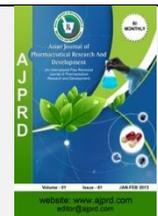


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Review Article

A Review on Transdermal Drug Delivery System

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ABSTRACT

Transdermal patches are designed to deliver drugs across the skin membrane without causing pain. This method of drug delivery, known as transdermal delivery, was first used in 1981 when Ciba-Geigy marketed Transdermal V (now marketed as Transderm Scop) to prevent nausea and vomiting associated with motion sickness. Transdermal patches are pharmaceutical preparations of varying sizes, containing one or more active ingredients, which are applied to unbroken skin to deliver the active ingredient after passing through the skin barriers, thus avoiding first-pass metabolism. Today, about 74% of drugs are taken orally and often prove ineffective. To improve drug efficacy, transdermal drug delivery systems have emerged. The main objective of these systems is to deliver drugs into systemic circulation through the skin at a predetermined rate with minimal inter- and intra-patient variations.

Keywords: Transdermal Drug delivery system, Patch, Systemic circulation, Topical administration, Permeation mechanism.

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INTRODUCTION:

Transdermal drug delivery is a painless technique of administering drugs through the skin. The drug enters the skin layers without accumulation in the dermal layer.⁽¹⁾ This method has been in use since the 10th century and has become one of the most reliable and effective drug delivery systems. In the 1980s and 90s, the technology generated excitement and interest among major pharmaceutical companies. Transdermal patches are topically applied medications that release drugs at a controlled rate.⁴ In the past, creams and ointments were commonly used for dermatological disorders. However, the development of novel delivery mechanisms for existing therapeutic molecules has increased patient compliance and overall therapeutic benefit to a significant extent. Such dosage forms have been modified to enhance drug diffusion and skin permeability, resulting in improved bioavailability, more uniform plasma levels, longer duration of action, reduced dosing frequency and side effects, and improved therapy due to maintenance of plasma levels up to the end of the dosing interval compared to conventional oral dosage forms. In recent times, dosage forms have been improved to enhance

the diffusion of drugs and increase skin permeability. There has been renewed interest in developing new delivery systems for existing drug molecules that improve efficacy, safety, patient compliance, and overall therapeutic benefits. These systems enhance bioavailability, result in more uniform plasma levels, and longer duration of action. As a result, dosing frequency is reduced, side effects are minimized, and therapy is improved.^(1,2)

Transdermal Drug Delivery Systems (TDDS) are self-contained, distinct dosage forms also known as "patches." These patches are applied to the skin to deliver the drug at a controlled rate to the systemic circulation. TDDS delivers a therapeutically effective amount of drug across a patient's skin.⁽³⁾ The FDA approved the first transdermal system, Transderm SCOP, in 1979 for preventing nausea and vomiting that occur while travelling. Most transdermal patches are designed to release the active ingredient at a zero-order rate for several hours to days after application to the skin. This is particularly useful for prophylactic therapy in chronic conditions. The evidence of drug absorption through the skin can be found by measuring the blood levels of the drug, detecting its excretion and metabolites in urine,

and observing the clinical response of the patient to the administered drug therapy⁽⁴⁾

Transdermal patches definition: Transdermal drug delivery system avoids gastrointestinal drug absorption difficulties covered by gastrointestinal pH, enzymatic activity and other orally administration of drug.⁽⁵⁾

ADVANTAGES:

1. Avoidance of first pass metabolism.
2. Avoidance of gastrointestinal incompatibility.
3. Minimizing undesirable side effects.
4. Avoiding in drug fluctuation drug levels.
5. Inter and intra patient variation
6. Provide suitability for self-administration.
7. Provide utilization of drug with short biological half-lives, narrow therapeutic window.
8. It is of great advantages in patients who are nauseated or unconscious
9. Dose frequency can be reduced.
10. Drug concentration can be reduced due to improved bioavailability.
11. First pass metabolism by liver can be escaped
12. Self-administration is possible with these systems
13. It reduces systemic drug interaction
14. It offers longer duration of action⁽⁸⁾

DISADVANTAGES:

1. Transdermal drug delivery system cannot deliver ionic drugs.
2. It cannot achieve high drug levels in blood.
3. It cannot develop for drugs of large molecular size
4. May cause allergic reaction
5. Long time adherence is difficult.
6. Suitable for Drugs with lesser molecular weight i.e., less than 500 Daltons
7. Only potent drugs are suitable for transdermal delivery.
8. Skin irritation may occur in some patient at the site of application
9. This system is uneconomic
10. Binding of the drug to the skin may cause dose dumping
11. Therapeutic efficacy of the medicament can be affected by Cutaneous metabolism
12. Suitable for Drugs with lesser molecular weight i.e., less than 500 Daltons⁽⁹⁾

ANATOMY AND PHYSIOLOGY OF SKIN: [Figure 1]

The skin is the largest organ of the body, covering an average area of 2 square meters in an adult human. It consists of multiple layers and receives approximately one-third of the body's circulating blood. Despite being only, a millimeter thick, the skin acts as a barrier, separating the body's internal circulation network from the external environment.⁽¹⁰⁾

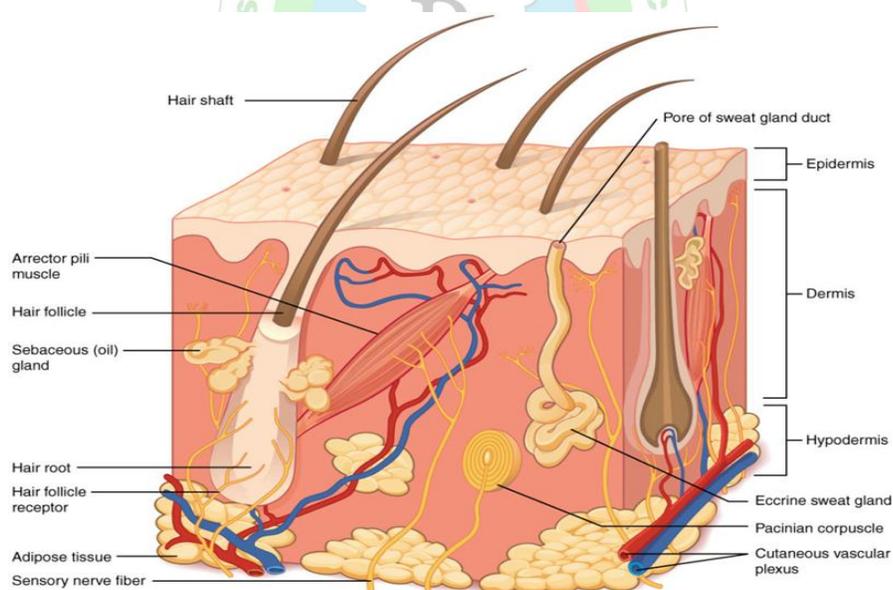


Figure 1: Structure of Human Skin⁽⁹⁾

Epidermis:

The thickness of the multi-layered epidermis varies depending on the size and number of cell layers, ranging from 0.8 mm on the palms and soles down to 0.06 mm on the eyelids. The epidermis consists of an outer stratum corneum and a viable epidermis.

Stratum corneum (Horney layer):

The outer layer of our skin, known as the horny layer, is usually about 10 μm thick when dry. However, it can swell

to several times its thickness when fully hydrated. This layer is made up of 10 to 30 layers of dead cells called corneocytes. Medicine molecules can penetrate the stratum corneum in three different ways depending on their physicochemical properties. Both hydrophilic and lipophilic drugs can be absorbed through the skin via various pathways.

- **Transcellular route**
- **Intercellular route**

• Trans follicular route

Viable epidermis:

The epidermis is the outermost layer of the skin and its thickness varies from 0.06 mm on the eyelids to 0.8 mm on the palms. It consists of several layers including the stratum granulosum, stratum lucidum, stratum spinosum, and the stratum basal. The basal layer is responsible for constantly reproducing the epidermis through mitosis divisions of the cells. This process compensates for the loss of dead horny cells from the skin's surface.

Dermis:

The dermis is a layer of skin that is typically 3 to 5mm thick. It consists of a matrix of connective tissue containing blood vessels, lymph vessels, and nerves. The blood supply in the dermis is essential for regulating body temperature. Additionally, it helps remove pollutants and waste while providing the skin with oxygen and nutrition. Molecules that penetrate the skin typically sink into capillaries located 0.2 mm below the skin's surface. Therefore, the blood supply helps to maintain a low concentration of a permeant in the dermis, and the concentration gradient across the epidermis plays a crucial role in transdermal penetration.

Hypodermis:

The skin is made up of two layers: the dermis and epidermis. These layers are supported by a layer of subcutaneous fat tissue called the hypodermis. The hypodermis serves as a storage place for fat, provides nutrients, offers mechanical protection, and helps regulate body temperature. It also connects the skin to the body's major blood vessels and nerves, and may contain pressure-detecting organs.

TECHNOLOGY FOR DEVELOPING TRANSDERMAL DRUG DELIVERY SYSTEM

A. Membranepemeation-controlled system:

B. Matrixdiffusion-controlled system

C. Adhesive dispersion type system

D. Micro reservoirtype-controlled system

A. Membranepemeation-controlled system:

This system consists of a drug reservoir that is completely enclosed in a compartment formed between a drug-impermeable backing laminate and a rate-controlling polymeric membrane. The drug molecules are allowed to be released through the rate-controlling membrane via a diffusion process through the pores. In the reservoir compartments, the drug solids are uniformly distributed in a solid polymeric matrix (such as polyisobutylene) suspended in an unreachable viscous liquid medium (such as silicon fluid) to create a gel-like suspension. Alternatively, they can be dissolved in a releasable solvent (such as an alkyl alcohol) to form a gel-like solution. The rate-controlling membrane can be made of either a microporous or non-porous polymeric membrane (such as ethylene-vinyl acetate copolymer) with specific drug permeability. On the top surface of the polymeric membrane, a thin layer of drug-compatible adhesive polymer (such as silicone adhesives) can be applied to ensure close contact of the transdermal

system with the skin surface. The release rate from this transdermal system can be adjusted by varying the polymer composition, thickness of the rate-controlling membrane, permeability coefficient, and adhesive. Examples of this system are TransdermScop (providing 3-day protection against motion sickness) and TransdermNitro (a once-a-day medication for angina pectoris).⁽¹⁰⁾

B. Matrixdiffusion-controlled system:

In this method, drug particles are evenly distributed in a polymer matrix that is either hydrophilic lipophilic, or a combination of both. This creates drug reservoirs. The polymer mixture is then shaped into a disc with a specific thickness and surface area. To disperse the drug particles in the polymer matrix, they can be mixed with a liquid polymer or a highly viscous base polymer, followed by cross-linking the polymer chains. Alternatively, the drug particles can be blended with a rubbery polymer at a high temperature and/or under vacuum.

The polymer disc, which contains the drug reservoir, is then attached to an occlusive base plate in a compartment made of a drug-impermeable backing. Then, an adhesive polymer is applied to create a strip of rim around the medicated disc. This type of transdermal system, known as a matrix dispersion type, is the best example of a nitroglycerin-releasing therapeutic system. The advantage of this system is that the polymer cannot rupture, preventing any dose dumping.⁽¹⁰⁾

C. Adhesive dispersion type system:

The drug delivery system is composed of a backing membrane that does not allow drugs to pass through, a drug reservoir made by dispersing the drug in an adhesive polymer and then spreading the medicated adhesive onto a flat sheet of drug-impermeable backing, which forms a thin drug reservoir layer. A layer of rate-controlling adhesive polymer (non-medicated) of constant thickness is spread on top of this to create an adhesive diffusion-controlled drug delivery system with a detachable release liner that is removed before applying the patch to the skin for a specific duration. An example of this type of system is the transdermal therapeutic system for angina pectoris and Valsartan, which is an angiotensin II type 1 selective blocker for one-day medication.⁽¹⁰⁾

D. Micro reservoir type-controlled system:

This system is a hybrid of reservoir and matrix-dispersion type of drug delivery system. In this approach, a drug reservoir is formed by suspending the drug in an aqueous solution of liquid polymer and then dispersing the drug suspension homogeneously in a lipophilic polymer e.g. silicone elastomers by high energy dispersion technique by shear mechanical force to form thousands of unreachable, and microscopic spheres of drug reservoirs. This technology has been utilized in the development of the Nitro disc. Release of a drug from a micro reservoir-type system can follow either a partition control or a matrix diffusion control depending upon the relative magnitude of solubility of the drug in the liquid compartment and the polymer matrix.

Example: Nitro disc system for angina pectoris

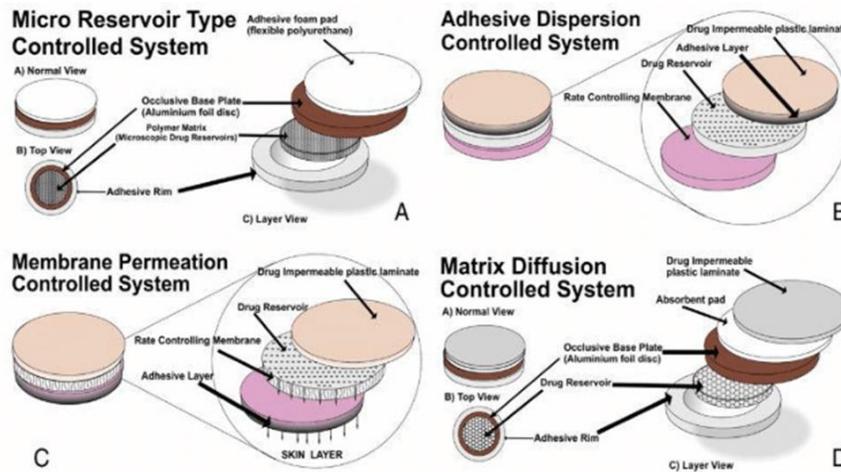


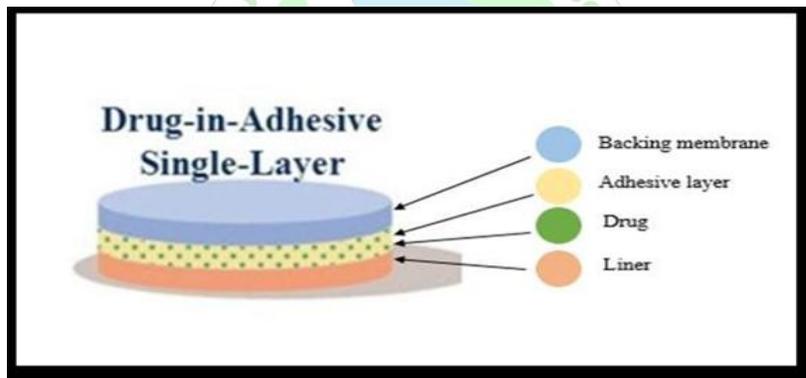
Figure1: Transdermal Drug Delivery System ⁽³⁵⁾

A. Types of transdermal patches

- a) Single-layer drug-in-adhesive.
- b) Multi-layer drug-in-adhesive.
- c) Reservoir.
- d) Matrix.
- e) Vapour patch.

a. Single-layer Drug-in-Adhesive:

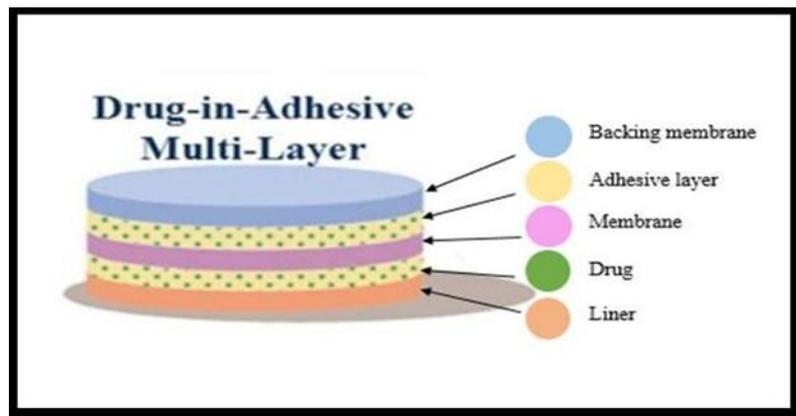
The transdermal system design is unique as it incorporates the medicine directly into the skin-contacting adhesive. The adhesive serves as the basis for the formulation and holds the medicine along with all the excipients in a single backing film. Additionally, it serves as a means of attaching the system to the skin. The rate at which the medication is released in this type of system depends on how quickly the drug diffuses through the skin ⁽¹¹⁾



b. The Multi-layer Drug-in-Adhesive:

The Multi-layer Drug-in-Adhesive is a type of drug delivery system that consists of either a membrane or multiple drug-in-adhesive layers positioned between two separate drug-in-

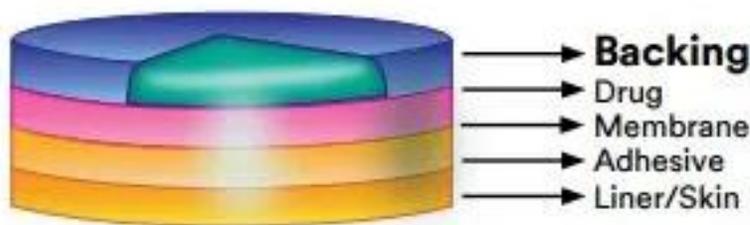
adhesive layers, all of which are placed under a single backing film. This system is similar to the Single-layer Drug-in-Adhesive, in which the drug is directly incorporated into the adhesive. ⁽¹²⁾



c. Drug Reservoir-in-Adhesive:

The product is composed of a liquid compartment that contains a solution or suspension of a drug. This compartment is separated from the release liner by a semi-

permeable membrane and adhesive. The adhesive component of the product responsible for skin attachment can be a continuous layer between the membrane and the release liner, or a concentric design surrounding the membrane.⁽¹²⁾

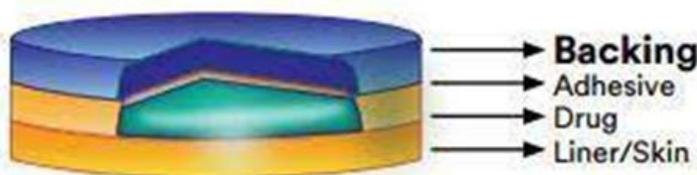


Reservoir

d. Drug Matrix-in-Adhesive:

The product comprises a semisolid matrix that contains a drug solution or suspension. This matrix is in direct contact

with the release liner. The overlay, which is responsible for skin adhesion, is incorporated and forms a concentric configuration around the semisolid matrix.



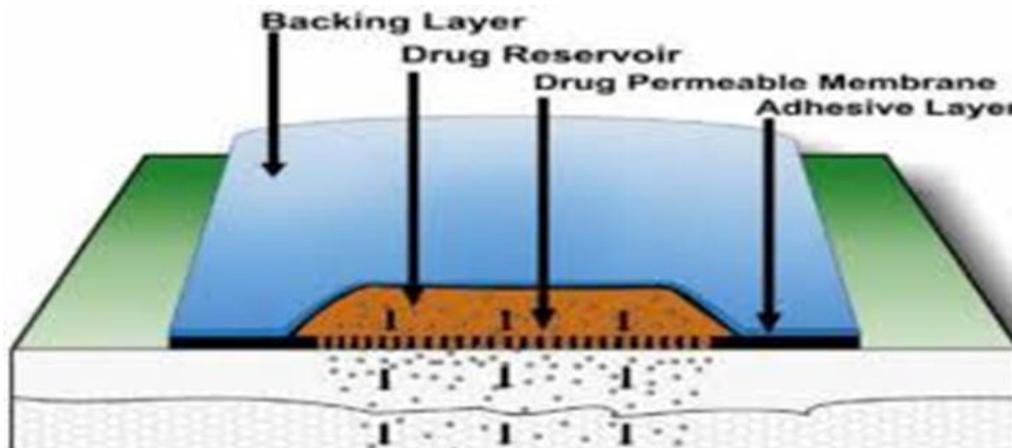
Matrix

BASIC COMPONENTS OF TRANSDERMAL DRUG DELIVERY SYSTEM: ^[13,14]

The components of transdermal drug delivery system include:

1. Drug substance

- 2. Polymer matrix
- 3. Penetration enhancers
- 4. Pressure sensitive adhesive
- 5. Backing membrane
- 6. Release liner



1. Drug substance: [Table 1]

IDEAL PROPWRITIES:

Parameter	Properties
Dose	Less than 20 mg/day
Molecular weight	Less than 1000 Dalton
Melting point	Less than 200°C
Half life	Less than 10 hours
Shelf life	Up to 2 years
Partition coefficient	1 to 4
Aqueous solubility	Greater than 1mg/mL
pH of the aqueous saturated solution	5-9
Skin permeability coefficient	Greater than $0.5 \times 10^{-3} \text{cm/h}$
Skin reaction	Non irritating and non-sensitizing
Oral bioavailability	Low

2. Polymer matrix: [Table 2]

Polymer is an integral and foremost important component of transdermal drug delivery system.

Ideal properties of a polymer to be used in a transdermal system:

- Molecular weight, chemical functionality of the polymer should be such that the specific drug diffuses properly and gets released through it
- The polymer should be stable.
- The polymer should be nontoxic
- The polymer should be easily of manufactured
- The polymer should be inexpensive
- The polymer and its deaggration product must be nontoxic or non-antagonistic to the host.
- Large amounts of the active agent are incorporated into it.

Table 2: Polymers Used for Transdermal Devices

Natural Polymers	Synthetic Polymers	Synthetic Elastomers
1. Cellulose derivatives	Poly vinyl alcohol	Hydrin rubber
2. Gelatine	Poly vinyl chloride	Silicone rubber
3. Waxes	Polyethylene	Polybutadiene
4. Proteins	Polypropylene	Nitrile
5. Gum	Polyamide	Acrylonitrile
6. Shellac	Polyurea	Neoprene
7. Natural rubber	Acetal copolymer	Chloroprene
8. Starch	Polystyrene	Polysiloxane
9. Chitosan	Epoxy	

3. PENETRATION ENHANCERS:

These are compounds that promote the penetration of topically applied drugs and are commonly known as absorption promoters, accelerants, or penetration enhancers.

Ideal properties of penetration enhancers:

- Controlled and reversible enhancing action
- Chemical and physical compatibility with drug and other pharmaceutical excipients
- Should not cause loss of body fluids, electrolytes or other endogenous materials
- Nontoxic, non-allergic, non-irritating
- Pharmacological inertness
- Ability to act specifically for predictable duration
- Odourless, colourless, economical and cosmetically acceptable.

4. Pressure sensitive adhesive:

A Pressure Sensitive Adhesive (PSA) is a material that helps in maintaining an intimate contact between transdermal system and the skin surface.

5. Backing membrane:

The backing laminate plays a crucial role in providing support to the dosage form. Its prime function is to prevent drugs from escaping through the top. To achieve this, it needs to be impermeable to drugs and permeation enhancers. Some commonly used materials for backing laminate are metallic plastic laminate, vinyl polyethylene and polyester films, aluminum foil, and foam pads.

6. Release linear:

Before applying the patch to the skin, it is important to remove the protective liner that covers it during storage. This liner acts as a shield to protect the patch while it is being stored. The release coating layer is made up of either silicon or Teflon.

EVALUATION OF TRANSDERMAL DRUG DELIVERY SYSTEM:

Evaluation studies are more important in order to ensure their desired performance and reproducibility under the specified environmental conditions. These studies are predictive of transdermal dosage form and can be classified into following types:

A) Physicochemical evaluation

- a. *In vitro* evaluation
- b. *In vivo* evaluation

A. Physicochemical Evaluation:

1. Thickness of the patch
2. Uniformity of weight
3. Drug content
4. Content uniformity
5. Determination of surface pH
6. Moisture content
7. Moisture uptake
8. Water vapour permeability (WVP) evaluation
9. Flatness
10. Folding Endurance

Adhesive properties:

- a) Shear adhesion test
- b) Peel adhesion test

Tack properties

- a. Thumb tack test
- b. Rolling ball tack test
- c. Quick-stick (peel tack) test
- d. Probe tack test

B. *In vitro* release studies:

1. Paddle over disc apparatus (USP apparatus 5)
2. Cylinder apparatus (USP apparatus 6)
3. The reciprocating disc (USP apparatus 7)

Thickness:

The thickness of transdermal film is determined by travelling microscope, dial gauge, screw gauge or micrometre at different points of the film.¹²

Uniformity of weight:

Weight variation is studied by individually weighing 10 randomly selected patches and calculating the average weight. The individual weight should not deviate significantly from the average weight.¹²

Drug content determination:

To estimate the amount of drug present in a film, take an accurately weighed portion of the film weighing around 100 mg. Dissolve this portion in a suitable solvent in which the drug is soluble. Keep the solution in a shaker incubator and shake continuously for 24 hours. After 24 hours, sonicate the solution and filter it. Now, measure the drug content in the filtered solution spectrophotometrically by appropriate dilution.

Content uniformity test:

To ensure the quality of transdermal patches, a content uniformity test is carried out. In this test, 10 patches are selected and the content of each patch is determined individually. If 9 out of 10 patches have content between 85% to 115% of the specified value and one patch has content not less than 75% to 125% of the specified value, then the patches pass the content uniformity test. However, if 3 patches have content in the range of 75% to 125%, then an additional 20 patches are tested for drug content. If these 20 patches have a range from 85% to 115%, then the transdermal patches pass the test.

Moisture content:

The procedure involves weighing each film and placing it in a desiccator with calcium chloride at room temperature for 24 hours. The films are re-weighed at specified intervals until they reach a constant weight. The percentage of moisture content is then calculated using the following formula.

$$\text{Percentage moisture content} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Final weight}} \times 100$$

Moisture Uptake:

The films are first weighed and then placed inside a desiccator at room temperature for 24 hours. After that, they are taken out and exposed to 84% relative humidity using a

saturated solution of Potassium chloride in another desiccator until a constant weight is achieved. The percentage of moisture uptake is then calculated using the following formula.

$$\text{Percentage moisture uptake} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

Flatness:

It is important for a transdermal patch to have a smooth surface and not become constricted over time. The patch's

flatness can be determined through a flatness study. To conduct this study, one strip is cut from the center and two strips are cut from each side of the patch. The length of each strip is measured and the percent constriction is calculated to

determine the variation in length. A patch with zero percent constriction is considered 100 percent flat. The percent constriction is calculated using the formula:

$$\% \text{ constriction} = (I1 - I2) / I2 \times 100$$

Where:

I1 = initial length of each strip

I2 = final length of each strip

Folding Endurance:

The process of evaluating the folding endurance of a film involves testing its ability to withstand repeated folding under extreme conditions. To determine the folding endurance, the film is repeatedly folded at the same spot until it breaks. The number of times the film can be folded at the same spot without breaking is then recorded as the folding endurance value.

Tensile Strength:

To measure the strength of a polymeric film, corked linear iron plates are placed on either side of it. One end of the film is secured with an iron screen and the other end is attached to a freely movable thread that runs over a pulley. Weights are gradually added to the pan that is connected to the hanging end of the thread. A pointer on the thread measures the elongation of the film. The weight that is just enough to break the film is recorded.

Tack properties:

It is the ability of the polymer to adhere to substrate with little contact pressure. Tack is dependent on molecular weight and composition of polymer as well as on the use of tackifying resins in polymer.³⁰

- **Thumb tack test:**

The force required to remove thumb from adhesive is a measure of tack.

- **Rolling ball test:**

This test involves measurement of the distance that stainless steel ball travels along an upward facing adhesive. The less tacky the adhesive, the further the ball will travel.⁽¹³⁾

- **Quick stick (Peel tack) test:**

The peel force required breaking the bond between an adhesive and substrate is measured by pulling the tape away from the substrate at 90 at the speed of 12 inch/min.¹⁷

Probe tack test:

Force required to pull a probe away from an adhesive at a fixed rate is recorded as tack.⁽¹⁴⁾

In vitro permeation studies: [Figure 10]

In vitro permeation studies can be conducted using a diffusion cell and full-thickness abdominal skin of male Westar rats weighing between 200 to 250 grams. To begin the experiment, hair from the abdominal region should be carefully removed using an electric clipper. The dermal side of the skin must be thoroughly cleaned with distilled water to remove any adhering tissues or blood vessels. The skin should then be equilibrated for an hour in a dissolution medium or phosphate buffer at pH 7.4 before being placed on a magnetic stirrer with a small magnetic needle to ensure a uniform distribution of the diffusion. The temperature of the cell should be maintained at $32 \pm 0.5^\circ\text{C}$ using a thermostatically controlled heater. The isolated rat skin piece should be mounted between the compartments of the diffusion cell, with the epidermis facing upward into the donor compartment. At regular intervals, a sample volume of a definite volume should be removed from the receptor compartment, and an equal volume of fresh medium should be replaced.

In vitro permeation studies can be carried out using diffusion cells. For this, the full-thickness abdominal skin of male Westar rats weighing 200-250g is used. The skin is cleaned and equilibrated before being mounted between the compartments of the diffusion cell. Samples are taken from the receptor compartment at regular intervals and analyzed by spectrophotometry or HPLC. To evaluate transdermal patches, a Franz diffusion cell can be used. The drug content is analyzed using suitable methods, and maintenance of a sink condition is essential.

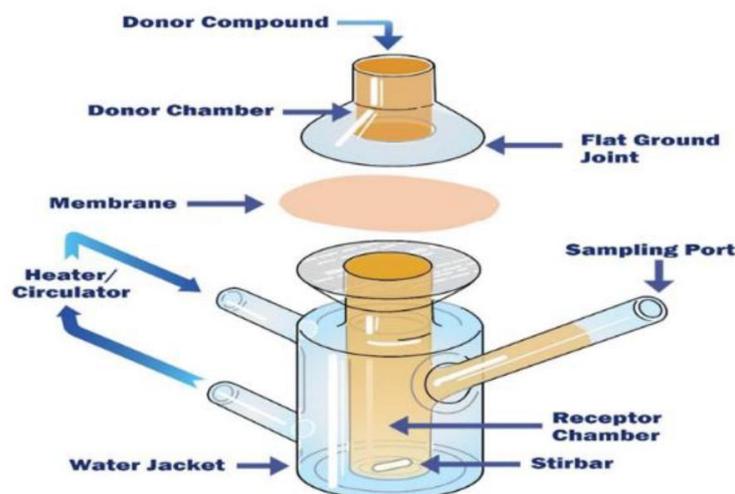


Figure 10: Franz Diffusion Cell

In vivo Studies:

To accurately evaluate the performance of transdermal patches, in vivo evaluations are necessary. These evaluations provide a true representation of how the drug works within a living organism, allowing for the exploration of variables that cannot be accounted for in vitro studies. In vivo evaluations of transdermal drug delivery systems (TDDS) can be conducted using either animal models or human volunteers.

Animal models:

Animal studies are often used to evaluate transdermal drug delivery systems due to the considerable time and resources required for human studies. Mice, rabbits, guinea pigs, hairless rats, hairless dogs, and hairless rhesus monkeys are among the most commonly used animal species for this purpose. Studies have shown that hairless animals are preferred over hairy ones for both in vitro and in vivo experiments. Rhesus monkeys are considered one of the most reliable models for in vivo evaluation of transdermal drug delivery in humans.

Human model:

Developing a transdermal device involves a crucial final step of testing the patch on human volunteers to collect pharmacokinetic and pharmacodynamic data. Clinical trials are carried out to determine its effectiveness, potential risks, and side effects, as well as patient compliance. The safety of the patch on volunteers is determined in phase I trials while phase II trials focus on its effectiveness and short-term

safety in patients. Phase III trials evaluate the safety and effectiveness of the patch on a large number of patients, while phase IV trials are conducted during post-marketing surveillance to detect any adverse drug reactions in the marketed patches. Although human studies require significant resources, they are the best way to evaluate the performance of the drug.

APPLICATIONS OF TRANSDERMAL PATCHES:

Transdermal patches are a type of medication delivery system that releases therapeutic agents through the skin and into the bloodstream. These patches are designed to provide a controlled and continuous release of drugs over some time. Some examples of transdermal patches include:

- Nicotine patches are used to help people quit smoking by releasing nicotine in a controlled manner.
- Transdermal patches containing antihypertensive drugs like clonidine and non-steroidal anti-inflammatory drugs are also available for certain conditions.
- Nitroglycerin patches are used in the treatment of angina pectoris.
- Transdermal agents for attention deficit hyperactivity disorder (ADHD) are also available.
- Selegiline transdermal patches (MAO inhibitors) are used for major depressive disorder.
- Hormone delivery transdermal patches include the contraceptive patch.

Marketed Products of Transdermal Drug Delivery System: ^[15]**Table 3:** Marketed Products of Transdermal Drug Delivery System

Brand Name	Drug	Manufacturer
Alora	Estradiol	TheraTech
Androderm	Testosterone	TheraTech/ GSK
Climaderm	Estradiol	Wyeth-Ayerest
Habitraol	Nicotine	Novartis
E-Trans	Fentanyl	Alza Corporation
Estraderm	Estradiol	Novartis
Nitrodisc	Nitroglycerin	Roberts Pharmaceuticals
TransdermScopR	Scopolamine	Alza/Novartis
NeuproR	Rigotine	UCB and Schwarz Pharma
NuPatch 100	Diclofenac diethylamine	Zydus Cadila
SonoDerm	Insulin	Imarx
Sono prep	Peptides	Sontra Medical corporation
Transderm nitro	Nitroglycerin	Novartis
Nicoderm	Nicotine	GlaxoSmithKline
Oxytrol	Oxybutynin	Watson Pharma

CONCLUSION:

This article provides valuable information on transdermal drug delivery systems. The details of the evaluation process of TDDS are a useful reference for research scientists. Transdermal drug delivery has great potential for delivering both hydrophilic and hydrophobic active substances, making it a promising option for drug delivery. TDDS is a practical application for the next generation of drug delivery systems. Due to its many advantages, new research is being conducted to incorporate newer drugs into the system. Transdermal drug delivery systems offer a beneficial innovation for drug delivery, especially for patients who cannot swallow or remember to take their medications. The controlled release of the drug into the patient enables a steady blood level profile, resulting in reduced systemic side effects and sometimes improved efficacy over other dosage forms. It offers the delivery of drugs at lowered doses, which can save the recipient from the harm of large doses while improving bioavailability. Transdermal patches have become a proven technology that offers a variety of significant clinical benefits over other dosage forms.

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REFERENCES: -

1. Han T, Das DB. Potential of combined ultrasound and microneedles for enhanced transdermal drug permeation: a review. *European Journal of Pharmaceutics and Biopharmaceutics*. 2015 Jan 1; 89:312-28.
2. Schoellhammer CM, Blankschtein D, Langer R. Skin permeabilization for transdermal drug delivery: recent advances and future prospects. *Expert opinion on drug delivery*. 2014 Mar 1;11(3):393-407.
3. Wilkosz MF. *Transdermal Drug Delivery: Part IUS Pharmacist*. Jobson publication. 2003;3(4):28.
4. Sudam KR, Suresh BR. A Comprehensive Review on: Transdermal drug delivery systems. *Int. J. Biomed. Adv. Res.* 2016; 7:147-59.
5. Mujoriya R, Dhamande KA. Review on transdermal drug delivery system. *Res J Sci Tech.* 2011 Oct 28;3(4):227-31.
6. Jalwal P, Jangra A, Dahiya L, Sangwan Y, Saroha R. A review on transdermal patches. *The Pharma Research*. 2010 Jun; 3:139-49.
7. Jalwal P, Jangra A, Dahiya L, Sangwan Y, Saroha R. A review on transdermal patches. *The Pharma Research*. 2010 Jun; 3:139-49.
8. Ramekte KH, Dhole SN, Patil SV. Transdermal drug delivery system: a review. *Journal of Advanced Scientific Research*. 2012 Feb 10;3(01):22-35.
9. Jatav VS, Saggi JS, Sharma AK, Sharma A, Jat RK. Design, development and permeation studies of nebigolol hydrochloride from novel matrix type transdermal patches. *Advanced Biomedical Research*. 2013;2.
10. Kumar JA, Pullakandam N, Prabu SL, Gopal V. Transdermal drug delivery system: an overview. *Int J Pharm Sci Rev Res.* 2010 Jul;3(2):49-54.
11. Ghume VK, Golhar AR, Merekar AN, Dokhe MD, Parjane SK. Transdermal drug delivery system: A review. *Am. J. PharmTech Res.* 2020; 10:34-47.
12. Allen LV, Ansel HC, Popovich NG. Pharmaceutical dosage forms and drug delivery systems. *Evaluation*. 2011; 56:44.
13. Upadhyay G, Verma S, Parvez N, Sharma PK. Recent trends in transdermal drug delivery system-a review. *Advances in biological research*. 2014;8(3):131-8.
14. Keleb E, Sharma RK, Mosa EB, Aljahwi AA. Transdermal drug delivery system-design and evaluation. *International journal of advances in pharmaceutical sciences*. 2010 Jul 1;1(3).
15. Thejaswi C, Rao KM, Gobinath M, Radharani J, Hemafaiith V, Venugopalaiah P. A review on design and characterization of proniosomes as a drug carrier. *IJAPN*. 2011; 1:16-9.