and can deliver many kinds of medicine. This technology is promising and could change how medicine is given through the skin. (4)

Advantages:

1. Improved Patient Compliance: Patients are more likely to adhere to treatment regimens when they don't have to experience pain.
2. Reduced Anxiety and Fear: Painless delivery reduces anxiety and fear associated with injections or other painful methods.
3. Increased Safety: Painless delivery methods like transdermal patches or microneedles can reduce the risk of needle-related injuries and infections.
4. Enhanced Therapeutic Effect: Controlled release of medication can lead to more consistent and effective treatment outcomes.
5. Convenience: Painless delivery methods can be self-administered, making it easier for patients to manage their treatment.
6. Reduced Risk of Needle Phobia: Painless delivery methods can be especially beneficial for individuals with needle phobia or trypanophobia
7. Improved Quality of Life: By reducing pain and discomfort, painless delivery methods can improve patients' overall quality of life.

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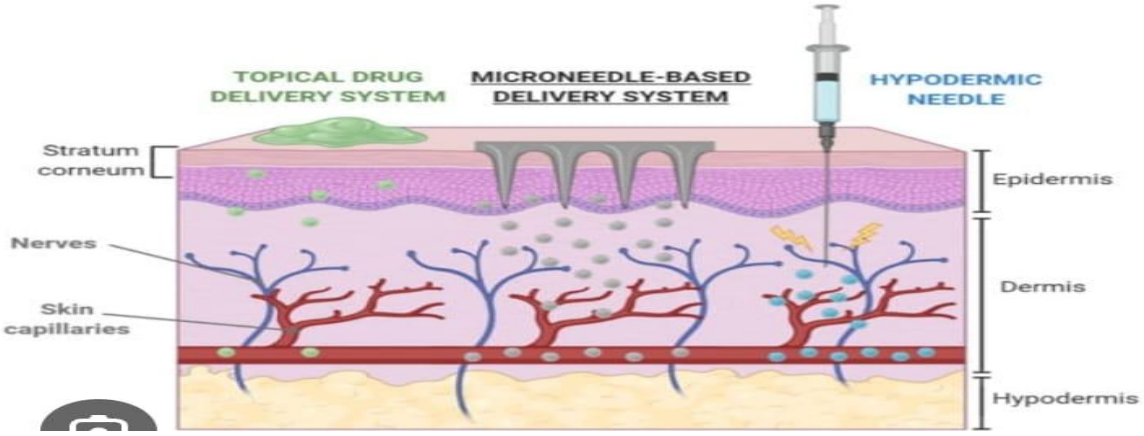
Disadvantages:

1.Limited Drug Range: Not all medications can be delivered through painless methods like transdermal patches or microneedles.

2.Skin Reactions: Some patients may experience skin irritation, redness, or allergic reactions to certain painless delivery systems.

3. Variable Absorption: The rate and extent of drug absorption can vary depending on skin type, location, and other factors.

4. Dose Limitations: Painless delivery systems may have limitations on the amount of medication that can be delivered



Types of transdermal patches:

1) Single layer

Transdermal pharmaceutical formulations entail the application of a discrete layer of therapeutic agents onto the epidermal surface, wherein the layer exhibits cohesive properties, thereby facilitating its adherence to the cutaneous substrate (Al Hanbali et al., 2019). A transdermal patch is comprised of a trilaminate structure, consisting of a backing membrane that provides occlusive properties, a medicated adhesive layer that contains the pharmacological agent, and a protective release liner layer that serves as a barrier to prevent premature exposure to the therapeutic agent.

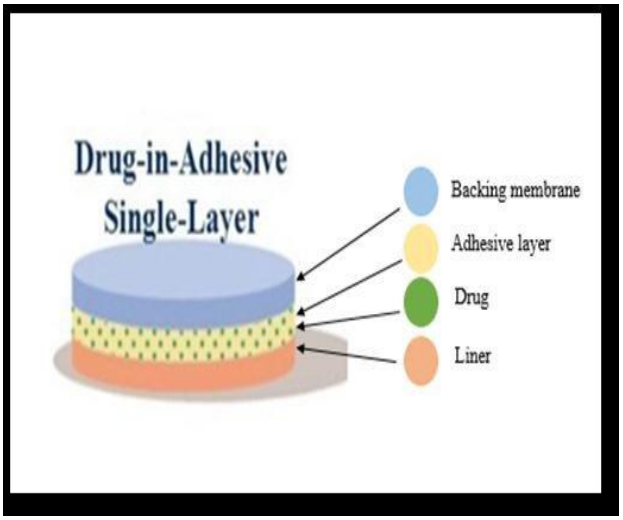


Fig: -Drug-in-Adhesive Single-Layer

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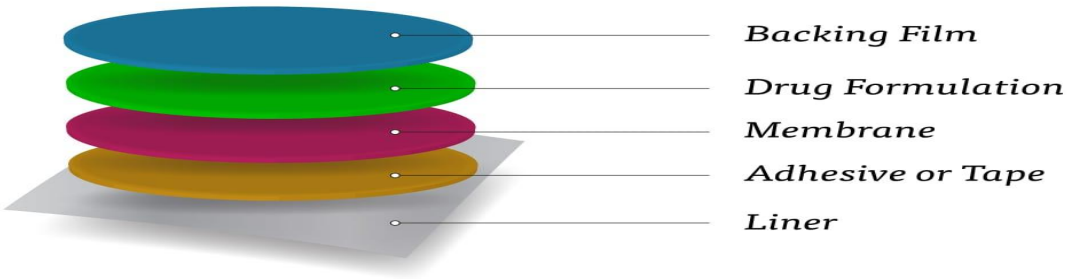
2) Multi-layer:



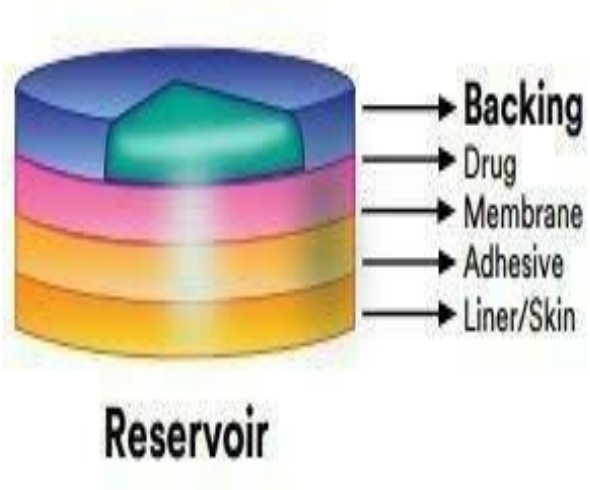
The pharmacological agent is liberated from the transdermal delivery system upon application to the cutaneous surface, typically via a bilayer (albeit not invariably) patch configuration. These transdermal patches comprise a durable backing membrane that provides structural integrity and a removable liner layer that serves as a protective barrier. A paradigmatic transdermal patch is composed of a quintuple-layered structure, consisting of a backing layer that affords mechanical support, an adhesive layer that facilitates patch adhesion, a rate-controlling membrane that regulates drug release, a secondary adhesive layer that enhances cutaneous contact, and a liner membrane that protects the patch from premature exposure.

3) Reservoir: -

The transdermal delivery system comprises a polymeric membrane affixed to a laminated backing substrate, which is encompassed by a molded compartmentalized structure. The diffusional processes occurring across the rate-controlling membrane facilitate the liberation of the pharmacological agent from the transdermal patch, resulting in a zero-order release kinetics, wherein the drug is released at a constant rate, independent of concentration gradients, thereby ensuring a predictable and therapeutic

4) Matrix: -

Transdermal patches fabricated utilizing this methodology are designated as monolithic patches, characterized by a homogeneous distribution of the therapeutic agent.



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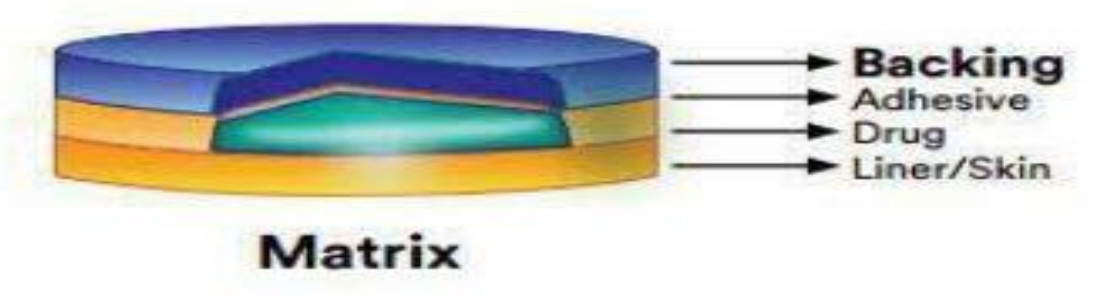
Monolithic patches typically employ drug-containing suspensions or solutions, which are dispersed throughout the matrix. In contrast, matrix patches exhibit a distinct structural configuration, wherein an adhesive layer encapsulates a drug-rich layer, facilitating controlled release of the pharmacological agent through the matrix



FDA APPROVED OTHER TRANSDRMAL SYSTEM.

DRUG	PRODUCT NAME	TDS
Flurandrenolide	Cordran®	Transdermal tape
Testoterone	AndroGel	Transdermal gel
Estradiol	Evamist	Transdermal spray
Fentanyl HCL	IONSYS	Iontophoretic patch
Insulin	Vyteris insulin patch	Iontophoretical patch
hydrocortisone	Tegaderm patch	Electrophotophoresis

Application:

Transdermal drug delivery systems (TDDS) have various applications, including:

1. Pain management: Fentanyl patches for chronic pain relief.
2. Hormone therapy: Estrogen patches for menopause symptoms and testosterone patches for hormone replacement.
3. Cardiovascular diseases: Nitroglycerin patches for angina management.
4. Smoking cessation: Nicotine patches to aid in quitting smoking.
5. Motion sickness: Scopolamine patches to prevent nausea and vomiting.
6. Contraception: Birth control patches that release hormones.
7. Alzheimer's disease: Rivastigmine patches to manage symptoms.
8. Parkinson's disease: Rotigotine patches for motor symptom managment.
9. Nicotine patches for smoking cessation

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Future prospective, Conclusion: -

The future of microneedle-based drug delivery systems is promising, with ongoing research and technological advancements driving innovation. The integration of nanotechnology into these systems, often referred to as "nanoneedles," is particularly exciting. Nanoneedles offer enhanced precision due to their nanoscale dimensions, enabling targeted drug delivery to specific skin layers or even individual cells. They cabe made biocompatible and biodegradable, reducing the risk of adverse reactions and eliminating the need for needle disposal. Researchers are also exploring multifunctional nanoneedles capable of delivering multiple drugs simultaneously, potentially revolutionizing the treatment of complex diseases. Additionally, nanoneedles equipped with sensors or biosensors can monitor physiological parameters or drug levels in real-time, leading to personalized treatment adjustments. They are also finding applications in vaccine delivery, cosmetics, and dermatology. In resourcelimited settings, nanoneedles could provide a cost-effective means of delivering essential medications and vaccines. As nanoneedle technologies mature, we can expect an increase in clinical trials and regulatory approvals, paving the way for a broader range of therapies and empowering patients to manage their treatments conveniently at home. Overall, nanoneedles hold great promise for enhancing drug delivery and improving patient care The versatility of microneedles is another key feature. With various types of microneedles available, including solid, hollow, dissolving, coated, and biodegradable options, researchers and healthcare professionals can tailor drug delivery systems to meet specific needs. This adaptability extends their applicability to a wide range of therapeutic compounds, including proteins and peptides that were previously challenging to deliver through the skin. In conclusion, microneedles represent a painless revolution in transdermal medicine, offering a promising future where patients can receive their medications comfortably and efficiently. As these systems continue to evolve, they hold the potential to transform the way we approach drug administration, ultimately enhancing the quality of life for patients worldwide. The future of microneedle-based drug delivery systems is bright, promising a new era of improved patient care and medical treatments.

REFERENCES

[1]. Rajwant kaur and vimal arora advancemets in microneedle-based drug delivery system:a painless revolution in transdermal medicine ICONN-2023 https://doi.org/10.1051/e3sconf/202450902002 2) OTHMAN A. AL HANBALI1,2*HAJI MUHAMMAD SHOAIB KHAN3MUHAMMAD SARFRAZ4,5MOSAB
[2]. ARAFAT4SHAKEEL JAZ3ABDUL HAMEED31 Transdermal patches: Design and current approachesto painless drug delivery https://doi.org/10.2478/acph-2019-0016
[3]. Chetan Y. Kadam, Ashok Machand, Pratiksha P. Alabade, Prashant P. Narwade, Sumit R. Khand international Journal of Scientific Development and Research (1JSDR) www.jadr.org
[4]. Woo Yeup Jeong+, Mina Kwont, Hye Eun Choit and Ki Su Kim Recent advances in transdermal drug delivery
[5]. Systems: a review Jeong et al. Biomaterials Research https://doi.org/10.1186/s40824-021-00226-5) L. Zhang and S. Mao, Application of quality by design in the current drugdevelopment, As. J. Pharm. Sci. 12 (2017) 1-8; https://doi.org/10.1016/j.ajps.2016.07.0062. M. R. Prausnitz and R. Langer, Transdermal drug delivery, Nat. Biotechnol. 26 (2008) 1261-1268; https://doi.org/10.1038/nbt.15043.
[6]. M. J. Tsai, I. J. Lu, Y. S. Fu, Y.P. Fang, Y. B. Huang and P. C. Wu, Nanocarriers enhance the transdermal bioavailability of resveratrol: In-vitro and in-vivo study, Colloids Surf. B Biointerfaces 148 (2016) 650-656; https://doi.org/10.1016/j.colsurfb. 2016.09.0454.
[7]. A Simon and M. I. Amaro, A. M. Healy, L. M. Cabral and V. P. De Sousa, Comparative evaluation of rivastigmine permeation from a transdermal system in the Franz cell using synthetic membranes and pig ear skin with in vivo-in vitro correlation, Int. J. Pharm. 512 (2016) 234-241; https://doi.org/10.1016/j.ijpharm.2016.08.0525.
[8]. E. M. Pridgen, F. Alexis and O. C. Farokhzad, Polymeric nanoparticle drug delivery technologies for oral delivery applications, Expert Opin. Drug. Deliv. 12 (2015) 1459-1473;
[9]. https://doi.org/10.1517/17425247.2015.10181756.

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International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
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Impact Factor: 7.67

[10]. M. Arafat, Approaches to achieve an oral controlled release drug delivery system using polymers: a recent review, Int. J. Pharm. Pharm. Sci. 7 (2015) 16-21.
[11]. R. Gannu, Y. V. Vishnu, V. Kishan and Y. M. Rao, Development of nitrendipine transdermal patches: in vitro and ex vivo characterization, Curr. Drug Deliv. 4 (2007) 69-76.
[12]. M. Arafat, Bilosomes as a Drug Delivery System, in Thesis, Doctor of Philosophy, University of Otago, NZ,(2012); http://hdl.handle.net/10523/21579.
[13]. M. N. Pastore, Y. N. Kalia, M. Horstmann and M. S Roberts, Transdermal patches: history, development and pharmacology, Br. J. Pharmacol. 172 (2015) 2179-2209; https://doi.org/10.1111/bph.13059
[14]. S. Chun and H. S. Song, J. Pharmacopuncture 24, 182 (2021)23. M. K. Hossain, T. Ahmed, P. Bhusal, R. K. Subedi, I. Salahshoori, M. Soltani, and M. Hassanzadeganroudsari, Expert Rev. Vaccines 19, 1153 (2020)24. F. Tasca, C. Tortolini, P. Bollella, and R. Antiochia, Curr. Opin. Electrochem. 16, 42 (2019)25.
[15]. Y. Zhang, K. Brown, K. Siebenaler, A. Determan, D. Dohmeier, and K. Hansen, Pharm, Res. 29, 170 (2012) 14. S. Fakhraei Lahiji, S. H. Seo, S. Kim, M. Dangol, J. Shim, C. G. Li, Y. Ma, C. Lee, G. Kang, H. Yang, K. Y. Choi, and H. Jung, Biomaterials 167, 69 (2018)
[16]. G. R. Ahn, J. M. Kim, S. J. Park, K. Li, and B. J. Kim, Lasers Surg. Med. 52, 396 (2020)28. E. Caffarel-Salvador, S. Kim, V. Soares, R. Y. Tian, S. R. Stern, D. Minahan, R. Yona, X. Lu, F. R. Zakaria, J. Collins, J. Wainer, J. Wong, R. McManus, S. Tamang, S. McDonnell, K. Ishida, A. Hayward, X. Liu, F. Hubálek, J. Fels, A. Vegge, M. R. Frederiksen, U. Rahbek, T. Yoshitake, J. Fujimoto, N. Roxhed, R. Langer, and G. Traverso, Sci. Adv. 7, 1 (2021)
[17]. Y. Ma, S. E. Boese, Z. Luo, N. Nitin, and H. S. Gill, (2015)30. G. L. Stein, A. M. Cupito, J. L. Mendez, J. Prandoni, N. Huq, D. Westerberg, K. Corona, B. Campos, C. Chen, Y. Bei, M. Germän, N. A. Gonzales, L. Dumka, Cho, Traber & Atkinson, M. G. T. And J. F. S. Wager, A. M. DiBello, R. Gonzales, C. M. Young, L. M. Rodriguez, C. Neighbors, A. J. Romero, M. Ruiz, S. J. Schwartz, G. L Stein, L. M. Gonzalez, A. M. Cupito, L. Kiang, and A. J. Supple, Physiol. Behav. 23, 1 (2007)
[18]. X. Zhang, Y. Wang, J. Chi, and Y. Zhao, 2020, (2020)32. A. S. P. Lin and M. R. Prausnitz, 28, 166 (2012) 18. R. Girdhari, G. R. Devi, T. V. Suresh, G. Prashant, V. Venkata, and V. Krishna, Drug Dev. Ind. Pharm. 0, (2020)
[19]. P. Bora, L. Kumar, and A. K. Bansal, (2008)35. H. Jeong, J. Kim, S. Kim, and J. Park, Eur. J. Pharm. Biopharm. (2018)
[20]. S. Liu, D. C. Yeo, C. Wiraja, H. Liang, M. Mrksich, and C. Xu, 258 (2017)37. M. Kirkby, A. R. J. Hutton, and R. F. Donnelly, Pharm. Res. 37, (2020)
[21]. T. T. Nguyen, T. T. D. Nguyen, N. M. A. Tran, and G. Van Vo, Biomed. Pharmacother. 145, 112393 (2022)39. J. W. Lee and M. R. Prausnitz, Expert Opin. Drug Deliv. 15, 541 (2018)40. G. Ma and C. Wu, J. Control. Release 251, 11 (2017)
[22]. R. F. Donnelly, T. R. Raj Singh, and A. D. Woolfson, Drug Deliv. 17, 187 (2010)42. R. Kaur, S. Arora, and M. Goswami, Mater. Today Proc. (2022)
[23]. R. F. Donnelly, M. J. Garland, K. Migalska, T. Mazlelaa, T. Mahmood, T. Raghu, R. Singh, and A. D. Woolfson, Expert Rev. Med. Devices 8, 459 (2011)
[24]. K. J. Lee, S. S. Jeong, D. H. Roh, D. Y. Kim, H. K. Choi, and E. H. Lee, Int. J. Pharm. 573, 118778 (2020)
[25]. Li Y, Guo L, Lu W. Laser ablation-enhanced transdermal drug delivery. Photonics Lasers Med. 2013;2(4):315-22.
[26]. Szunerits S, Boukherroub R. Heat: a highly efficient skin enhancer fortransdermal drug delivery. Front Bioeng Biotechnol. 2018;6:15.https://doi.org/10.3389/fbioe.2018.00015.
[27]. Parhi R, Mandru A. Enhancement of skin permeability with thermal ablationtechniques: concept to commercial products. Drug Delivery Translat Res. 2021;11:817-41.
[28]. Babaie S, Del Bakhshayesh AR, Ha JW, Hamishehkar H. Invasome: A novelnanocarrier for Transdermal drug delivery. Nanomaterials.2020;10(2):341.https://doi.org/10.3390/nano10020341.

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[29]. Palac Z, Engesland A, Flaten GE, Škalko-Basnet N, Filipović-Grčić J, Vanić Ž.Liposomes for (trans) dermal drug delivery: the skin-PVPA as a novel in vitrostratum corneum model inFormulation development. J Liposome Res. 2014;24(4):313-22.https://doi.org/10.3109/08982104.2014.899368.

[30]. Rajan R, Jose S, Mukund VP, Vasudevan DT. Transferosomes-a vesiculartransdermal delivery system for enhanced drug permeation. J Adv Pharm Technol Res. 2011;2(3):138-29. https://doi.org/10.4103/2231-4040.85524.63.

[31]. Zhang Z, Liu Y, Chen Y, Li L, Lan P, He D, etAl. Transdermal delivery of 5-aminolevulinic acid by nanoethosome gels for photodynamic therapy ofhypertrophic scars. ACS Appl Mater Interfaces. 2019;11(4):3704-14https://doi.org/10.1021/acsami.8b17498.

[32]. Stanekzai A, Sudhakar CK, Zhakfar AM, Karan VS. Recent approaches intransdermal drug delivery system. Res J Pharm Tech. 2019;12(9):4550-8.https://doi.org/10.5958/0974-360X.2019.00783.2.

[33]. Hadgraft J, Lane ME. Passive transdermal drug delivery systems. Am J Drug Deliv. 2006:4(3):153-60. https://doi.org/10.2165/00137696-200604030-00003