TRANSDERMAL DRUG DELIVERY SYSTEM - AN OVERVIEW

S. HARSHAVARDHAN REDDY[1], V.MANIMARAN[1]*, T.TAMILANBAN[1], J.NARAYANAN[1], K.GAYATHIRI[1]

[1]Department of Pharmaceutics, SRM College of Pharmacy, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, 603203, India

***Address for Correspondence :** V.MANIMARAN, Email: manimarv@srmist.edu.in

ABSTRACT:

Transdermal drug delivery systems (TDDS) have always been a challenging area for research due to the barrier properties exhibited by the outermost layer of the skin's stratum corneum. The transdermal drug delivery system has been shown to be a reliable technology with considerable therapeutic advantages in comparison to all other dosage forms during the last two decades. Transdermal drug administration is able to maintain steady state blood concentration because it provides a regulated and predefined rate of drug release into the patient. When administering pharmacological compounds via the skin, morphological, biological, and physicochemical characteristics are taken into account for systemic effects. This approach offers a more regulated medication release and blood level profile than other dose forms, resulting in fewer side effects. It is a simple and painless procedure for patients. Transdermal drug delivery has made a substantial contribution to clinical practice; it has yet to reach its full potential as a substitute for oral drug delivery and hypodermic injections. The market for TDDS is expected to increase at a rapid pace in the next few years. This highlights the generations of transdermal drug administration in a new era of drug delivery. In this review, we discussed the many types of TDDS, their advantages and limitations, *in-vitro* and *in-vivo* investigations, development, and applications in a variety of disciplines.

KEYWORDS: Transdermal drug delivery system (TDDS), mechanism of transport, iontophoresis, infusion mechanism, route of administration, microneedles.

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INTRODUCTION:

The term "transdermal drug delivery system" refers to topically delivered medication that is applied to the skin at a predetermined and controlled rate. Drugs are taken via different routes, including oral, nasal, parenteral, rectal, intravaginal, ophthalmic, transdermal etc[1]. When compared to other methods, oral administration is the most common and popular, but it has significant downsides such as first-pass metabolism, drug ruin in the gastric system owing to enzymes, pH, etc.

In order to get around the flaws, a novel delivery system (drug) should be developed with a combination of polymers and should release in a controlled and predetermined manner from the polymer matrix[2]. When manufacturing transdermal patches, a specific membrane is employed that is used to regulate the drug's release. This is especially important in liquid medicine patch reservoirs, which can easily penetrate the skin and be followed by blood circulation[3].

It improves drug administration consistency, controlled release, and short half-life, which reduces unwanted side effects. Transdermal patches have been shown to be beneficial in finding new uses for existing therapies as well as decreasing the effects of first-pass metabolism degradation[3].

In 1979, the FDA accepted the first transdermal device, Transdermal SCOP, for the avoidance of travel-related vomiting and nausea.

Most transdermal patches have an active ingredient that releases at a zero-order rate over a few hours to several days after being applied to the skin[4]. It is terribly beneficial as a preventative approach in the treatment of chronic illnesses. Percutaneous drug absorption can be demonstrated using quantifiable blood levels of the medication, obvious drug and metabolite excreted through urine, and the patient's clinical response to the pharmacological therapy[5].

TABLE 1: ADVANTAGES & DISADVANTAGES TRANSDERMAL DRUG DELIVERY SYSTEM

S.no	Advantages	Disadvantages
1	First-pass metabolism to be avoided	Long-time adhere is difficult
2	To avoid issues with gastrointestinal drug absorption and to maintain enzymatic activity, gastrointestinal pH, and other orally administered drugs.	The delivery of ionic drugs is not suitable for TDDS.
3	In order to avoid gastrointestinal incompatibility	It is suitable for potent drugs.
4	Suitable for administering drugs having a short half-life and a small therapeutic range.	It cannot deliver drugs in a pulsatile manner.
5	Parenteral treatment is avoided since it is non-invasive	Long time adhere is difficult

ANATOMY AND PHYSIOLOGY OF SKIN:

The skin is the largest organ in the human body, having a total surface area of about 2 m2. One-third of the blood that flows throughout the body runs through this multi-layered organ[5]. The skin protects the underlying blood circulation system from environmental factors. Even though it is just a millimetre thick. Human skin is made up of three distinct layers[6].

A. The "epidermis" is a stratified, vascular, and cellular layer.

B. Dermis, connective tissues beneath the epidermis.

C. Underlying dermis is Hypodermis.

THE SKIN PERMEATION PATHWAY FOR DRUGS:

When a drug molecule is passing through the skin, it may either pass through the epidermis or diffuse across a "shunt" pathway, which is made up of hair follicles, sweat ducts, and sebaceous glands. As a result, there are two major ways for drugs to get into the body[7].

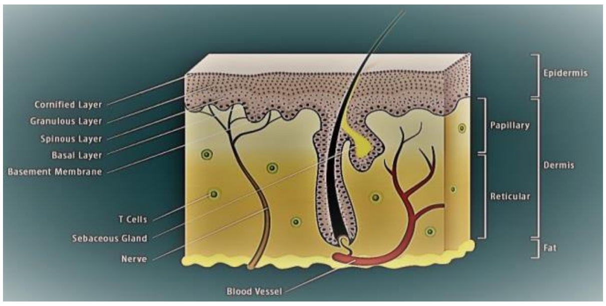

Fig. 1: Anatomy of the Human Epidermis

TRANSCORNEAL INFUSION:

Intra cellular infusion:

Drug molecules penetrate the stratum corneum cells through intracellular penetration. This route is used by hydrophilic medications in general. As the stratum corneum hydrates, water concentrates towards the outermost layer of the polypeptide chains. Polar molecules seemed to travel through immobilised water[8].

Intercellular infusion:

Non-ionic chemicals are transported through intracellular channels using intercellular penetration[8]. The non-aqueous lipid matrix that has been absorbed between the protein filaments dissolves and diffuses these molecules[9].

Transappendageal Infusion:

The shunt pathway is another name for transappendageal permeation. Drug molecules can pass through sebaceous glands, hair follicles, or the salty sweat glands' aqueous pathways during transappendageal permeation. Because of its limited size, the transappendageal route is thought to be of minimal consequence (less than 0.01 percent of the entire surface)[10]. Although for big polar compounds, this technique may be important. The physico-chemical properties of the penetrant, particularly its propensity to partition into different skin phases, play a substantial role in determining the path of penetration[11]. Due to sufficient peripheral circulation, the capillaries and the liver tissue layer are porous. As a result, the rate-limiting phase is via the stratum corneum diffusion[11]. So the rate-limiting mechanism is penetrated through the stratum corneum. To some extent, the stratum corneum serves as a passive diffusion medium. In transdermal medication delivery, A modest multi-layered model, as shown in Figure 2, can represent multiple layers of skin tissue[12].

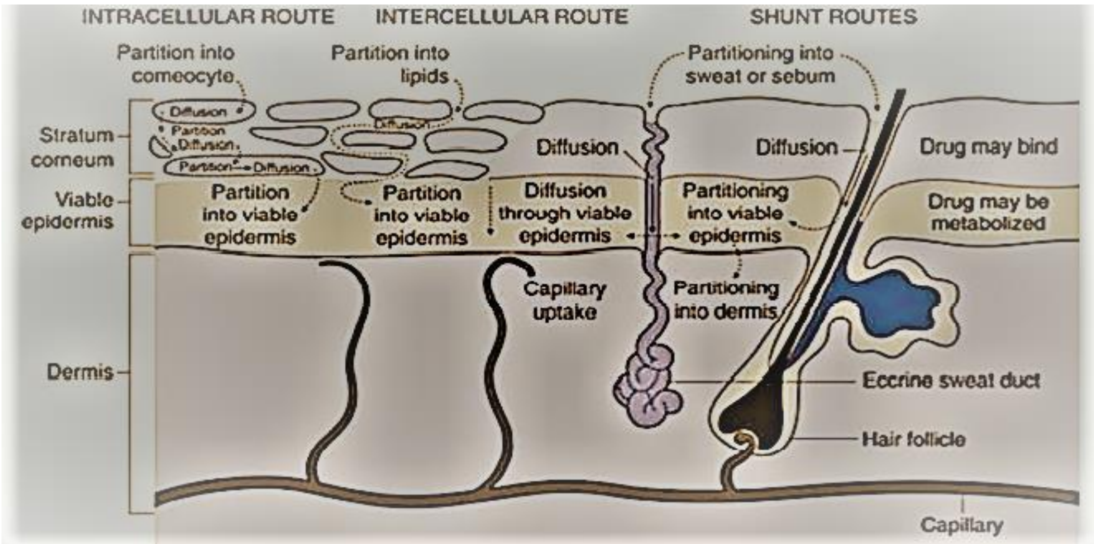

Fig. 2: Drug penetration through the skin via several routes

FACTORS AFFECTING TRANSDERMAL INFUSION:

The following three categories, describe the elements that influence skin permeability.

I.Physico-chemical properties of penetrant molecules

II.Physico-chemical properties of drug delivery systems

III. physiological and pathological characteristics skin

TABLE 2: FACTORS AFFECTING TRANSDERMAL PERMEATION

S. no	Physico-chemical properties of penetrant molecules	Physico-chemical properties of the drug delivery systems	Physiological and pathological characteristics skin
1	Molecular size and shape	The vehicle's affinity for the drug compounds	Skin age
2	Partition co-efficient	Composition of drug delivery system	Lipid film
3	Ph condition	Enhancement of transdermal permeation	Skin hydration
4	Ionization	-	Skin temperature
5	Drug concentration	-	Cutaneous drug metabolism
6	Molecular size & shape	-	Species differences
7	Partition co-efficient	-	Obsessive damage to the skin
8	-	-	Flow of blood
9	-	-	Metabolism of skin

BASIC COMPONENTS OF TRANSDERMAL DRUG DELIVERY SYSTEM:

The basic components of transdermal drug delivery system consists of :

1. Drug reservoir
2. Penetration enhancers
3. Polymer matrix
4. Backing membrane layer
5. Pressure sensitive adhesive layer
6. Release linear Drug reservoir

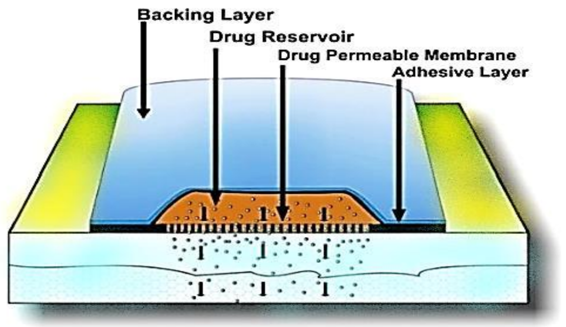

Fig. 3: Basic components of Transdermal Drug Delivery System

BIOPHARMACEUTICAL PARAMETERS IN DRUG SELECTION FOR TRANSDERMAL PATCH:

TABLE 3: TABLE REPRESENTS IDEAL PARAMETERS FOR DRUG SUBSTANCES USED IN TRANSDERMAL DRUG DELIVERY SYSTEM

Parameter of TDDS	Properties of TDDS
Dose induced in patches	< 20 mg/day
Mol. Wt. (Molecular weight)	< 1000 Dalton
M.P(melting point)	< 200°C
$t_{1/2}$ (Half-life)	< 10 hours
Coefficient of Skin permeability	> 0.5×10-3cm/h
Solubility in water	> 1mg/mL
pH	4.5 - 9
Shelf life	Up to 2 years
Reaction to the skin	Non irritant
Bioavailability(orally)	Very less
Partition coefficient	1 to 4

Polymer matrix: Polymer is an essential and primary significant constituent of transdermal drug delivery system[11,12,13].

TABLE 4: POLYMERS USED FOR TRANSDERMAL DEVICES

Natural Polymers	Synthetic Polymers	Synthetic Elastomers
Proteins	Polypropylene	Nitrile
Waxes	Polyethylene	polybutadiene
Cellulose derivatives	Poly vinyl alcohol	Hydrin rubber
Shellac	Polyurea	Neoprene
Natural	Acetal copolymer	Polysiloxane
Gelatin	Poly vinyl chloride	Silicone rubber
Starch	Polystyrene	Chloroprene
Chitosan	Epoxy	-
Gum	Polymeric amide	Acrylonitrile

DIFFERENT LAYERS OF TDDS:

Penetration Enhancers: Penetration enhancers are substances that help drugs penetrate when administered topically[13]. Absorption promoters, accelerants, and penetration enhancers are some of the terms used to describe these substances[14].

Pressure Sensitive Adhesive:

It is a substance that tends to protect the transdermal system and the membrane surface in close contact[15]. Polyisobutylene, polyacrylate, and silicones are the three most commonly used adhesives in TDDS

Backing Membrane:

The backing laminate plays an essential role in providing constant support. The backing membrane protects the medications after they drain out of the dosage form at the top of the backing membrane[16]. Impermeable drugs and permeation enhancers must not pass through the beckoning membrane. Examples: polyester films, foam pads, metallic plastic laminate, and aluminium foil[16].

Release Linear:

The patch is protected by a liner during storage, and it has been removed and untended before applying the patch to the skin. It keeps the patch from becoming unstable while it is being stored. The coating layer, which is composed of silicon or Teflon, also safeguards the surface[16,17].

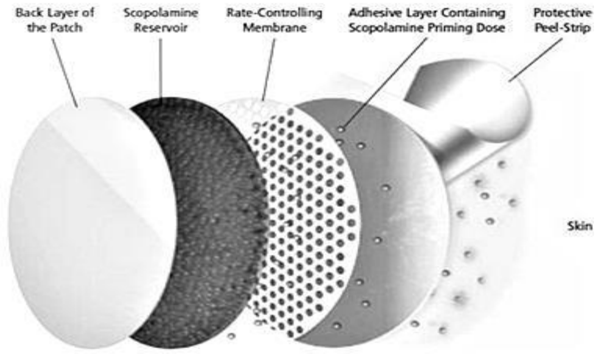

Fig. 4: Different layers of TDDS

APPROACHES IN THE DEVELOPMENT OF TRANSDERMAL DRUG DELIVERY SYSTEM:

Membrane permeation controlled system:

A polymeric membrane with rate control and a drug-impermeable backing laminate produce a compartment in which the drug reservoir is completely submerged[17]. By diffusing through the pores, drug molecules can pass through the rate-controlling membrane[18]. The disseminated reservoir chambers are made up of drug solids. To make a gel-like suspension, it is either homogeneously suspended in a viscous liquid medium that is inaccessible, such as silicon fluid, or it is dissolved in a releasable solvent, such as alkyl alcohol, to produce a gel-like solution[19]. A non-porous or microporous polymeric membrane, such as an ethylene–vinyl acetate copolymer, having predetermined drug permeability. A small coating of drug-compatible adhesive polymer, such as silicone adhesive, may be placed on the top layer of the polymeric membrane to bring the transdermal system into contact with the skin's surface[20]. To adjust the rate of release via the transdermal system, the thickness of the polymer composition, the rate-regulating membrane, and the adhesive permeability coefficient may all be altered, and a few instances of transderm Nitro for angina pectoris and transdermscop for motion sickness were a few instances[21].

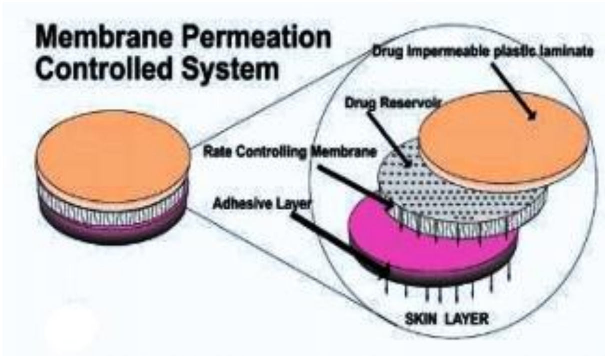

Fig. 5: Membrane permeation controlled system

Micro reservoir type controlled system:

A reservoir and a matrix-dispersion system are combined to provide a microreservoir-controlled drug delivery system. This involves suspending a drug in an aqueous solution that contains the liquid polymer and evenly distributing the drug suspension on a lipophilic polymer. This approach was mainly used to create thousands of inaccessible, small spheres of drug reservoirs, such as silicone elastomers, employing a high energy dispersion method and shear mechanical force[22]. The drug's solubility in the polymer matrix and the liquid compartment differs depending on their respective magnitudes. Drug release can be controlled using either a matrix diffusion control or a partition control method in a micro-reservoir system[23]. Consider the Nitro disc system for angina pectoris as an example of this type of system.

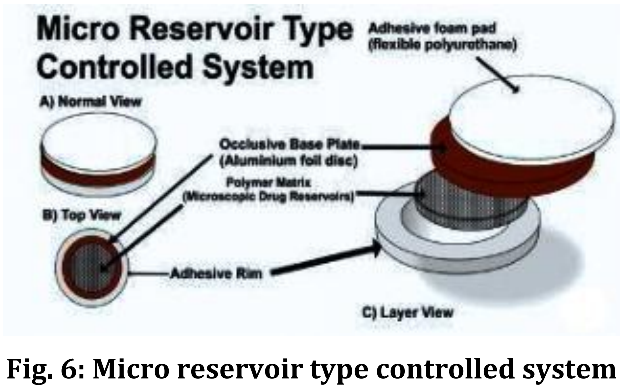

Fig. 6: Micro reservoir type controlled system

Adhesive dispersion type system:

A drug-impermeable backing membrane is a drug reservoir made by directly distributing drugs into an adhesive polymer and then adhering the medicated adhesive to a flat sheet[24].

A thin layer of drug reservoir is created by hot melting or solvent casting to create the drug-impermeable backing[25]. An adhesive drug delivery system with a removable release liner that is regulated by diffusion. It is then created by applying a non-medicated, constant-thickness layer of rate-controlling adhesive polymer on top of the layer[26]. In a sufficient period of time, the patch would be removed after adhering to the skin. The development and marketing of a transdermal drug delivery system for angina pectoris with Valsartan as an angiotensin II type 1 selective blocker for one-day therapy is one of the examples, and it is also included in the commercialization[27].

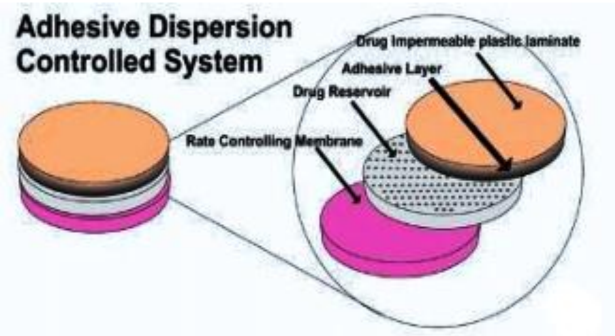

Fig. 7: Adhesive dispersion type system

Matrix diffusion controlled system:

Drug reservoirs are synthesised homogeneously in this process by scattering drug particles in an aqueous or lipophilic polymer matrix, or a mixture of the two polymers. The resulting medicated polymer is then moulded into a medicated disc of a certain thickness and surface area[28]. Either homogeneous mixing or granular mixing can be used to increase the number of drug particles dispersed in a polymer matrix. The powdered drug particles are blended with a highly viscous base polymer or a liquid polymer, and the polymer chains are cross-linked by either homogeneously mixing drug solids with an elastomeric polymer at extreme temperatures or under vacuum[29]. In a drug-impermeable backing segment, the polymer disc connects the drug reservoir to an occlusive base plate. Therefore, consequently, an adhesive polymer is deployed to the medicated disc to generate a rim strip[30]. Nitro-glycerine is an illustration of a matrix type transdermal system. So the polymer cannot be disrupted. This technique has a low rate of dose discarding, which is a benefit of this technique[31].

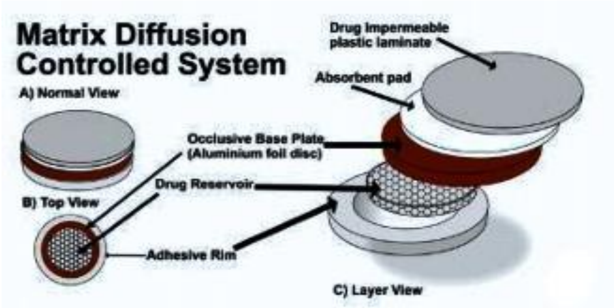

Fig. 8: Matrix diffusion controlled system

PREPARATION METHODS OF TDDS

1. IPM Membranes Method
2. TPX Membrane Method (Asymmetric)
3. EVAC Membranes Method
4. Mercury Substrate Method
5. Circular Teflon Mould Method
6. Free Film Method
7. Proliposomes Preparation by using TDDS

1. IPM Membranes Method

In a mixture of polymer and water, the drug is distributed and agitated for 12 hours in a magnetic stirrer [Popylene Glycol contains Carbomer 940 polymer].The dispersion of drug is neutralised and viscous with the accumulation of triethanolamine[32]. The drug substance of an aqueous solution contains very less solubility. The pH buffer 7.4 is used to make a solution gel. Thus, the resulting gel will be injected through the IPM membrane[33].

2. TPX Membrane Method (Asymmetric)-(Bernerand John 1994)

In order to make a prototype patch, a heat sealed polyester film [3m,type1009] with a 1 cm in diameter concave can be used as a backing membrane[33]. A concave membrane is used to disperse the drug and then TPX asymmetric Poly (4-methyl-1-pentene) membrane is adhesive-coated and sealed. [34].

Preparation of asymmetric TPX membranes: They are developed by using the dry-wet inversion technique. Asymmetric TPX is neutralised in a solvent mixture at 60 °C with cyclohexane and non-solvent ingredients to produce a polymer solution[35]. After being kept at

40°C for 24 hours, the polymer solution is cast on a glass plate. The casting film is then evaporated for 30 seconds at 50 ° C. Before the glass plate is placed in a 25 ° C coagulation bath[36]. The membrane may be removed after 10 minutes of immersion and air-dried for 12 hours at 50°C in a circulation oven.

3. EVAC Membranes Method

One percent of Ethylene vinyl acetate copolymer (EVAC), polyethelene (PE) and carbopol reservoir gel membranes can be employed as rate control membranes in the manufacture of a target transdermal drug system. Propylene glycol can be used to prepare the gel if the drug is insoluble in water[37]. The drug substance will be diluted in propylene glycol, followed by the addition of carbopol resin and neutralisation with a 5% w/w NaoH solution[38]. A backing layer sheet is used to apply the medicated gel form to covers appropriate area. To create a leak-proof device over the gel, The ends will be sealed with heat and a rate-controlling membrane will be inserted[39].

4. Mercury Substrate Method

The drug and plasticizer are dissolved in the polymeric solution. It is stirred for 10–15 minutes to get a homogeneous dispersion, then poured onto a flat mercury surface and covered with an inverted funnel to keep the solvent from evaporating[40].

5. Circular Teflon Mould Method-(Baker and Heller1989)

As an organic solvent, a polymeric solution is used in different ratios. The solution was divided into two parts. A determined quantity of drug is dissolved in one part, then enhancers in various concentrations are dissolved in the other part, and the two parts are then homogenously mixed together. In the drug polymer solution, a plasticizer (such as Di-N butyl phthalate) is added[41]. The entire mixture must be stirred for 12 hours before being placed into a circular Teflon mould. In a laminar flow hood model with an air speed of 0.5 m/s, the moulds should be positioned on a flat surface and covered with an inverted funnel to manage solvent vaporisation[42]. In this type, the solvent is allowed to evaporate for 24 hours. To remove ageing effects, the dried films must be kept for another 24 hours at 25±0.5°C in desiccators containing silica gel before being evaluated[43].

6. Free Film Method

A cellulose acetate-free film produces moulding over a mercury surface. The chloroform can be used to make a 2% w/w polymer solution. The amount of plasticizers should be added at a rate of 40% of the polymer content by given weight. 5mL of solution (polymer) was transferred to a glass jar and placed in a glass petri dish over the mercury surface area[44].

The extent of solvent evaporation may be regulated by placing the funnel over the top of the petri dish. Examine the mercury surface for the formation of a layer after the solvent has entirely evaporated. The dried film would be removed and the desiccator would be placed within the wax paper sheets until it's required again[45]. By altering the amount of polymer solution used, free films of various thicknesses may be created.

7. Proliposomes Preparation by using TDDS

Proliposomes are made using the carrier approach and the film deposition technique. As an optimum ratio from prior studies, the ratio of drug to lecithin should be 0.1:2.0. Place 5 mg of mannitol powder in a 100 ml round-bottom flask, maintain it at 60–70°C, rotate it at 80–90 rpm, and vacuum dry it for 30 minutes to develop proliosomes[46]. After drying, the temperature of the water bath is raised to 20–30 °C.After fully drying, the drug and lecithin are dissolved in a suitable organic solvent mixture, and a 0.5ml aliquot of the organic solution is added to a round flask at 37°C. The flask containing the proliposomes is connected to a lyophilizer after the final loading, and the drug-loaded mannitol powders (proliposomes) are maintained in a desiccator overnight and sieved through 100 mesh[47]. The powder is collected and stored in a glass bottle at a low temperature until charaterization.

EVALUATION OF TRANSDERMAL DRUG DELIVERY SYSTEM:

Evaluation studies are very substantial in order to maintain that the desired performance and consistency are achieved beneath the particular ecological conditions[22,23,24]. These studies are prescient of the transdermal dosage form and are categorised as follows:

A) Physico-chemical Evaluation of TDDS

a. In vitro Evaluation of TDDS

b. *In vivo* Evaluation of TDDS

TABLE 5: PHYSICOCHEMICAL EVALUATION OF TRANSDERMAL DRUG DELIVERY SYSTEM (In vitro)

S.no	Evaluation parameters	Adhesive properties	Tack properties
1	Thickness of the patch	Shear adhesion test	Thumb tack test
2	Uniformity of weight	Peel adhesion test	Rolling ball tack test
3	Drug content	-	peel tack test
4	Content uniformity	-	Probe tack test
5	Flatness test	-	-
6	Moisture content test	-	-
7	Determination of surface pH	-	-
8	Uptake of Moisture test	-	-
9	Evaluation of water vapour permeability	-	-
10	Folding Endurance test	-	-

***IN- VITRO* RELEASE STUDIES:**

1. Paddle over disc apparatus (USP apparatus 5/PhEur 2.9.4.1):

A disc or cell at the end of the extremity of a moderate vessel contains medium at 32.5°C, which is connected to the transdermal system. The paddle over disc apparatus and the USP paddle dissolution apparatus are identica[48].

2. Cylinder apparatus (USP apparatus 6/PhEur 2.9.4.3):

The cylinder type apparatus was adhered to the inside of a hollow cylinder and absorbed in a liquid medium containing 32.5 °C, which is comparable to the USP basket type dissolution apparatus[49].

3.The reciprocating disc (USP apparatus 7/PhEur 2.9.4.2):

The patches were mounted on holders that oscillated in a small volume of medium in the reciprocating disc apparatus, allowing the system to deliver low drug concentrations[49]. Furthermore, It is possible to use the paddle over extraction cell method.

***In vitro* permeation studies:**

An in vitro permeation study can be carried by using a dispersion cell. Male Westar rats weighed 200 to 250 g with a full-thickness abdomen skin. Hair from the abdomen region is wisely taken out with an electric clipper. In order to do this, the dermal side of the skin has been thoroughly cleansed with refined water to remove any blood vessels or adherent tissues. The skin was stabilised for an hour in disintegration medium or phosphate solution containing pH 7.4 before being placed on a magnetic stirrer with a very fine needle to obtain equal and uniform distribution permeation[50]. A thermostatically controlled radiator keeps the cells' temperature at 32 °C. The detached rat skin piece must be put amongst the dispersion cell compartments, with the epidermis facing up into the donor compartment. The epidermis facing up into the donor compartment and the dispersion cell compartments must be filled with the detached rat skin fragment. At regular intervals, a volume sample will be taken from the receptor compartment, and an equivalent amount of a different medium will be reintroduced. Before being analysed with spectrophotometry or HPLC, samples will be filtered through a filtering medium[51]. The flux was calculated directly by dividing the initial drug load. The permeability coefficients were computed by dividing the flow by the drug penetration (mg cm-2) vs. time in hours (mg cm-2) at steady-state[52].

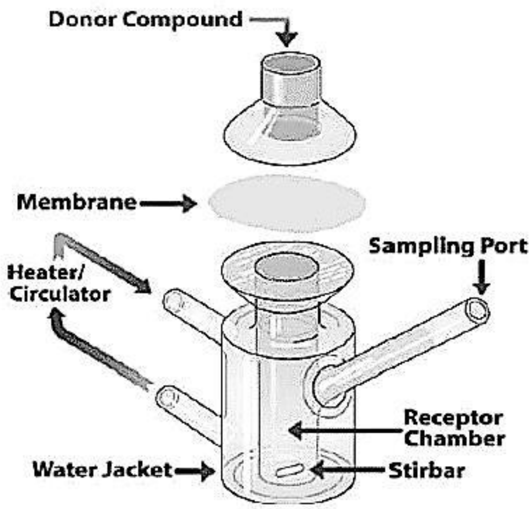

Fig. 9: Franz diffusion cell

IN -VIVO STUDIES:

In vivo studies are the most accurate representation of a drug's effectiveness. *In vivo* investigations can thoroughly examine aspects that cannot be taken into consideration during *in vitro* studies[28,29,30,31].

In vivo evaluation of TDDS can be carried out by using the following models:

a) Animal Study models

b) Human Study models

Animal Study models:

To some extent, resources, efforts, and time are necessary to conduct human studies, so small-scale animal trials are preferable. The most well-known animal species used to examine transdermal drug delivery systems are rabbits, hairless rats, hairless dogs, guinea pigs, hairless rhesus monkeys, and mice[53]. Several investigations were carried out in both *In vitro* and *in vivo* examinations, which led to the conclusion that hairless animals are preferable over hairy ones[54]. The Rhesus monkey is the most dependable model for evaluating transdermal drug delivery in humans.

Human Study models:

It is necessary to obtain pharmacokinetic and pharmacodynamics data from human volunteers once the transdermal patch has been applied to humans as a final step in its development stage[55]. There have been 39 clinical trials to evaluate the effectiveness, risks, side effects, and patient compliance, among other things. Volunteers are the primary focus of phase I clinical trials, while patients are the primary target of phase II clinical trials[56]. Phase III trials show that the patches are safe and effective for a significant number of patients. For marketed patches, phase IV studies with post-marketing surveillance are conducted to identify adverse drug reactions. However, human studies are the most effective way to evaluate the drug's performance, despite the fact that they cost substantial resources[57].

APPLICATIONS OF TRANSDERMAL PATCHES:

- Nitro-glycerine patches are primarily used to treat angina pectoris.
- Transdermal patches are also available for antihypertensive drugs. Some of the examples include Clonidine and nonsteroidal anti-inflammatory drugs.
- A nicotine-containing transdermal patch that distributes nicotine in a precise manner to assist in the reduction of tobacco use.
- For major depressive disorder, the first transdermal delivery agent for a patch containing the MAO inhibitor, selegiline, has been approved.
- The contraceptive patch is one type of transdermal patch for hormone delivery.

RECENT PROGRESSES IN THE FIELD OF TRANSDERMAL PATCHES:

1. Pain-free diabetic transdermal patches
2. Patch technology for protein delivery
3. Chronic pain relief patches
4. By using nanotechnology acquisition hold patches
5. Ovarian failure transdermal patches
6. Transdermal patch of oxybutynin, which is used for overactive bladder.

TABLE 6: NAME OF DRUG PATCHES AVAILABLE IN THE MARKET

Brand Name	Drug	Manufacturer
NeuproR	Rigotine	Ucb And Schwarz Pharma
Transderm nitro	Nitroglycerin	Novartis
Androderm	Testosterone	Thera tech
Ortho evra	norelgostromin	Ortho-McNEIL
Matrifen	Fentanyl	Nycomed
Nuvelle TS	Estrogen, progesterone	Ethical holdings-schering
Climaderm	Estradiol	Wyeth-Ayerest

MARKET OF TRANSDERMAL PATCHES :

In reality, the market for transdermal products has been steadily increasing, and this trend is expected to continue in the near future[58]. Although product approvals for new TDD products have not proliferated as some hoped after the early and mid-90s triumph of TDD nicotine products, a growing proportion of TDD drugs persist to provide actual therapeutic benefits for patients throughout the world[59]. In the United States, more than 35 TDD products have been approved for sale, and approximately 16 active components have been approved for usage in TDD products across the world[60]. From 2000 to 2001, TDD sales volume climbed by 23% in the United States and by 9% in Europe over the same period[61].

CONCLUSION:

This article includes essential information about transdermal drug delivery systems. The intricacies of the TDDS review procedure make it a more relevant resource for researchers. The research on transdermal medication delivery reveals that it has considerable promise for converting both hydrophobic and hydrophilic active substances into viable delivery pharmaceuticals. Because TDDS is a feasible and practical application in the next generation of drug delivery systems and due to its numerous advantages, many new studies are currently being conducted to incorporate novel medications via the system.

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CONFLICT OF INTEREST:

The authors declare no conflict of interest.

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