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# REVIEW ARTICLE ON HERBAL TRANSDERMAL PATCH

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## **Abstract:**

Herbal transdermal patches are innovative medicine delivery methods designed to transport herbal active ingredients over the skin and into systemic circulation. They offer advantages such as regulated release, avoidance of first-pass metabolism, better bio-availability, and enhanced patient compliance. An overview of herbal trans-dermal patch formulation, components, evaluation, benefits, drawbacks, and recent developments are provided in this paper. The usefulness and efficacy of herbal transdermal patches are supported by a summary of pertinent research and literary sources.<sup>1</sup>

## **Introduction**

The transdermal route of drug administration has gained significant attention in recent years due to its numerous advantages over traditional routes such as oral and injectable methods. Among the various transdermal systems developed,<sup>2</sup> herbal transdermal patches represent a unique and promising approach that combines the ancient wisdom of herbal medicine with modern drug delivery technology. A transdermal patch is a medicated adhesive system placed on the surface of the skin that delivers therapeutic substances into the systemic circulation through skin layers at a controlled rate. When this patch contains herbal extracts or active phytoconstituents, it is termed a herbal transdermal patch.<sup>3</sup>

Herbal medicine has been used for thousands of years and is the foundation of many traditional systems, including Siddha, Unani, Ayurveda, and Traditional Chinese Medicine (TCM). In recent years, scientists have started incorporating these natural medicines with modern drug delivery systems to boost efficacy, reduce side effects, and enhance patient compliance. This integration has led in the development of herbal transdermal patches.<sup>4</sup>

## **1. Concept of Herbal Transdermal Patch**

One kind of medication delivery device that enables herbal active ingredients to directly reach the bloodstream or target tissues through the skin is a herbal transdermal patch. These patches are meant to distribute the herbal medication in a controlled and sustained manner over a longer period.<sup>6</sup>

The transdermal approach permits immediate absorption into systemic circulation, in contrast to oral administration, which may result in the breakdown of herbal compounds in the stomach and liver (first-pass metabolism). Because of this, herbal transdermal patches are quite useful for effectively administering sensitive phytochemicals.<sup>5</sup>

Typically, these patches include:

Herbal extract (active substance)

Polymer matrix

Plasticizer

Enhancers of penetration

Adhesive layer

Membrane behind

Liner release

They give a non-invasive and painless method for herbal medicine delivery, maximizing therapeutic effects with minimal discomfort.

## 2. Herbal Transdermal Patch Requirement <sup>6</sup>

Despite the widespread usage of herbal remedies, its conventional forms, such as powders, decoctions and tablets have numerous limitations:

Low bioavailability

Short half-life

Need for frequent dosing

Poor patient compliance

Unpleasant flavor or odor

Degradation of active chemicals in GIT

To overcome these challenges, modern pharmaceutical technology introduced transdermal drug delivery systems (TDDS). When herbal medications are included into TDDS, they offer:

Improved absorption

Sustained release

Reduced dosing frequency

Better patient compliance

Reduced gastrointestinal side effects

steady blood concentration

Thus, herbal transdermal patches are regarded a creative and successful technique to apply ancient herbal knowledge in a modern pharmaceutical manner<sup>7</sup>

## 3. Skin as a Route of Drug Delivery<sup>8</sup>

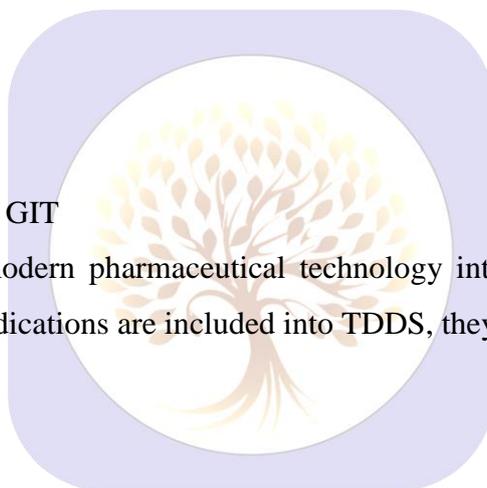
The skin is the biggest organ of the human body and works as a protective barrier. It comprises of three primary layers:

1. Epidermis

2. Dermis

3. The hypodermis

The outermost layer known as the stratum corneum is the principal barrier for drug entry. However, with the help of permeation enhancers such as essential oils (clove oil, eucalyptus oil, menthol), herbal medications can successfully pass this barrier and reach the systemic circulation.



Another benefit of herbal transdermal patches is the use of herbal boosters, which are safer and more biocompatible than synthetic chemicals.

#### 4. Advantages of Herbal Transdermal Patches<sup>9</sup>

Avoid first-pass metabolism  
 Continuous and regulated medication release  
 Reduced gastrointestinal irritation  
 Improved patient compliance  
 Easy and painless administration  
 Rapid cessation of therapy by patch removal  
 Minimal toxicity and fewer adverse effects

#### 4. Limitations

Limited permeability of some herbal compounds  
 Skin irritation possible  
 Only suited for powerful herbal extracts  
 restricted ability to load drugs

#### 5. Skin Structure and Permeation Mechanism<sup>10</sup>

The skin is made up of:

Stratum Corneum: Primary barrier

Epidermis: Non-vascular diffusion area

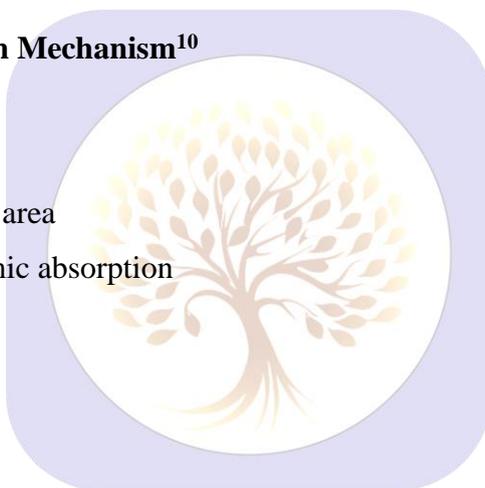
Dermis: Vascular region for systemic absorption

Herbal molecules permeate via:

Transcellular route

Intercellular route

Appendageal (follicular) route



#### 6. Herbs Used in Herbal Transdermal Patches<sup>11,12</sup>

Herb	Active Constituent	Activity
Capsicum	Capsaicin	Analgesic
Curcuma longa	Curcumin	Anti-inflammatory
Zingiber officinale	Gingerols	Anti-inflammatory
Boswellia serrata	Boswellic acid	Anti-arthritis
Mentha piperita	Menthol	Cooling, analgesic
Camphora officinarum	Camphor	Stimulant, analgesic
Aloe vera	Aloin, polysaccharides	Wound healing
Neem (Azadirachta indica)	Azadirachtin	Antimicrobial
Eucalyptus	Cineole	Anti-inflammatory
Green tea	Catechins	Antioxidant

## 7. Components of Herbal Transdermal Patch<sup>14</sup>

1. The backing layer
2. Drug matrix or reservoir
3. The layer of adhesive
4. A liner for release
5. Enhancers of penetration (oleic acid, ethanol)
6. Plasticizers (PEG, glycerol)
7. Polymers (Eudragit, PVP, and HPMC)

## 8. Formulation Methods<sup>13-21</sup>

### Solvent evaporation method

The solvent evaporation method is one of the most regularly used processes for the manufacture of transdermal patches, including herbal-based patches. In order to create a thin, consistent medicated film (patch), this procedure entails dissolving all of the patch-forming ingredients in an appropriate solvent and then letting the solvent slowly evaporate.

This process is simple, inexpensive, and ideal for both laboratory-scale and industrial manufacture of patches.

### Principle

The polymer, plasticizer, herbal extract (drug), and other additives are dissolved in a volatile organic solvent or solvent mixture using the solvent evaporation process. This solution is then poured into a mould or Petri dish and allowed to dry. As the solvent evaporates, a thin polymeric film containing uniformly distributed herbal medicine is created.

After the patch has completely dried, it is removed and cut to the appropriate size.

### Materials Used

#### 1. Herbal extract

(For instance, ashwagandha extract, aloe vera gel, ginger extract, turmeric extract, etc.)

#### 2. Polymer (agent that forms films)

Hydroxypropyl Methylcellulose, or HPMC

Polyvinyl Alcohol, or PVA

Ethyl Cellulose

Sodium Alginate Chitosan

#### 3. Glycerin

Plasticizer PEG 400 Propylene Glycol

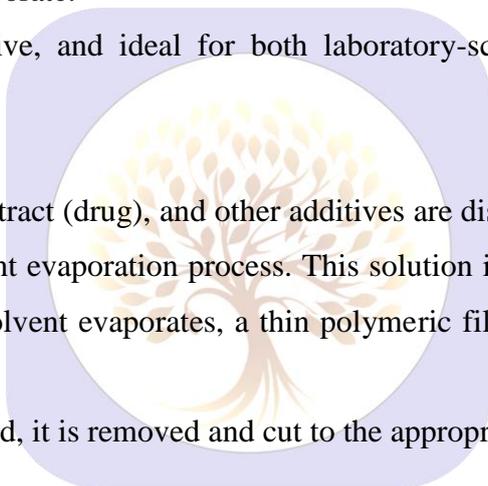
#### 4. Penetration enhancer (optional)

Menthol, eucalyptus oil, clove oil, oleic acid, and DMSO (for use solely in research)

#### 5. Solvent

Distilled water, ethanol, and methanol

Acetone



Hydro-alcoholic combination

## 6. Backing membrane

Aluminium foil / Teflon sheet / Polyethylene sheet

Equipment Needed

A magnetic stirrer

Petri dish or glass mould

A beaker

Measuring cylinder

Balance weighing

Hot air oven / Room temperature drying

Spatula

Desiccator

### Step-by-Step Procedure

#### Step 1: Preparation of Polymer Solution

Weigh the needed amount of polymer (e.g., HPMC or PVA).

Add it slowly to the solvent (ethanol, water, or hydromethanolic combination) in a beaker.

Use a magnetic stirrer to constantly stir until a clear, uniform solution is achieved.

To get rid of air bubbles, let the solution stand for a while.

#### Step 2: Preparation of Herbal Drug Solution

Take the measured amount of herbal extract.

Dissolve it in a little quantity of appropriate solvent.

If necessary, add a penetration enhancer (eucalyptus oil or menthol).

Mix until a homogeneous herbal solution is created.

#### Step 3: Addition of Plasticizer

Now add a sufficient amount of plasticizer (example: 30% w/w of polymer weight, e.g., 0.3 ml glycerin per 1 g polymer).

Gently stir the mixture.

Plasticizer promotes flexibility and softness of patch.

#### Step 4: Mixing of Herbal and Polymer Solutions

Slowly add the herbal medication solution to the polymer solution.

Stir continuously to get a homogenous mixture.

A uniform, viscous casting solution is created as a result.

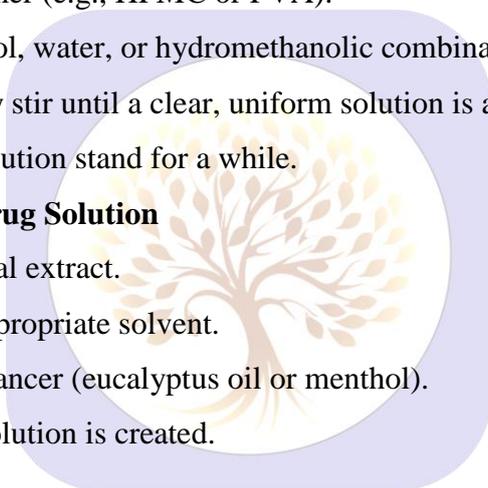
#### Step 5: Casting of the Patch

Pour the prepared solution into a Petri dish or mould lined with aluminium foil.

Spread evenly to make a thin coating.

The patch's thickness is determined by:

Quantity of the solution



Size of mould

Polymer concentration

### **Step 6: Drying (Solvent Evaporation)**

Allow the solvent to evaporate at:

24 to 48 hours at room temperature

OR

40–50°C in hot air oven

After complete evaporation of solvent, a thin, solid film (patch) is created.

### **Step 7: Cutting and Storage**

Carefully remove the dry film from the mould.

Cut into required sizes (e.g., 2 × 2 cm or 5 × 5 cm).

Store the patches in a desiccator to avoid moisture absorption.

### **Advantages**

Simple and affordable

No sophisticated equipment required

Uniform drug distribution

Suitable for heat-sensitive herbal medications

Better control over thickness and size

Perfect for laboratory and research applications

### **Disadvantages**

Use of organic solvents may be harmful if not removed correctly  
requires more time to dry

If drying is not thorough, residual solvent may be present.

Environmental issues

### **Applications in Herbal Patch Preparation**

This approach is extensively used for making herbal transdermal patches of:

Turmeric (anti-inflammatory)

Ginger (pain alleviation)

Neem (antimicrobial)

Aloe vera (skin healing)

Capsicum (analgesic)

Ashwagandha (stress relief)

### **Matrix dispersion technique**

#### **Solvent Evaporation Method for Herbal Transdermal Patch**

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**2. Polymer** (agent that forms films)

HPMC (Hydroxypropyl Methylcellulose) PVA (Polyvinyl Alcohol)

Ethyl Cellulose

Chitosan

Sodium Alginate

**3. Plasticizer**

Glycerin PEG 400 Propylene glycol

**4. Penetration enhancer (optional)**

Menthol

Eucalyptus oil Clove oil

Oleic acid

DMSO (only for use in research)

**5. Ethanol Methanol Solvent**

Distilled water

Acetone

Hydro-alcoholic combination

**6. Backing membrane**

Aluminium foil / Teflon sheet / Polyethylene sheet

Equipment Needed

A magnetic stirrer

Petri dish or glass mould

A beaker

Measuring cylinder

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Stir continuously to get a homogenous mixture.

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Spread evenly to make a thin coating.

The patch's thickness is determined by:

Quantity of the solution

Size of mould

Polymer concentration

### Step 6: Drying (Solvent Evaporation)

Let the solvent evaporate at either room temperature (24–48 hours) or 40–50°C in a hot air oven.

After complete evaporation of solvent, a thin, solid film (patch) is created.

### Step 7: Cutting and Storage

Carefully remove the dry film from the mould.

Cut into required sizes (e.g., 2 × 2 cm or 5 × 5 cm).

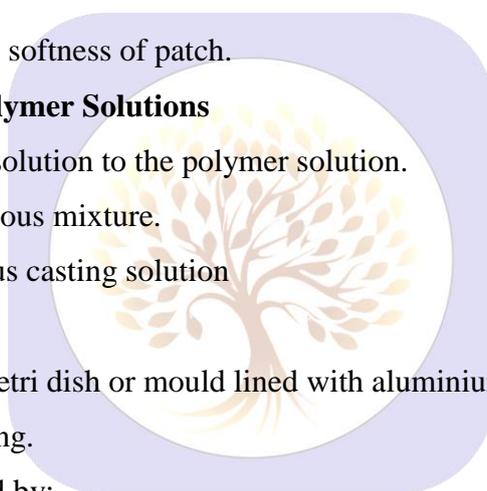
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Better control over thickness and size  
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Use of organic solvents may be harmful if not removed correctly  
requires more time to dry  
If drying is not thorough, residual solvent may be present.  
Environmental issues

### **Uses for Preparing Herbal Patches**

This approach is extensively used for making herbal transdermal patches of:

Turmeric (anti-inflammatory)  
Ginger (pain alleviation)  
Neem (antimicrobial)  
Aloe vera (skin healing)  
Capsicum (analgesic)  
Ashwagandha (stress relief)

### **Drug-in-adhesive technique<sup>22-26</sup>**

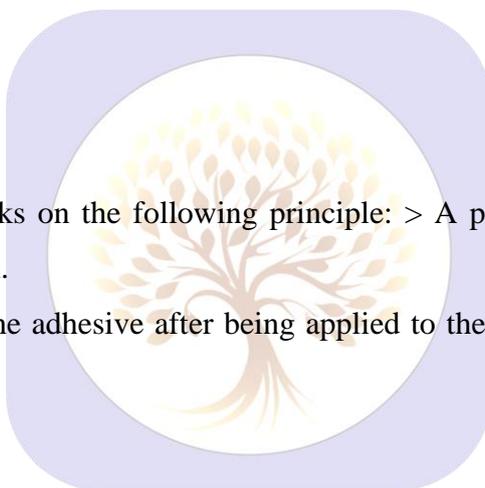
#### **Principle**

The drug-in-adhesive method works on the following principle: > A pressure-sensitive adhesive (PSA) is combined with a herbal medication.

The medication is released from the adhesive after being applied to the skin, diffusing across the layers of skin to have a therapeutic effect.

#### **Using this method:**

No distinct drug reservoir exists.  
The drug release rate is regulated by the sticky layer.  
A concentration gradient causes the medication to disperse.



### **Drug-in-Adhesive System Types**

#### **1. Drug-in-Adhesive Single-Layer System**

Within this system:  
One adhesive layer contains the drug.  
The skin is directly in contact with this layer.  
The top is covered by a backing layer.

#### **Structure:**

Skin → Drug + Adhesive layer → Backing layer

#### **2. Drug-in-Adhesive System with Multiple Layers**

Within this system:  
There are two distinct layers of glue employed.  
One layer might include drugs in it, while the other might not.

It facilitates improved medication release control.

Organization:

Materials Used: Backing layer → Drug adhesive layer → Control adhesive layer → Skin

### 1. Herbal Medicines (Extracts)

Curcuma longa, or turmeric; Zingiber officinale, or ginger; Ashwagandha

Neem

Aloe vera and capsicum

Biloba ginkgo

**These herbs provide:**

Analgesic

Anti-inflammatory, antioxidant, antimicrobial, and calming properties

### 2. Adhesives that are sensitive to pressure (PSA)

The DIA system's most crucial components are as follows:

Acrylic adhesives

Silicone glues

Adhesives based on rubber

PIB, or polyisobutylene

The adhesive needs to be:

Non-toxic

Not irritating

Consistent

Biocompatible

Robust enough to adhere to skin



### 3. Penetration Enhancers

(Used to improve permeability of the skin)

Eucalyptus oil and menthol

Oil of cloves

Oleic acid

Camphor with limonene

They also aid medication molecules in passing through the stratum corneum and have herbal effects.

### 4. Vehicle/Solvent Ethanol

Alcohol isopropyl

Acetate of ethyl

These aid in the herbal extract's dissolution and even mixing with the glue.

### 5. Membrane Backing

protects the sticky layer and gives the patch support.

For instance, polyethylene film

PVC, aluminum foil, and polyester film

## 6. The Release Liner

Prior to application, this layer shields the glue.

Examples include Teflon sheets and silicone-coated paper.

### Method by Method (Drug-in-Adhesive Technique)<sup>27-31</sup>

#### Step 1: Herbal Drug Solution Preparation

Take the herbal extract that has been weighed.

Use an appropriate solvent (such as ethanol or isopropyl alcohol) to dissolve it.

If necessary, add a penetration enhancer (eucalyptus oil or menthol).

To obtain a clear solution, thoroughly stir.

#### Step 2 – Mixing With Adhesive

Measure out the pressure-sensitive adhesive solution.

Add the herbal medication solution to the adhesive gradually.

Continue stirring until the mixture is homogenous.

The drug-in-adhesive matrix is the name given to this combination.

#### Step 5: Backing Layer in Step Three

The produced drug-adhesive mixture should be poured or coated onto the backing membrane (plastic sheet).

Use an applicator or glass rod to spread it evenly.

Verify that the thickness is consistent.

#### Step 4: Drying

Let the coated layer dry in a hot air oven at 40°C or at room temperature for a full day.

A dry, sticky film of herbal medication forms on the backing membrane as the solvent evaporates.

#### Step 5 – Addition of Release Liner

To protect the dried adhesive layer, place a release liner over top.

To ensure appropriate adhesion, gently press.

#### Step 6: Storage and Cutting

Cut the created patch into the necessary dimensions, such as 2 x 2 cm.

Keep in an airtight container

Desiccator

### Mechanism of Drug Release

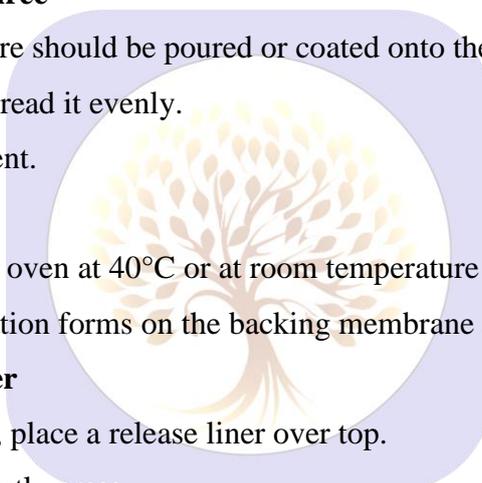
When the skin is covered with the patch:

1. Drug diffusion is activated by skin moisture
2. The medication enters the skin through the adhesive
3. It penetrates the stratum corneum
4. Affects blood circulation and the dermis

#### The release is contingent upon:

Herbal medication solubility and adhesive qualities

Condition of the skin



## Patch thickness Benefits of the Drug-in-Adhesive Method

Excellent skin contact, controlled drug release, and a simple, thin patch design

Better patient compliance

No drug spills

Adaptable and cozy

Minimal production costs

Commercially widely accepted

### **Disadvantages**

restricted ability to load drugs

Strong adhesive may cause skin irritation; it is not appropriate for medications with really high dosages.

## Herbal Drug-in-Adhesive Patch Applications

### **Used in treatment of:**

Pain in the joints

Arthritis

Pain in the back

cramping in the muscles

Anxiety and tension

Menstrual discomfort

An inflammatory response

### **Patch preparation of the reservoir type** <sup>32</sup>

#### Overview

The herbal medication (extract) in the reservoir-type transdermal patch is kept in a different reservoir compartment, typically as a gel, solution, or suspension. This reservoir, which controls the drug's release onto the skin, is positioned between a backing layer and a rate-controlling membrane.

In contrast to matrix or drug-in-adhesive systems, this method keeps the medication in a separate medicated compartment rather than mixing it directly into the polymer or adhesive. This permits:

More exact control over the release of drugs

Increased drug loading

Continuous and regulated delivery

It is frequently utilized for strong herbal extracts that need to be released continuously and for an extended period of time.

### **Reservoir Transdermal Patch Structure** <sup>33</sup>

From the top to the skin:

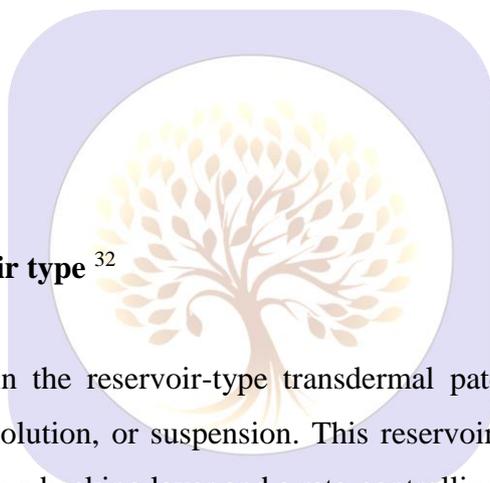
Layer of Support

Drug Reservoir (solution or gel made of herbs)

Rate-Regulating Membrane <sup>60</sup>

The Adhesive Layer

→ Skin



## Each Layer's Function

### Function of the Layer

The backing layer provide support and protects the patch.

The herbal medication is contained in a gel or solution in the drug reservoir.

Rate-controlling membrane regulates the medication release rate.

The adhesive layer secures the patch to the skin.

### The fundamental idea

A semi-permeable membrane called the rate-controlling membrane controls the release of the herbal medication when it is placed in a reservoir system.

The medication diffuses from the reservoir, passes through the membrane, reaches the skin, and enters the body when the patch is placed to the skin.

According to Fick's law of diffusion, the rate of release is dependent upon:

### **Type of membrane**<sup>58</sup>

Drug concentration

Drug solubility

Membrane thickness

The temperature

Supplies Used 1. Extracts from Herbs (Drug)<sup>34</sup>

Herbs that are frequently used:

Curcuma longa, or turmeric

Zingiber officinale, or ginger

The capsicum

Neem

Ashwagandha

Biloba ginkgo

Aloe vera

Dosage form within the reservoir:

Because it offers stability, Solution Gel Suspension Gel is most frequently utilized.

### **2. Polymer for Reservoir Gel**<sup>35-40</sup>

#### **To prepare herbal gel:**

Carbopol 934/940 HPMC

CMC of sodium

Poloxamer Chitosan

The liquid extract is transformed into a stable gel by these polymers.

### **3. Rate-Regulating Membrane**

The drug release rate is managed by this layer.

Typical materials consist of:

Cellulose ethyl



Acetate of cellulose

Polyurethanes

The silicone membrane

#### **4. Layer of Adhesive**<sup>57</sup>

Acrylic adhesives made with polyisobutylene

Silicone glues

#### **5. Penetration Enhancers (Optional)**

Clove oil, eugenol, and menthol

Oleic acid

Oil of eucalyptus

#### **6. Layer of Support**

Polyester film made with polyethylene

Aluminum foil

Detailed Instructions (Reservoir Type Patch)

#### **Step 1: Herbal Gel (Drug Reservoir) Preparation**<sup>41</sup>

1. Weigh the necessary quantity of herbal extract.
2. Use ethanol or distilled water to dissolve or disperse it.
3. Include a gelling agent, such as Carbopol.
4. Continue stirring until a homogenous gel forms.
5. If necessary, add a penetration booster.
6. To stabilize the gel, let it stand.

The reservoir for the herbal medication is this gel.

#### **Step 2 – Preparation of Rate-Controlling Membrane**<sup>42-44</sup>

1. Use an organic solvent to dissolve a polymer, such as ethyl cellulose.
2. Apply the mixture to a level surface, such as a glass plate or Petri dish.
3. To create a thin membrane film, let the solvent evaporate.

Drug diffusion will be regulated by this membrane.

#### **Step 3: Patch Layer Assembly**<sup>56</sup>

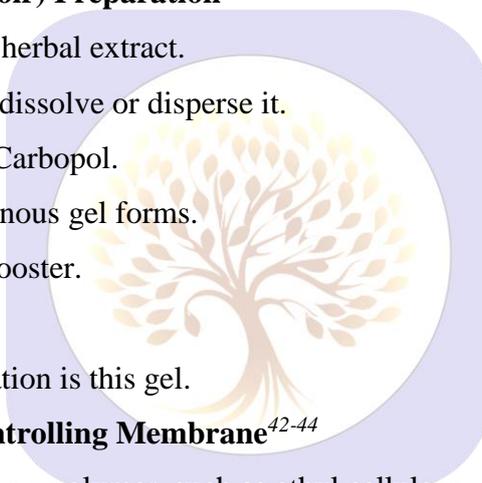
1. Lay the backing membrane flat.
2. Put a precise quantity of herbal gel in the middle.
3. Place the rate-controlling membrane over the gel.
4. Coat the membrane's borders with a thin layer of glue.
5. Correctly seal the layers.

The patch should completely surround the medication.

#### **Step 4 – Drying and Sealing**

Let the patch air dry at room temperature.

To stop medication from leaking, thoroughly seal the edges.



### Step 5: Storage and Cutting

Cut to the appropriate size, such as 2 × 2 cm or 4 x 4 cm.

Keep in:

Airtight container

Desiccator

A dry, cool area

Reservoir Patch Benefits

Outstanding control over the rate of medication release

Potentially higher drug loading

Long-term sustained release

Ideal for strong herbal medications

More precise dosage

#### Disadvantages<sup>45</sup>

1.intricate manufacturing procedure

2.Dose dumping risk in the event that the membrane ruptures

3.More expensive than a matrix system

4.larger than a medication-in-adhesive patch

5.Reservoir Herbal Patch Applications

Utilized in:

1.Management of chronic pain

2.Anti-inflammatory treatment

3.Anxiety and tension

4.Herbal hormone regulation

Arthritis and tight muscles

Prolonged treatment

#### 10. Evaluation Parameters<sup>46-51</sup>

1.Physical characteristics

2.Uniformity in weight and thickness

3.Folding stamina

4.Absorption and moisture content

5.homogeneity of drug content

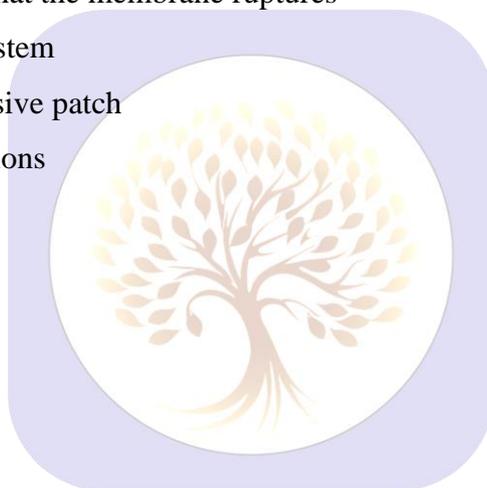
6.Tests for adhesion

7.Drug release in vitro

8.Ex vivo penetration

9.Studies on stability

10.Tests for skin inflammation



**. Uses**<sup>52</sup>

1. Joint discomfort and arthritis
2. Pain in the muscles
3. Reduction of stress
4. Healing of wounds
5. Antioxidant treatment
6. Anti-inflammatory treatment
7. Antimicrobial action
8. Slimming patches (ginger, green tea)

**12. Recent Advances**<sup>53-55</sup>

- Nanoemulsion-based herbal patches
- Microneedle-assisted transdermal systems
- Herbal patches with intelligence
- Polyherbal transdermal films
- Phytosome-filled herbal patches

**13. Conclusion**

Herbal transdermal patches successfully integrate cutting-edge medication delivery technology with conventional herbal therapy. They are practical, safe, non-invasive, and helpful for long-term treatment. The effectiveness of herbal transdermal patches can be further enhanced by ongoing research and cutting-edge formulation techniques including nanotechnology and microneedle technologies.

**14. References**

1. Prausnitz MR, Langer R. Transdermal drug delivery. *Nat Biotechnol.*
2. Guy RH. Current status and future prospects of transdermal drug delivery. *Pharm Res.*
3. Barry BW. Novel mechanisms and devices to enable successful transdermal drug delivery. *Eur J Pharm Sci.*
4. Jain NK. Controlled and Novel Drug Delivery.
5. Kaliya L, et al. Herbal transdermal patches: A review. *Int J Pharm Sci Rev Res.*
6. Sharma A, et al. Herbal approaches in transdermal drug delivery. *J Pharma Innov.*
7. Akhila A, et al. Formulation and evaluation of herbal transdermal patch. *Asian J Pharm.*
8. WHO. Quality Control Methods for Herbal Materials.
9. Gupta M, et al. Herbal drug delivery systems. *Pharmacogn Rev.*
10. Kulkarni R, et al. Herbal transdermal films for pain management. *Int J Green Pharm.*
11. Lahoti SR, et al. Permeation enhancers for transdermal patches. *J Adv Pharm Res.*
12. Chandana VR, et al. TDDS: A review. *Int J Pharm Bio Sci.*
13. Singh J, et al. Herbal anti-inflammatory patches. *Ind J Nat Prod.*
14. Bhowmik D, et al. Herbal transdermal drug delivery systems. *Pharm Lett.*
15. Patel D, et al. Transdermal patches: A review. *Int J Drug Dev Res.*
16. Mukherjee PK. Quality control of herbal drugs.
17. Rajesh N, et al. Herbal excipients in transdermal systems. *J Pharm Tech.*
18. Singh S, et al. Green tea based transdermal systems. *Int J Pharm Sci.*
19. Zaidi SMA. Transdermal films: Recent developments. *Res J Pharm Tech.*
20. Bairy I, et al. Formulation of curcumin patch. *Pharm Times.*
21. Tiwari G, Tiwari R. TDDS—An overview. *J Pharm Res.*

22. Kaur LP, et al. Aloe vera in dermatology. *Ind J Dermatol*.
23. Dash S, et al. Kinetic modeling of drug release. *Acta Pol Pharm*.
24. Patel N, et al. Microneedle based herbal delivery. *J Drug Deliv Sci Tech*.
25. Patel P, et al. Polymeric systems for TDDS. *Int J Pharm*.
26. Chien YW. Transdermal drug delivery systems.
27. Jain N, et al. Ginger-based anti-inflammatory patches. *J Herb Med*.
28. Koley S, et al. Curcumin transdermal films. *Int J Pharm Sci Rev*.
29. Sahoo SK, et al. Nano-herbal patches. *J Nanomed*.
30. Devi A, et al. Phytosome-loaded patch for arthritis. *Ind J Pharm Educ*.
31. Aulton ME. *Pharmaceutics: Design of medicines*.
32. Tripathi KD. *Essentials of Medical Pharmacology*.
33. Vedavati R, et al. Eucalyptus based herbal patches. *J Aromat Plants*.
34. Bansal K, et al. *Boswellia serrata* transdermal formulations. *J Ayurveda Integr Med*.
35. Ramesh K, et al. Capsaicin patch formulations. *J Drug Deliv*.
36. Kumar A, et al. Permeation studies of herbal drugs. *Int J Drug Deliv*.
37. Pathak P, et al. Plant actives in TDDS. *Pharmacog Commn*.
38. Nayak BS, et al. Neem in dermatology. *J Clin Biomed Sci*.
39. Chang RK, et al. Role of polymers in film formation. *Pharm Tech*.
40. Reddy KR, et al. Transdermal penetration enhancers. *Pharm Rev*.
41. Bhowal M, et al. Polyherbal patches. *Int J Pharm Pharm Sci*.
42. Patel S, et al. Formulation technologies in TDDS.
43. Sonawane R, et al. Evaluation parameters of TDDS. *J Appl Pharm*.
44. Jadhav A, et al. Antioxidant herbal patches. *J Pharmacogn Phytochem*.
45. Singh G, et al. Natural penetration enhancers. *Ind Drug*.
46. Ghode P, et al. Ginger transdermal systems. *Res Pharm Sci*.
47. Khan N, et al. Herbal pain relief patches. *J Ethnopharmacol*.
48. Khanna S, et al. Herbal patches for wound healing. *J Wound Care*.
49. Prajapati RM, et al. Herbal TDDS in Ayurveda. *AYU Journal*.
50. Bhosale U, et al. Assessment of natural polymers in patches. *Int J Pharm Chem Sci*.
51. Oliveira G, et al. Skin absorption pathways. *J Derm Sci*.
52. Wang M, et al. Herbal microneedle systems. *Adv Drug Deliv Rev*.
53. Mehta R, et al. PEG-based film systems. *J Pharm Dev*.
54. Salunkhe PS, et al. Herbal matrix patches. *J Pharm Anal Res*.
55. Patil S, et al. Transdermal systems: A comprehensive review. *J Pharm Bioall Sci*.
56. Desai S, et al. Herbal analgesic patches evaluation. *J Nat Remedies*.
57. Bakshi P, et al. Techniques for TDDS. *Pharma Rev*.
58. Verma R, et al. Herbal drug penetration studies. *J Appl Res Nat Prod*.
59. Gupta A, et al. Antimicrobial herbal TDDS. *J Microbiol Biotech*.
60. Raut S, et al. Menthol-based transdermal films. *IJPSR*