

Herbal Transdermal Patch: Formulation and Evaluation

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Abstract—Herbal transdermal patches are an emerging promising niche for the controlled release of bioactive phytochemicals in an unconventional, patient-centric transdermal method that avoids bioavailability restrictions in oral delivery by promoting transdermal permeability. The herbal compactions in the transdermal patches were developed using the solvent evaporation method by incorporating lipophilic extracts of neem, gingerol, menthol, capsaicin, curcumin from turmeric and *Centella asiatica* in suitable concentrations of HPMC, PVA, EC, and PVP in glycerin plasticizers (20% v/v concentrations), DMSO, and an ethanol and water solvent mixture (1:1 proportions), which were cast and evaporated in Petri dishes. Comprehensively rigorous evaluations included uniformity testing (weight, thickness, and uniformity of Herbal contents by UV techniques at 276nm wavelengths), mechanical testing (folding endurance, tensile strength, and elongations at break), and also comprehensive physicochemical characterizations such as moisture content and absorption capacity, surface pH of 5-6, release characteristics in fluid media, and also *ex vivo* skin permeability using the Franz cell system utilizing pigskins and adhesion force/tensile methods using tack and peel tests by imaging .

Index Terms—bioactive phytochemicals, biodegradable carrier agents, comprehensive physicochemical analysis, controlled release characteristics, *ex vivo* permeability studies, Herbal drug delivery, matrix polymers, Natural Herbal Patches, permeability-enhancing agents, solvent evaporation method

I. INTRODUCTION

People are increasingly using herbal medicines and natural remedies because of their advantages in the expanding field of healthcare. Because they are natural and typically have fewer side effects than synthetic drugs, herbs have been used for thousands of years to

treat a variety of illnesses and promote health. However, when these herbal remedies are taken orally, they may occasionally lose their potency because of liver breakdown or digestion before they enter the bloodstream. Scientists have created herbal transdermal patches, a novel method of administering herbal remedies directly through the skin, in order to address these issues. A transdermal patch is a tiny, sticky patch applied to the skin that allows the herbal active ingredients to enter the body gradually and under controlled conditions.

By avoiding the stomach and liver, this technique gradually improves the medication's effectiveness. Easy use, painless administration, better control over the amount of medication the body receives, and increased patient comfort are the primary benefits of herbal transdermal patches. They do away with the necessity of regularly administering injections or pills, which can be frightening or inconvenient for some people. This project entails creating and researching herbal transdermal patches by choosing potent herbs with therapeutic qualities and mixing them with substances that aid in the patch's adherence to the skin and appropriate medication release.

The quality of the patches will be evaluated, including how well they adhere, how consistently the herbal dosage is applied, how thick they are, and how the medication is released over time. The project's goal in creating these patches is to make it easier, safer, and more natural to use herbal remedies. This could provide patients with a cutting-edge option that honors traditional herbal knowledge while utilizing the most recent scientific methods. In the end, herbal transdermal patches may help people manage their health with more dependable and user-friendly natural remedies.

II. INGREDIENTS

1. ACTIVE HERBAL EXTRACT (PRIMARY NATURAL REMEDY)

This is the main natural medicine made from plants such as neem extract, gingerol, menthol, capsaicin, turmeric (curcumin), and Centella asiatica.

The choice depends on the required action, such as wound healing, pain relief, antimicrobial, or anti-inflammatory effects, and how well it can penetrate the skin.

The extract can be incorporated into the patch in different ways. To regulate release, liquid extracts can be evenly distributed as tiny droplets in the form of a Nano emulsion.



2. FILM-FORMING POLYMER (PATCH MATRIX)

This material forms the base of the patch, holds the herbal extract, and controls its release.

Commonly used polymers include:

Hydroxypropyl Methylcellulose (HPMC)

Polyvinyl Alcohol (PVA)

Ethyl Cellulose (EC)

Polyvinylpyrrolidone (PVP)

Chitosan (also provides skin-friendly adhesion)

The type of polymer affects the patch's strength, flexibility, moisture barrier, and the rate at which the herb is released onto the skin.

3. PLASTICIZER (MAINTAINS PATCH FLEXIBILITY)

Plasticizers prevent the patch from becoming brittle or hard.

Typical plasticizers include:

Glycerin

Propylene glycol

Polyethylene glycol (PEG 400)

The amount used influences how soft the patch is and whether any residue remains on the skin after use.

4. PERMEATION ENHANCERS (HELP HERB ENTER SKIN)

These ingredients temporarily open the skin surface to help herbal actives penetrate.

Examples include:

Propylene glycol

Fatty acids such as oleic acid and lauric acid (used sparingly)

Ethanol (sometimes also used as a solvent)

They are selected to balance effective delivery with skin comfort and safety.

5. SOLVENT SYSTEM (FOR PATCH FILM PRODUCTION)

Solvents dissolve the polymers and uniformly distribute the herbal extract during patch preparation.

Common solvents include:

Water

Ethanol

Isopropanol

The solvent chosen should dissolve both polymer and herb effectively, be safe, and leave minimal residue after drying.

6. BACKING LAYER OR BASE SUPPORT

The backing layer protects the patch from moisture and environmental damage.

It may be made of:

Polymer-coated aluminum foil

Multilayer polymer films

In some patches, this layer may also help hold and release the drug.

7. ADHESIVE (HELPS PATCH STICK TO SKIN)

Many patches include an adhesive layer to keep the patch firmly attached to the skin.

Typical adhesives include:

Acrylic-based adhesives (polyacrylates)

Polyisobutylene

In herbal patches, the adhesive may be separate or integrated into the patch matrix.

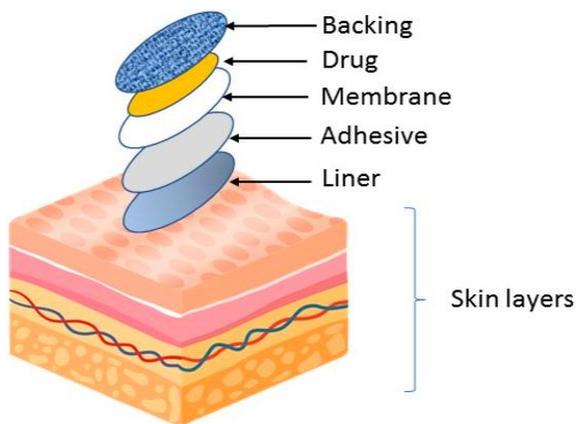
8. STABILIZERS AND OTHER EXCIPIENTS

These are added to maintain stability and comfort, such as:

Antioxidants or metal-binding agents to protect herbal actives from degradation.

Humectants or moisturizers to keep the patch comfortable on the skin.

Surfactants or emulsifiers to help mix and spread the herbal extract evenly.



III. PREPARATION OF TRANSDERMAL PATCH

Polymers of various kinds and quantities are meticulously weighed. These polymers will serve as the patch's foundation or matrix.

A 1:1 ratio of ethanol to water is used to dissolve the polymers. This solvent facilitates the correct dissolution of the polymers, resulting in a transparent solution.

After adding the herbal medication (active ingredient) to the polymer solution, the mixture is continuously mixed until it turns clear, signifying that the medication has been distributed uniformly.

20% of the total polymer volume is added to glycerin, which serves as a plasticizer to maintain the patch's flexibility.

Different concentrations of permeation enhancers, such as Dimethyl Sulfoxide (DMSO), are added. These compounds aid in the herbal medication's improved skin penetration.

To make sure all the ingredients are well combined, thoroughly stir the entire mixture.

Ten milliliters of this finished solution are poured (cast) onto a sterile Petri dish to serve as a surface for the formation of a film.

To regulate the rate of evaporation and avoid contamination during drying, an appropriately sized inverted funnel is placed over the Petri dish.

The solvent (ethanol-water) is allowed to slowly evaporate and form a dry, solid patch film by leaving the Petri dish at room temperature for a full day.

The patches are carefully taken out of the Petri dish once they have dried.

To shield the dried patches from light and moisture, they are wrapped in aluminum foil.

To prevent contamination, the wrapped patches are subsequently placed inside self-sealing covers.

Lastly, the patches are kept dry until further use, like evaluation tests, by being kept in desiccators, which are containers with moisture-absorbing substances



IV. MECHANISM OF DRUG PENETRATION

The drug's capacity to cross the skin barrier and enter the bloodstream determines how effective herbal patches are.

The stratum corneum, the skin's outermost layer, functions as a sturdy wall composed of "bricks and mortar": Corneocytes, which are dead skin cells, make up the bricks.

Lipids, or fatty substances, are what make up the mortar between these cells.

The medication has several ways to get past this barrier:

1. INTERCELLULAR PATHWAY (BETWEEN SKIN CELLS):

The medication passes through the lipid (fatty) layers between the cells. Drugs most frequently enter the body through the skin in this manner.

Drugs that like fat (lipophilic) can easily pass through the lipid layers because they are composed of ceramides, fatty acids, and cholesterol.

Herbal actives like curcumin, menthol, camphor, and terpenoids are fat-loving, so this route suits them well. Natural oils in herbs, such as eucalyptus oil and clove oil, help loosen this lipid barrier, making it easier for the drug to pass.

2. TRANSCELLULAR PATHWAY (VIA SKIN CELLS):

Here, the medication travels directly through the fatty and watery portions of the skin cells. Because the cells

are densely packed with keratin and allow little to pass through, this route is less common.

This pathway may be used by smaller herbal molecules such as flavonoids and alkaloids.

By altering the behavior of skin fats, nanotechnology carriers such as liposomes can assist medications in using this pathway.

3. SHUNT (APPENDAGEAL) ROUTE:

Drugs enter through microscopic pores such as oil glands, sweat glands, and hair follicles. Although they only cover a small portion of the skin, these apertures serve as drug shortcuts.

Because it is difficult for large or charged molecules to move through or between cells, they may take this route.

Nanoparticles and ethosomal formulations of herbs like curcumin or aloe vera use this route.

Hair follicles can also hold drugs and release them slowly over time.

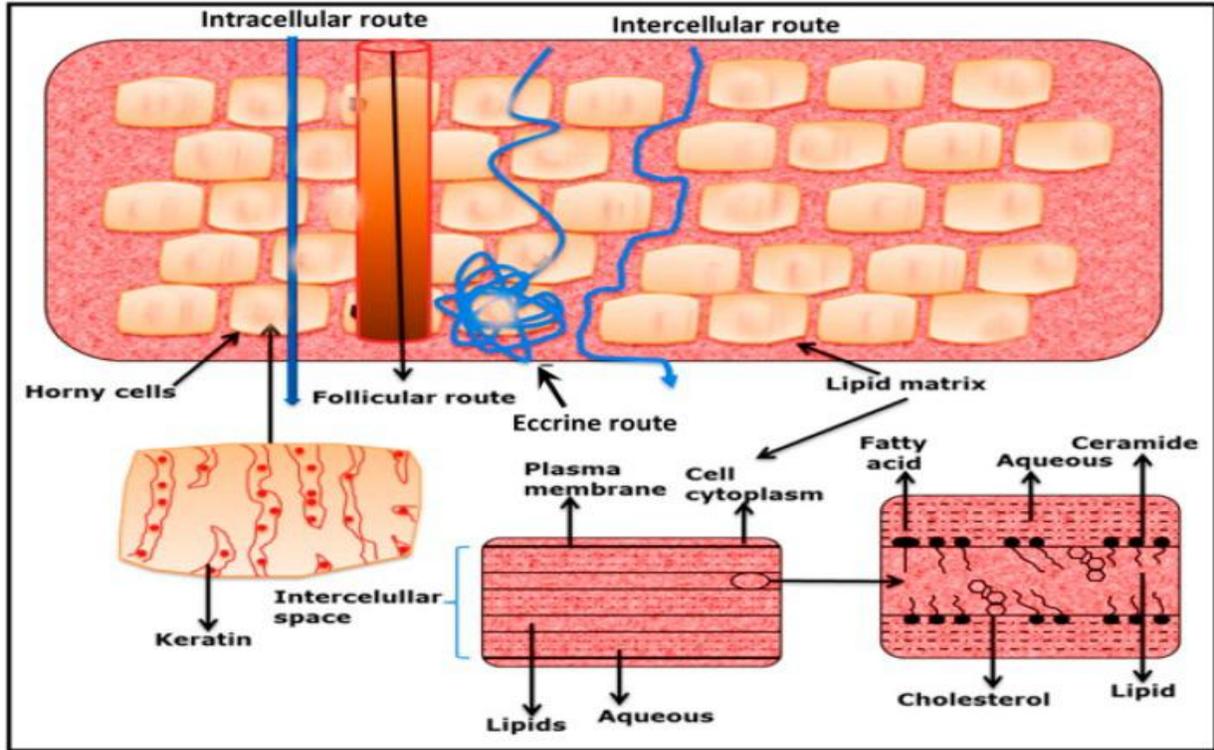
4. ENHANCED OR ASSISTED ROUTES:

Certain chemicals and physical techniques are used to temporarily open channels or alter the structure of the skin in order to help medications pass through the difficult skin barrier.

By releasing skin fats, herbal compounds such as menthol, camphor, and oleic acid improve penetration. Among the physical techniques is iontophoresis, which uses electricity to force medications through.

Sonophoresis (with ultrasonic waves). Microneedles: tiny holes created by tiny needles Electroporation (transient apertures created by electric pulses).

The amount of herbal medication that can pass through is momentarily increased by these techniques



V. EVALUATION METHODS:

1. PHYSICAL APPEARANCE (VISUAL INSPECTION):

Color: Ensures the patch has a uniform and appropriate color, consistent across batches to indicate proper formulation.

Clarity: Checks whether the patch is transparent, translucent, or opaque; clarity affects patient appeal and perceived quality.

Flexibility: Assesses how easily the patch bends without cracking or breaking, important for comfort during application.

Smoothness: Examines the surface texture to ensure there are no rough spots or irregularities that might irritate the skin.

These observations help ensure patient acceptance and skin safety.

2. UNIFORMITY OF WEIGHT:

Ten randomly selected patches are weighed individually and the average weight is calculated. Large weight differences may indicate inconsistent drug dose, affecting effectiveness and safety.

Uniform weight shows that the manufacturing process is well controlled.

3. MEASUREMENT OF THICKNESS:

Thickness is measured at different points using a micrometer screw gauge.

Ensures uniform distribution of the polymeric film or backing material.

Uniform thickness supports consistent drug release and mechanical strength and prevents the patch from feeling too thick or thin on the skin.



4. FOLDING ENDURANCE:

A small piece of the patch is repeatedly folded at the same place until it breaks.

The number of folds indicates flexibility and durability during handling, application, and removal.

Low folding endurance means the patch is prone to cracking or breaking and is unsuitable for practical use.

5. MOISTURE CONTENT:

The patch is weighed before and after drying in a desiccator.

Weight loss after drying indicates the percentage of moisture present.

Moisture affects physical properties and shelf life.

Very low moisture causes brittleness and cracking, while high moisture makes the patch soft or sticky. Proper moisture balance ensures stability and good texture.

6. MOISTURE UPTAKE PERCENTAGE:

After drying, the patch is kept in a humid environment and weighed over time.

Increase in weight shows moisture absorbed from the air.

Excessive moisture uptake may damage patch integrity and drug stability.

Optimal humidity resistance is important.

7. UNIFORMITY OF DRUG CONTENT:

The patch is dissolved in a suitable solvent (e.g., methanol), diluted with distilled water, and filtered.

Absorbance is measured using a UV spectrophotometer at a specific wavelength (e.g., 276 nm).

Confirms uniform distribution of the active herbal ingredient.

Ensures accurate drug dose for effectiveness and safety.



SURFACE PH:

The patch surface is moistened with distilled water and pH is measured using a pH meter or pH paper.

Surface pH should be close to skin pH (about 5–6).

Prevents irritation, redness, or allergic reactions.

Unsuitable pH can reduce comfort and patient compliance.

8. PERCENTAGE ELONGATION AND TENSILE STRENGTH:

Tensile strength: Force required to pull and break the patch, indicating resistance to tearing.

Percentage elongation: Measures how much the patch can stretch before breaking, showing flexibility.

A balance of strength and flexibility is needed to keep the patch intact and comfortable during use.

9. IN VITRO DRUG RELEASE:

The patch is placed in a solution that simulates body fluids.

Samples are taken at regular intervals to measure drug release.

Determines whether the drug is released consistently and sufficiently.

Indicates therapeutic effectiveness.

10. IN VITRO SKIN PERMEATION STUDY:

Uses animal or synthetic skin membranes (e.g., pig skin, Franz diffusion cells).

Measures the amount of drug passing through the skin. Predicts systemic drug delivery.

Helps optimize formulation to improve absorption without skin irritation.

11. TACK AND ADHESIVE STRENGTH:

Adhesive strength: Measures how well the patch sticks to skin or a test surface during normal activities.

Tack: Indicates how quickly and easily the patch adheres.

Tested using peel tests and tack testers.

Good adhesion ensures effectiveness, but removal should be painless and leave no residue or skin damage.

12. MICROSCOPIC ANALYSIS OF SURFACE MORPHOLOGY:

Patch surface is examined using microscopes such as scanning electron microscopy.

Evaluates smoothness, uniform drug distribution, and presence of cracks, pores, or particles.

A smooth and uniform surface reflects good formulation, quality control, performance, and comfort.

13. STABILITY STUDIES:

Patches are stored for weeks or months under controlled temperature and humidity.

Appearance, drug content, moisture content, and mechanical properties are re-evaluated.

Ensures safety and effectiveness throughout shelf life.

Helps determine expiration date and storage conditions.

VI. ADVANTAGES

- Steady release of herbs gives a long-lasting effect.
- Drug enters through skin, not stomach, so more reaches the blood.
- Can be designed for specific uses like pain, stress, or energy.
- Helps larger, water-loving molecules pass through the skin.
- Easy, quick, and painless to apply.
- Can be removed easily if side effects occur.
- Provides continuous and controlled drug delivery.

- Avoids liver metabolism, so the drug works better.
- Lower chance of interacting with other medicines.
- Patients can use it by themselves.

VII. DISADVANTAGES

- Poor Skin Penetration of Some Drugs.
- The application site may become red, itchy, or swollen for some users.
- Patches work better for long-term ailments than for sudden relief or emergencies.
- This system is ineffective for drugs that have electric charges, or ions.
- If the patch is damaged, an excessive amount of medication may be abruptly released, which could be dangerous.
- Compared to conventional tablets or capsules, transdermal patches are typically more costly

VIII. APPLICATION:

1. PAIN RELIEF:

Herbal transdermal patches with capsaicin, menthol, and turmeric are commonly used to manage muscle and joint pain. They deliver anti-inflammatory and pain-relieving herbs through the skin, allowing for local relief without the need for oral medication. These patches effectively ease back pain, arthritis, and sports injuries.

2. ANTI-INFLAMMATORY THERAPY:

Patches made with aloe vera, boswellia, and ginger target inflammation directly. They are useful for arthritis, localized swelling, and other inflammatory issues. These patches reduce redness, swelling, and discomfort, offering a natural solution for chronic inflammation.

3. WOUND HEALING AND SKIN CARE:

Patches containing centella asiatica, neem, and calendula support faster healing and skin repair. They lower infection risk and promote skin regeneration through their antibacterial, anti-inflammatory, and soothing properties. They are ideal for minor cuts, burns, and skin irritation.

4. MIGRAINE AND HEADACHE MANAGEMENT:

Patches with feverfew or peppermint oil help relieve migraines and tension headaches. They provide quick, targeted relief through the skin without affecting the digestive system. This approach minimizes side effects and offers a comfortable alternative to traditional treatments.

5. ANTIMICROBIAL AND ANTIFUNGAL TREATMENT:

Herbal patches with neem, tea tree oil, or clove oil address bacterial and fungal skin infections. These natural ingredients either kill or inhibit harmful microbes.

6. HORMONAL AND MENSTRUAL SUPPORT:

Patches deliver herbal phytoestrogens and other plant-based compounds to help balance hormones and relieve menstrual discomfort. They ease symptoms of menstruation and menopause, such as pain, cramps, and mood swings. These patches offer a gentle and convenient alternative to hormonal pills or creams.

7. COSMETIC AND ANTI-AGING USES:

Patches with antioxidants like green tea and rosemary improve skin texture and fight signs of aging. They support collagen production and protect skin from damage caused by free radicals. People often use them to reduce wrinkles and enhance skin smoothness.

8. LOCAL MUSCLE RELAXATION:

Patches containing eucalyptus, camphor, or similar herbal oils help relax tense muscles and reduce stiffness. They improve blood flow and deliver soothing compounds directly through the skin. These patches are useful for sore backs, neck tension, and post-workout soreness.

9. STRESS RELIEF AND SLEEP AID:

Patches with lavender or chamomile extracts help reduce stress and promote restful sleep. They provide gradual, calming effects to relax both body and mind, making them beneficial for insomnia and daily stress.

10. SUPPORT FOR CHRONIC CONDITIONS:

Herbal patches can help manage chronic diseases like diabetes or hypertension. They provide a slow and steady release of active compounds, enhancing

treatment while helping to reduce side effects and improve patient adherence during long-term care.

11. ALLERGY AND SKIN CONDITIONS:

Patches with calendula, neem, and chamomile are effective for managing allergies, eczema, and psoriasis. They deliver natural compounds that soothe irritated skin, lessening redness and itching while promoting healing. Using these patches avoids drug ingestion, making them gentler for sensitive skin.

12. DETOXIFICATION AND BODY CLEANSING:

Certain herbal patches promote detoxification by supporting the body's natural cleansing processes. Ingredients like turmeric and green tea boost circulation and help with toxin removal through the skin. Applying these patches to specific areas may enhance waste elimination and support overall health and clearer skin.

13. RESPIRATORY HEALTH:

Herbal patches containing eucalyptus and menthol relieve nasal congestion, cough, and chest tightness. They are applied to the chest or back, allowing active vapors to provide gentle relief to the skin and airways. These patches soothe discomfort, enhance breathing, and may reduce the need for oral medications.

14. IMMUNE SYSTEM SUPPORT:

Patches that deliver adaptogenic herbs like ashwagandha and ginseng help strengthen the body's defenses against infections and stress. These herbs help balance hormones and boost energy, aiding the body in resisting illness. The steady absorption through patches is convenient for busy individuals and those who struggle with swallowing pills.

15. WEIGHT MANAGEMENT:

Herbal ingredients such as green tea, caffeine, and garcinia cambogia in patch form aid weight loss by increasing metabolism and fat breakdown. They release active compounds gradually, providing consistent metabolic support without the side effects associated with oral supplements. When combined with diet and exercise, these patches can assist with weight control.

16. ANTI-DIABETIC EFFECTS:

Herbal patches featuring bitter melon or fenugreek help regulate blood sugar levels. These herbs enhance insulin activity and decrease sugar absorption. Their slow and controlled release through patches may support diabetic patients by minimizing blood sugar fluctuations as part of a management plan.

17. SUPPORT IN CANCER CARE:

Herbal patches containing antioxidants like curcumin and resveratrol are being explored for their potential benefits in cancer treatment. They may help lower oxidative stress, protect healthy cells, and reduce side effects from chemotherapy. The transdermal route provides a non-invasive means to deliver these compounds steadily, improving comfort and treatment outcomes.

IX. FUTURE SCOPE:

1. IONTOPHORESIS:

A small electric current, usually a few milliamperes, is passed through the skin using an electrode that contains the drug. This process helps drug molecules move across the skin.

Example: Pilocarpine is used to induce sweating for the diagnosis of cystic fibrosis. Lidocaine provides rapid local anesthesia.

2. ELECTROPORATION:

Short, high-voltage electric pulses, around 100 volts or more, are applied to the skin. These pulses create tiny, temporary pores in the skin, increasing permeability. This allows large and small molecules like DNA, peptides, and proteins to pass through.

3. MAGNETOPHORESIS:

The skin is exposed to a magnetic field. The magnetic force helps certain drug molecules move through the skin. Stronger magnetic fields improve drug absorption.

4. MICROCHANNEL FORMATION (BY METAL PARTICLES):

Tiny metal particles with sharp edges remove the outer dead skin layer. This forms microchannels that allow drugs to pass easily through the skin.

5. MICROPORATION:

Very small needles, known as microneedles, puncture only the stratum corneum, the outermost skin layer. They do not reach nerve endings, making the process painless.

Types:

1. Hollow microneedles: the drug is inside.
2. Solid microneedles: the drug is coated on the surface.

This method effectively improves drug absorption.

6. ABRASIVE SKIN TECHNIQUE:

The outer skin layers are mechanically roughened or removed. This makes it easier for drugs to enter. It is similar to cosmetic microdermabrasion used for pigmentation, scars, or acne.

7. MICRONEEDLE PATCH (DETAILED USE):

Microneedle patches deliver drugs gradually and painlessly. They are suitable for proteins, DNA, or vaccines.

Example: Microneedles have been used to deliver naltrexone, which is used for addiction treatment, through the skin.

8. ELECTRO-OSMOSIS:

When voltage is applied across a charged membrane, like skin, it helps drug molecules move through the skin after they dissolve. There is no difference in drug concentration on either side, but the electric field facilitates movement.

9. LASER RADIATION:

A controlled laser beam removes the stratum corneum without damaging deeper tissues. This increases the absorption of both fat-soluble and water-soluble drugs. Lasers can also create temporary gaps for drug entry.

10. THERMOPHORESIS:

This method involves slightly increasing skin temperature, typically to 32°C or higher. Heat improves drug absorption and release from patches. It works best for small molecules, less than 500 Daltons, such as fentanyl or tetracaine.

X. CONCLUSION:

The development of herbal transdermal patches represents a promising step forward in delivering natural medicines. By merging traditional herbal knowledge with modern pharmaceutical technology, these patches provide a non-invasive, convenient, and effective way to administer bioactive plant compounds through the skin. This method avoids the gastrointestinal tract, bypassing first-pass metabolism and improving the bioavailability of herbal ingredients, which often struggle with oral administration.

Throughout this project, we formulated herbal transdermal patches using biocompatible polymers, natural herbal extracts, plasticizers, and permeation enhancers. This combination ensured optimal drug release, patch flexibility, and skin adhesion. We prepared the patches using a solvent casting method, which allowed for uniform distribution of active compounds and resulted in patches with suitable physical and mechanical properties.

Evaluation tests showed that the patches maintained consistent thickness, drug content, moisture balance, and adhesive strength. These factors are essential for ensuring quality, stability, and patient comfort. The controlled release and sustained permeation profile confirmed the potential of these patches for effective therapeutic applications.

Herbal transdermal patches provide several benefits, including pain relief, anti-inflammatory effects, wound healing, and management of migraines, infections, and chronic conditions. Their use extends beyond medicinal therapies to cosmetic, hormonal, and stress relief applications, highlighting their versatility. However, challenges such as possible skin irritation, formulation complexity, and variability in skin absorption point to the need for further research and customization.

In summary, herbal transdermal patches have significant potential as safe and natural alternatives for drug delivery. Continued innovation and clinical validation could lead to wider acceptance and commercial production, making herbal therapy more accessible and patient-friendly in the future.

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