JOURNAL OF HEALTH PHARMA AND LIFE SCIENCES

Article Received on 12th July 2025,
Accepted on 18th September 2025,
Published on 30th September 2025

Journal of Health Pharma and Life Sciences
Available on: http://jhpls.in DOI:10.46647/smhtvm53 Volume: 01 Issue: 01, September, 2025

TRANSDERMAL DRUG DELIVERY SYSTEM IN ADVANCED TECHNOLOGY

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Abstract

Overview of transdermal drug delivery (TDDS), its advantages, challenges, and recent advanced technologies such as microneedles, nanoparticles, iontophoresis, and smart patches. The transdermal drug delivery systems, also known as TDDS, are the most effective alternative to the oral and parenteral routes to deliver therapeutic molecules across the skin in order to produce systemic effects. TDDS possess several benefits such as self-administrable nature, escape of first-pass metabolism, minimize dose, less side effects, better dosage regimen, termination of dosing at any time, absence of gastric irritation, and improved patient compliance. In the earlier scenario, TDDS was indicated only for the transdermal patches. These patches include matrix devices, reservoir type, micro-reservoir forms, and adhesive controlled systems. In the present situation, various state of the art technologies were introduced in advancing TDDS utilization. For passive drug delivery, nanovesicles, polymeric nanocarriers adhesive-controlled and nanoemulsions were implemented.

Introduction

The skin provides a large, accessible surface for drug delivery. TDDS avoids first-pass metabolism, improves patient compliance, and maintains steady drug levels. Limitations include the skin barrier (stratum corneum), restricting drug penetration.

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➢ **Solid Microneedles:** Used to create temporary pores, followed by the application of a drug-containing patch or formulation.

➢ **Coated Microneedles:** The drug is coated on the surface of the needles, which dissolves rapidly upon insertion into the skin.

➢ **Dissolving Microneedles:** Made of drug-loaded polymers that dissolve within the skin, releasing the encapsulated therapeutic agent.

➢ **Hollow Microneedles:** Function like miniature hypodermic needles, allowing for the direct infusion of liquid drug formulations.

Materials and Methods

This review is based on published research articles from journals, books, and databases. Keywords: "Transdermal Drug Delivery," "Microneedles," "Nanoparticles," "Iontophoresis." Relevant studies were selected and analyzed to highlight recent advances.

Results

Microneedles: Solid, coated, dissolving, hollow; painless and effective.

Nanoparticles: Liposomes, ethosomes, SLNs, NLCs improve solubility and penetration.

Active methods: Iontophoresis (electrical current), Sonophoresis (ultrasound).

Smart patches: AI/IoT-enabled, responsive to physiological signals.

Overall, advanced TDDS improves penetration, provides controlled release, and enhances patient comfort.

Acknowledgement

The author expresses gratitude to Dr. B.V. Ramana (Guide) and Dr. K.V. Subba Reddy Institute of Pharmacy for guidance and support.

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AND LIFE SCIENCES

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Available on: http://jhpls.in **DOI:10.46647/smhtvm53** **Volume: 01 Issue: 01, September, 2025**

Conclusion

TDDS has evolved from simple patches to advanced systems integrating nanotechnology and smart devices. It offers safe, effective, and patient-friendly drug delivery with future potential in personalized medicine.

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