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Formulation and Evalution of Transdermal Patch of Simvastatin

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Abstract

A simvastatin transdermal patch is a drug delivery system designed to deliver Simvastatin through the skin in a controlled and sustained manner. It is developed as an alternative to oral tablets, which have low bioavailability due to extensive first-pass metabolism in the liver.

The patch typically contains polymers such as HPMC or Eudragit that help regulate drug release over time. By bypassing the gastrointestinal tract, it reduces side effects and maintains more consistent plasma drug levels. Simvastatin patches are mainly studied for the treatment of hyperlipidemia, aiming to improve patient compliance and therapeutic effectiveness.

Overall, this system offers advantages like prolonged drug action, reduced dosing frequency, and better control of cholesterol levels, although it is still largely in the research and development stage

The patch can be prepared using the solvent casting method with different polymers to achieve optimal mechanical strength, drug permeability, and adhesive properties. In vitro drug release studies are performed using Franz diffusion cells to evaluate the rate and extent of simvastatin permeation through synthetic membranes as well as excised animal skin. Various physicochemical characteristics, including thickness, tensile strength, moise content, and uniformity of drug content, are also assessed.

The results indicate that the optimized formulation provides a sustained drug release over a period of 24 hours, along with effective skin permeation and a minimal lag time. The study concludes that a simvastatin -loaded transdermal patch represents a practical and efficient drug delivery system for the treatment of inflammatory conditions, offering a non-invasive and patient-friendly alternative.

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1. INTRODUCTION

Despite these benefits, the skin's natural barrier function significantly limits the permeation of drug molecules. For transdermal therapy to be effective, drugs must penetrate the skin and reach the bloodstream in sufficient quantities to produce a therapeutic effect. In recent decades, considerable research efforts have been directed toward developing advanced transdermal systems capable of enhancing drug transport across the skin. This article highlights the role of chitosan in designing efficient transdermal drug delivery system. [1]

Despite their widespread use, conventional medication delivery methods have a number of drawbacks that can be overcome using other strategies. When contrasted with the expensive and time-consuming process of creating novel medicinal compounds, these unconventional approaches are frequently attractive. The transdermal approach has drawn a lot of interest among these options. Transdermal drug delivery methods have been the subject of much research over the years because of their benefits, which include avoiding the liver's first-pass metabolism, making therapy withdrawal simple, providing painless administration, and preventing degradation by gastric and intestinal fluids.

Introduction to skin:

The skin is the largest organ of the human body and covers the entire outer surface. It is composed of three main layers: the epidermis, dermis, and hypodermis, each having distinct structures and functions. The skin forms a complex protective system that acts as the body's first line of defense against harmful agents such as pathogens, ultraviolet (UV) radiation, chemicals, and physical injury. In addition, it plays a key role in regulating body temperature and controlling water loss.[2]

The thickness of the skin varies across different parts of the body and depends mainly on the thickness of the epidermal and dermal layers. The thickest skin is found on the palms of the hands and soles of the feet, where an additional epidermal layer called the stratum lucidum is present. Areas that lack this layer are classified as thin skin. Among these, the skin on the back is relatively thicker due to a well-developed epidermis.[3]

The protective function of the skin also makes it vulnerable to various inflammatory and infectious disorders. Furthermore, aspects such as wound healing, sensory function, and cosmetic appearance are important considerations in medical and surgical practice. Therefore, a thorough understanding of skin structure and function is essential for diagnosing and managing a wide range of health conditions.[4]

The skin is the largest organ of the body. It has three layers:

- The epidermis [outer layer]
- The dermis [middle], and
- The hypodermis [inner /fatty] layer.

The epidermis is the outermost layer of the skin and is made up of multiple layers, each with specific roles and cell types. From deepest to most superficial, these layers are the stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum.

The stratum basale, also called the stratum germinativum, lies just above the basement membrane that separates it from the dermis and anchors it through structures called hemidesmosomes. This layer consists of cuboidal to columnar cells that act as actively dividing stem cells, continuously producing new keratinocytes. It also contains melanocytes, which are responsible for pigment production.[5]

Above this is the stratum spinosum, made up of about 8 to 10 layers of cells. It is often referred to as the prickle cell layer because the cells appear spiny due to cytoplasmic projections. These projections connect neighboring cells through desmosomes, giving the layer structural strength. Dendritic (immune) cells are also present in th The dermis is the middle layer of the skin, located beneath the epidermis, and is mainly composed of dense connective tissue. It contains collagen and elastin fibers, which provide strength, flexibility, and elasticity to the skin. This layer also houses blood vessels, nerves, hair follicles, and glands, all of which are essential for maintaining skin function and overall homeostasis.[6]

The dermis is divided into two main regions: the papillary dermis and the reticular dermis.

Papillary Dermis:

The papillary dermis is the upper, thinner portion of the dermis. It consists of loose connective tissue and forms projections known as dermal papillae that extend into the epidermis. These structures improve the attachment between the epidermis and dermis and enhance nutrient exchange. This region contains capillaries that supply oxygen and nutrients to the epidermis, along with sensory nerve endings that contribute to touch perception. It also plays a role in maintaining the skin's mechanical properties.[7]

Reticular Dermis:

The reticular dermis is the deeper and thicker part of the dermis, made up of dense connective tissue with a high concentration of collagen and elastin fibers. This layer provides the skin with structural strength and the ability to withstand mechanical stress. It also contains larger blood vessels, nerve fibers, sebaceous glands, sweat glands, and hair follicles. The reticular dermis plays a major role in maintaining the skin's durability, elasticity, and overall structural integrity.

The hypodermis, also called the subcutaneous fascia, lies beneath the dermis and forms the deepest layer of the skin. It is primarily composed of fat (adipose) tissue arranged in lobules, along with sensory nerves, blood vessels, and a few skin appendages such as hair follicles.[8]

Mechanism of the drug transfer:

Several advanced techniques have been developed to enhance drug transport across the skin. These include the ethosomal technique, iontophoresis, electroporation, and microneedles.

Ethosomal Technique:

Transdermal drug delivery systems (TDDS) are versatile platforms that deliver active pharmaceutical ingredients either for local action or systemic circulation through the skin. One of the major challenges in this approach is overcoming the barrier

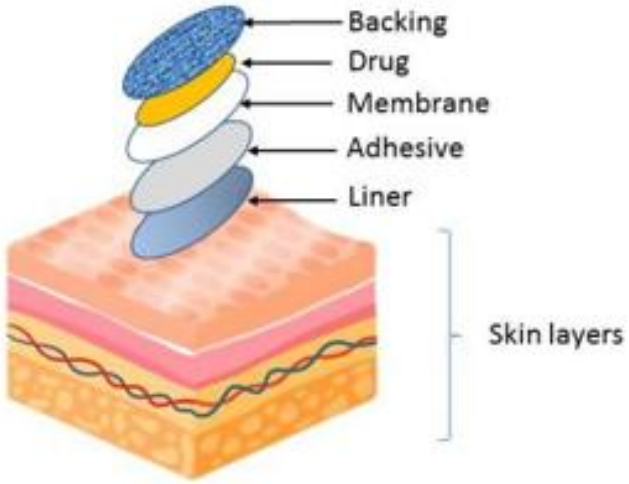
function of the stratum corneum. In recent years, lipid-based vesicular systems have gained popularity due to their ability to carry both hydrophilic and lipophilic drugs. Ethosomes are a novel class of such vesicles that are biocompatible, biodegradable, and non-toxic. They are similar to liposomes but contain a high concentration of ethanol, which enhances their ability to penetrate deeper layers of the skin. Ethosomes are mainly composed of phospholipids, ethanol, water, and the active drug. They are relatively easy to prepare and offer several advantages over conventional liposomes due to the presence of ethanol. This technique has been widely studied for its penetration mechanism, benefits, limitations, characterization, and various applications.[9]

Iontophoresis:
Iontophoresis is a technique that uses a low electrical current to enhance drug permeation through the skin, effectively bypassing the stratum corneum barrier. It is considered a non-invasive and patient-friendly method that improves drug delivery efficiency and expands the range of drugs suitable for transdermal administration. This method works by driving charged drug molecules across the skin using an electric field. Recent advancements have focused on improving iontophoretic systems and combining them with other enhancement techniques. Despite its advantages, certain challenges remain, and only a limited number of iontophoretic devices have been approved for clinical use.

Electroporation:
Electroporation involves the application of short, high-voltage electrical pulses to temporarily increase the permeability of the skin. This process creates transient pores in the skin, allowing drugs to pass through more easily. It has been shown to enhance the delivery of a wide variety of molecules, including both small and large, hydrophilic and lipophilic, as well as charged and neutral substances. The efficiency of drug delivery depends on electrical parameters and drug properties. Although generally well tolerated, electroporation may cause muscle contractions. Proper electrode and patch design are important to minimize discomfort. This technique can also be combined with other methods to further improve drug delivery.[10]

Microneedles:
Microneedles are a promising innovation in transdermal drug delivery, designed to increase skin permeability by creating microscopic channels. These tiny needles are available in various sizes, shapes, and materials. Studies have shown that microneedles significantly enhance the delivery of drugs with different molecular weights. In vivo research has demonstrated effective delivery of substances such as insulin, oligonucleotides, and vaccines, along with the ability to trigger immune responses. Importantly, microneedles are generally painless when applied to human skin, making them a patient-friendly option. Due to these advantages, they are considered a highly promising technology in the field of transdermal drug delivery.[11]

Transdermal Patch:



A transdermal drug delivery system (TDDS) is a widely used approach for administering drugs through the skin. It provides several benefits, including better patient compliance and avoidance of first-pass metabolism [12] . TDDS is specifically designed to enable drugs to enter the bloodstream via the skin while reducing their retention and metabolic breakdown within the skin layers. Drug transport primarily occurs through the intercellular micro route. Additionally, permeation enhancers play an important role by decreasing the barrier resistance of the skin's outermost layer, the stratum corneum, without damaging the underlying viable cells.[13]. Transdermal patches represent a widely utilized form of transdermal drug delivery systems (TDDS), capable of delivering drugs either locally to the skin or systemically to tissues beneath it. Compared to

conventional dosage forms and controlled-release oral systems, these patches offer significant advantages. Depending on the therapeutic objective, skin-care formulations may exert either local or systemic effects. Transdermal delivery can simulate the steady infusion of drugs similar to intravenous administration, but with reduced associated risks. Additionally, one of the key benefits of transdermal patches is the ease with which therapy can be discontinued, as patients can simply remove the patch in case of adverse effects [14]

Simvastatin is commonly prescribed alongside a balanced diet to reduce levels of low-density lipoprotein (LDL) cholesterol and triglycerides while increasing high-density lipoprotein (HDL) cholesterol. It belongs to the class of drugs known as statins. Some individuals taking simvastatin may experience mild side effects such as confusion or memory disturbances. In rare instances, it may lead to muscle-related complications, including rhabdomyolysis or autoimmune myopathy. There is also a slight risk of liver-related issues, which may present as abdominal discomfort, nausea, vomiting, jaundice, or dark-colored urine. Therefore, proper medical supervision is necessary to ensure safe use and to manage any potential adverse effects. [15]

The average half-life of short-acting statins is approximately six hours, which refers to the time required for the body to eliminate half of the administered dose. Simvastatin is administered as a prodrug and is converted in the liver into its active beta-hydroxy acid form. This active metabolite has a plasma half-life of about five hours and typically reaches peak plasma concentrations within two to four hours. [16]

A factorial design is a type of experimental approach that involves two or more independent variables, also known as factors. This design enables researchers to evaluate not only the individual (main) effects of each factor but also their interaction effects. [17]

Central composite design (CCD) is a specialized form of factorial design commonly used in response surface methodology. It is particularly useful for developing quadratic models without requiring a full three-level factorial experiment. CCD aids in process optimization and in understanding the relationship between independent variables and the response [18].

In CCD, each factor is examined at five different levels: a high extreme (star point), a high level, a low level, a low extreme (star point), and a central point. The central point is often repeated to estimate experimental error. This design allows researchers to generate response surface contours, which help visualize how different variables influence the outcome within the studied range. [19]

Overall, factorial designs, including central composite design, serve as powerful tools for studying the effects and interactions of multiple variables, enabling researchers to test hypotheses and draw meaningful conclusions. [20]

Simvastatin use:

Simvastatin is a medication primarily used to manage cholesterol levels and reduce the risk of cardiovascular diseases. Its main uses include:

1. Lowering Cholesterol:

Simvastatin helps reduce levels of **low-density lipoprotein (LDL)**, often called "bad cholesterol," and **triglycerides** in the blood, while increasing **high-density lipoprotein (HDL)** or "good cholesterol."

2. Prevention of Heart Diseases:

It is widely prescribed to lower the risk of:

- Heart attacks
- Stroke
- Coronary artery disease

This is especially important for individuals with risk factors such as diabetes, high blood pressure, or a history of heart problems.

3. Management of Dyslipidemia:

Simvastatin is used in patients with abnormal lipid levels (dyslipidemia), including inherited conditions like familial hypercholesterolemia.

4. Post-Cardiovascular Event Therapy:

It is often given to patients who have already experienced cardiovascular events to prevent recurrence and improve long-term outcomes.

Advantages:

1. Effective cholesterol reduction: Lowers LDL ("bad" cholesterol) and triglycerides while
2. Cardiovascular protection: Reduces the risk of heart attack, stroke, and other cardiovascular diseases.
3. Prevention of disease progression: Slows the buildup of plaque in arteries (atherosclerosis).
4. Widely studied and proven: Has strong clinical evidence supporting its safety and effectiveness.
5. Oral administration: Easy to take as a tablet, improving patient convenience and compliance.
6. Cost-effective: Available as a generic medication, making it affordable for long-term use.
7. Suitable for long-term therapy: Can be used safely over extended periods under medical supervision.
8. Complementary to lifestyle changes: Works well alongside diet, exercise, and weight management programs.

Disadvantages:

1. Muscle-related side effects: May cause muscle pain, weakness, or cramps; in rare cases, it can lead to serious conditions like rhabdomyolysis.
2. Liver toxicity risk: Can affect liver function, requiring regular monitoring of liver enzymes.
3. Drug interactions: Interacts with several medications (e.g., certain antibiotics, antifungals), increasing the risk of side effects.
4. Gastrointestinal issues: May cause nausea, abdominal pain, constipation, or diarrhea.
5. Neurological effects: Some users report memory loss or mild confusion.
6. Not suitable during pregnancy: Contraindicated due to potential harm to the fetus.

7. Limited dosing flexibility: Higher doses increase the risk of adverse effects, especially muscle toxicity.

2. MATERIAL AND METHOD

Materials:

Simvastatin drug Oiclofcnac sodium is collected from the pharmaceutical industry. All the reagents and materials were of analytical or pharmacopoeia grade. Formulation of Transdermal patch- drug, backing agent, plasticizer, penetration enhancer and solvents are use. Ingredients list mention in Table 1

Table 1: List of Chemicals

SR. NO.	Name of Ingredients	Category
1	Simvastatin	Active Ingredient (Drug)
2	Polyvinyl Pyrrolidone (PVP)	Polymer
3	Propylene Glycol (PG)	Plasticizer
4	PEG-400	Plasticizer
5	Glycerine	Preservative
6	Dibutyl Phthalate	Penetration Enhancer
7	Water	Solvent
8	Ethanol	Co-solvent

Table no. I -Method of preparation of simvastatin

Preparation of transdermal patch:

1. Calculate each exact proportion of each ingredient according to the formula.

⇩

2. Weighed all the ingredients according to the required amount.

⇩

3. An accurately weighed amount of simvastatin [0.5 g] was dispersed in a prepared amount of aqueous solution and sonicated for 5min to from a homogenous mixture or liquid medication.

⇩

4. Then, PVP and dibutyl phthalate is added in mixture to from solid mass.

⇩

5. Add PEG to the top and continuously stir on magnetic stirrer

⇩

6. Add the contents and sonicate air trap for approximately 10minutes.

⇩

7. pour the above solution into a petri dish with aluminium foil and evaporate the solvent at room temperature for 24 hours

⇩

8. Cut the dried film into squares that are 2 × 2 cm.

⇩

9. The prepared simvastatin transdermal patches were kept in a desiccator at room temperature.

Figure 1: Patch formulation

Table 2: formulation design

Ingredient	F1	F2	F3
Simvastatin (mg)	500	500	500
Polyvinylpyrrolidone (PVP) (mg)	200	250	300
PEG-400 (mL)	1.5	1.5	1.5
Propylene Glycol (PG) (mL)	1.2	1.2	1.2
Ethanol (mL)	5	5	5
Glycerine (mL)	1.5	1.5	1.5
Dibutyl Phthalate (mL)	1.2	1.2	1.2
Water (mL)	5	5	5

Figure 2: Patch formulation

Table 3: List of Instruments

Sr.no.	NAME OF INSTRUMENT	MODEL/ MANUFACTURER
1	Analytical weighing balance	Labelling Analytical balance
2	UV spectrophotometer	Cary Win UV
3	Magnetic Stirrer	Remi Equipments
4	Sonicator	Citizen
5	Hot Air Oven	Thermolab, Mumbai
6	Digitat PH meter	Hanna Instruments

EVALUATION OF MEDICATED PATCH

After selecting the optimal formulation containing an accurate amount of Simvastatin, it was subjected to further evaluation for characterization. These studies included assessment of physical appearance, patch thickness, weight uniformity, and folding endurance. Additional tests such as percentage moisture content, moisture uptake, and content uniformity were also carried out. The formulation was further analyzed for drug content, shear adhesion strength, and peel adhesion properties. Moreover, water vapour transmission and stability studies were conducted to ensure the quality and performance of the patch.

1.Physical appearance: physical appearance of the formulated transdermal patches was satisfactory, showing smooth surface, uniform texture, and good flexibility, indicating proper film formation. The general appearance of TDDs its visual identity and all over elegance shape, colour, surface textures. All these parameters are essential for consumer acceptance

2.Weight variation: Each transdermal patch was weighed using an analytical balance, and the average weight for each film was calculated. Maintaining a nearly uniform weight among the films is important, as it helps confirm that each patch contains the correct and consistent amount of both excipients and active pharmaceutical ingredient (API).

3.Thickness of Patch: The thickness of each patch was measured at five different points using a micrometer screw gauge, and the average of the recorded values was calculated. This evaluation is important to ensure uniform thickness across the film, as it directly influences the accuracy and consistency of the drug dose in the patch.

4. Surface of PH: The patches were placed in glass tubes containing 10 ml of phosphate buffer (pH 7.4). The surface pH was measured at time intervals of 1, 2, 3, 4, 5, 6, 7, and 8 hours. This was done by positioning the tip of a glass microelectrode from a digital pH meter near the surface of the patch and allowing it to equilibrate for one minute before recording the PH , and the ideal PH range was found to be 6 .12 approximately

5.Folding endurance: The patch is essential to study the elasticity of the film during storage and handling. lhc folding endurance of the patch was determined by tepc;jtcdt',' folding one film at the same place till it breaks. This is considcrcd to reveal good film properties. film (2 X 2 cm) was cut event'/ and repeatedly folded at thc same place till it breaks. All determinations were performed in triplicate.

6. Moisture content: The prepared patch was weighed and kept in the desiccator with fused calcium chloride for around twenty-four hours. After that, it was taken out and weighed once again. The percentage of moisture content was calculated using the following formula:

$$\% \text{ of moisture content} = \frac{[\text{final weight} - \text{initial weight}]}{\text{Final weight}} \times 100$$

7. Drug content: A specified area of patch was dissolved in buffer solution. The content was stirred to dissolve the film. The content was transferred to a volumetric flask. The absorbance of the solution was measured at wavelength 238 nm and determines the drug content

Drug Content Analysis: Cut the transdermal membrane of one area (7,065 cm) into small pieces, dissolve in 50 ml of phosphate buffer pH 6.8 and sonicate for 5 min. The chemical sample was filtered through Whattsmann filter paper and the filter was placed in a 100 ml volumetric flask. Then, the volume was completed to 100 ml with phosphate buffer pH 6.8 remove 1 ml of the above solution and dilute to 100 ml with phosphate buffer (pH 6.8). Absorbance is measured at 238 nm and 246 nm.

8. In vitro analysis: Franz diffusion cell is used, which consists of two compartments: the donor and the receptor. The simvastatin-loaded patch or formulation is placed in the donor compartment, while the receptor compartment is filled with a suitable medium (usually phosphate buffer pH 7.4) that mimics physiological conditions. A semi-permeable membrane (such as synthetic or animal skin) separates the two compartments. The system is maintained at a controlled temperature (around 37°C) and continuously stirred. At specific time intervals, samples are withdrawn from the receptor compartment and analyzed (commonly using UV spectrophotometry) to determine the amount of simvastatin diffused. This study helps in determining drug release rate, permeability, and overall performance of the transdermal system.

3. RESULTS:

1. PHYSICAL APPEARANCE:

Table no.4- Physical appearance

Sr. No.	Physical Appearance Parameter	Result
1	Colour	Off White
2	Surface Texture	Smooth
3	Shape	Cube

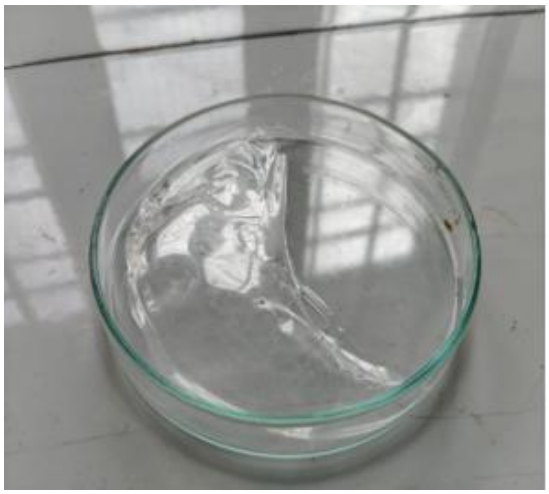


Figure 3. Physical appearance.

2. Weight variation:

Table 5: Weight variation

Sr. No.	Batch	Weight Variation (mg)
1	F1	46 mg
2	F2	48 mg
3	F3	50 mg

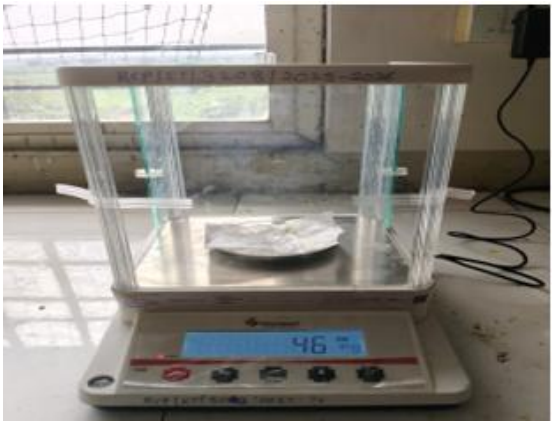


Fig 4. Weight variation.

3. Thickness:

Table 6: Thickness

Sr. No.	Batch	Thickness (mm)
1	F1	0.14 mm
2	F2	0.15 mm
3	F3	0.13 mm

Figure 5: Thickness

4. Determination of surface pH:

Table 7: Surface pH

Sr. No.	Batch	Surface pH of Patches
1	F1	6.15
2	F2	6.10
3	F3	7.00

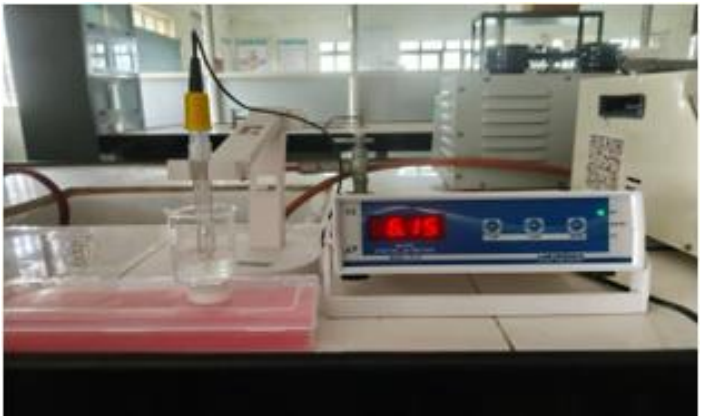


Figure 6: Surface pH of the patch.

6. Folding endurance:

Table 8: Foldin endurance

Sr. No.	Batch	Folding Endurance of Patches
1	F1	15 times
2	F2	12 times
3	F3	18 times

Figure 7: Folding endurance

7. Moisture content:

Table 9: Moisture content.

Sr. No.	Batch	Moisture Content (%)
1	F1	0.98
2	F2	5.20
3	F3	5.50

7. Drug Content Estimation: (Franz Diffusion cell):
A distinct and steady absorbance peak at 238 nm was revealed by the UV spectrophotometric measurement, indicating the drug's existence without any interference or degradation. Good analytical reliability was demonstrated by the calibration curve's linearity over the chosen concentration range. The Beer-Lambert law governed the connection between absorbance and concentration, and the resulting calibration equation was:

Using both the lowest and the highest way

Slope = $\Delta A/\Delta C$

A = 0.065 × C;

Where, A=Absorbance
C = Concentration (µg/ml)
slope=**0.065** (absorbance increase per unit concentration

Sr. No.	Concentration	Absorbance
1	0.50	0.023
2	1.00	0.058
3	1.30	0.075

Slope = ΔA/ΔC = 0.075 - 0.023 / 1.30 - 0.30 = **0.052/0.8= 0.065**

❖ **Drug Concentration Calculation:**

➢ **At 10 minutes:**
C=A/0.065
C = 0.032 / 0.065= **0.3538 µg/ml**

➢ **At 15 minutes:**
C=A/0.065
C = 0.058 / 0.065 = **0.8923 µg/ml**

➢ **At 20 minutes :**
C=A/0.065
C = 0.075/ 0.065 = **1.1538 µg/ml**

►**Cumulative Drug Release Calculation:**
Cumulative drug release was calculated using a standard correction method.
Receptor volume (V) is the total volume of liquid present in the receptor compartment (the lower chamber of the Franz diffusion cell).
This compartment contains the **diffusion medium** (phosphate buffer) It collects the drug that diffuses through the membrane, the egg membrane was used as barrier to mimic the skin barrier

- Receptor volume (V) = 20 ml
- Sample volume withdrawn (v) = 3 ml

It is used to calculate **total drug amount released (µg)**

Q = C × V
At 10 minutes:
Q_{10} = (C1 × V)
Q_{10}= (0.35 × 20)
Q_{10}=**7 µg**

At 15 minutes:
Q_{15} = (C2 × V) + (C1×v)
Q_{15} = (0.89 × 20) + (0.35× 3)
Q_{15} = 17.8+ 7
Q_{15} = **24.8 µg**
At 20 Minutes:
Q_{20}= (C3 × V) +(C2 × v)+ (C1× v)
Q_{20} = (1.1538× 20) + (0.89 × 3)+(0.35× 3)
Q_{20}= 23.07 + 17.8 + 7
Q_{20}**= 47.87 µg**

❖ **Percentage Drug Release:**
Total drug content = **2000µg. (**single patch 2×2)

➢ **At 10min:**
% Release = (7 /2000) X 100 = **0.35 %.**

➢ **At15min:** % Release = (24.8/ 2000) X 100 =**1.24 %.**

➢ **At 20min:**
% Release = (47.87 /2000) X 100 = **2.39 %.**

❖ **Percentage Drug Release at 24 hrs:**

➢ **Using the Higuchi Model**

$Q = k\sqrt{t}$

- Q = cumulative drug release (µg)
- k = release constant at 20 min
- t = time (hours)
- Q = cumulative drug release (µg)
- 1hr = 60 min

Q_{60}= 47.87×$\sqrt{60}$**= 370.8 µg**
Total drug = 2000µg
%=370.8/2000×100 **= 18.54%**
% Drug Release at 1 hr(60 min) ≈ 18.54%

Figure 8: UV Spectroscopy

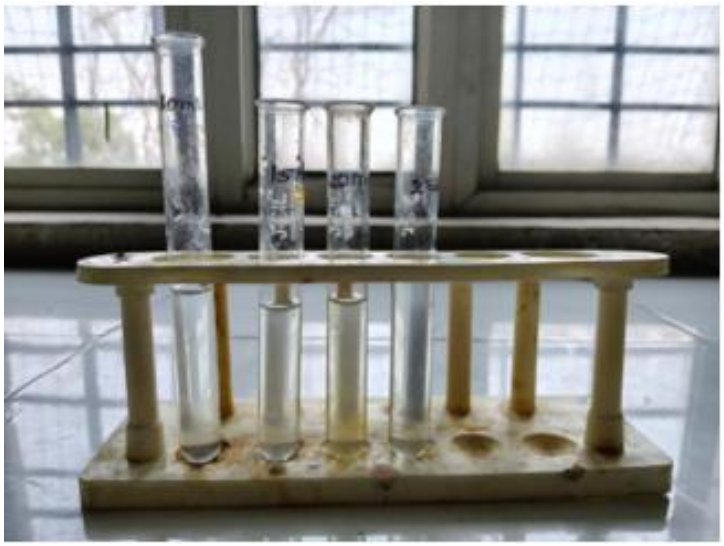


Figure 9: Dilutions of drug with Concentration

4. CONCLUSION

The transdermal patch of Simvastatin was prepared successfully by using different concentration of ethyl cellulose by solvent casting method. The present work can further be proceeding with in-vivo study on the healthy animals to evaluate the pharmacokinetic profile. Thin, flexible, smooth and transparent films were obtained with PVP, polymers using glycerine as plasticizers. Thickness of all the formulations remained uniform with low SD values. All the system containing EC polymer showed good release than that of PVP systems.

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