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TEXTILE MATERIALS FOR TRANSDERMAL THERAPY IN MEDICINE AND PSYCHIATRY

BY

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Abstract. Technological development and our lifestyle of constant stress and ongoing overstimulation have led to an increase and worsening of various psychiatric and psychological disorders in both adults and children. Oral treatment has low tolerability and compliance; it cannot be used in some patient groups and also has numerous side effects.

Textiles for medicine and healthcare have advanced significantly, resulting in notable improvements and innovations. Recent developments in transdermal drug delivery, such as 3D patches, smart patches with various sensors, and absorbable biodegradable patches, highlight the need for ongoing research, particularly in psychiatry, where patients require viable alternatives to oral medications to prevent treatment refusal. This article provides an overview of medical patches, considering the growing trend towards using transdermal patches as an alternative method of administering medication through the skin.

Keywords: smart textiles, medical patches, psychiatric disorders, alternative to oral treatment.

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1. Introduction

Textiles have been part of our lives for as long as we can remember. Recently, due to numerous changes and technological developments, the textile industry has made significant progress, especially in medicine and healthcare. Today, smart textiles equipped with various materials, sensors, and microencapsulated active ingredients for improved drug delivery and release systems, antimicrobial textiles for wound care, and biomaterials have been produced (Lis Arias, 2021).

However, every advance comes at a cost, and in recent years there has been an increase in psychiatric disorders in both adults and the paediatric population. A 2024 study in the UK found that, in addition to the urgent need for skilled health care professionals, there was a 21% increase in patients seeking psychiatric care between 2016 and 2019. The mental health crisis has been exacerbated also by COVID, with more than 1,4 million people on waiting lists in order to get professional treatment for psychiatric problems (British Medical Association 2020). For example, depressive disorders are the leading cause of disability, affecting 300 million people worldwide. The World Health Organization has stated that by 2030, depression will be the leading contributor to premature death and years lived with disability (YLWD - a measure reflecting the impact of an illness on quality of life; disease severity index) (World Health Organization, 2017). Symptoms of depression include difficulty concentrating, difficulty remembering details and making decisions, feelings of guilt, worthlessness and helplessness, pessimism and hopelessness, insomnia, irritability, low self-esteem, loss of interest in previously enjoyable activities, and suicidal thoughts or attempts (American Psychiatric Association, 2022). Oral treatment has many disadvantages, it cannot be used in some patient groups (geriatric patients with certain neurological problems, pediatric population) and also has numerous side effects: weight gain, digestive problems, liver disease. These results highlight the need for research to develop more efficient treatment methods.

This article briefly presents transdermal drug delivery and medical patches as an exciting and promising alternative to conventional routes of medication administration.

2. Drug delivery routes

There are traditional methods of administering medication, many of which have various disadvantages, as summarised in Table 1.

Table 1

Conventional routes of drug administration and their disadvantages

2.1. Oral route ✓ has many sides effects ✓ requires high dosages ✓ it cannot be used in some group patients (geriatric patients with neurological conditions and difficulty swallowing, pediatric patients).
2.2. Intravenous/intramuscular route ✓ is painful ✓ has the risk of infection
2.3. Inhalatory route ✓ is used mainly in hospital settings ✓ is difficult in achieving the right dosage ✓ has risk of pollution ✓ is not environment-friendly.

Transdermal drug delivery

Recent trends and research focus on the use of transdermal drug delivery as a convenient and easy alternative for administering medication via the skin. It offers numerous advantages over conventional methods of drug administration, as summarised in Table 2 (Mishra *et al*., 2025).

Table 2

Advantages and disadvantages of transdermal drug delivery route

Advantages	Disadvantages
✓ Less invasive ✓ Patient-friendly ✓ Easy to apply ✓ Does not require digestive absorption ✓ Avoids first pass metabolism ✓ Continuous dosing ✓ Can be terminated anytime ✓ Multi-day treatment (up to 9H-9days)	✓ Limited type of medication ✓ Skin irritation ✓ Patch failure ✓ Inconsistent absorption ✓ Limited dosing options ✓ Unusable in acute/emergency situations

The first medical patch was developed in 1979, containing the active ingredient scopolamine, which is used to treat motion sickness. Shortly afterwards, a second patch was developed with nitroglycerin to treat cardiovascular disease, such as angina and hypertension (Pastore *et al*., 2015).

Currently, many patches are available on the market for the treatment of various diseases. For cardiovascular disease, there is the Bisoprolol patch; for pain therapy, Lidocaine, Fentanyl, and Buprenorphine patches; for hormonal

therapy, Estrogen and various forms of Estradiol patches; and for anti-emetic therapy, the Granisetron patch (Le *et al*., 2017; Chen *et al*., 2013; Swaminathan *et al*., 2020).

As a non-invasive method of delivering medication through the skin, transdermal drug delivery has gained increasing enthusiasm and interest over time, keeping pace with recent developments in the medical field and providing patients with an alternative means of administering medication.

Being very easy to use, it increases patients' compliance with treatments, does not require digestive absorption, facilitates rate-controlled dosage, and can be applied daily or, depending on the treatment, even weekly. Considering the worldwide shortage of sufficient medical staff, patches offer another significant advantage, as they do not require medical assistance, unlike intravascular or intramuscular administration. Patches can represent an easy, safe, and self-administered method of treatment (Rotake *et al*., 2024).

Patch structure and components

A transdermal patch consists of several layers in order to deliver medication through the skin, as illustrated in Fig. 1 (Wong *et al*., 2023).

The backing layer: the outer layer that protects the patch from the external environment.

The active substance layer: it contains the drug that will be delivered at a certain rate.

The rate controlling membrane: it controls the rate at which the active substance is released within a semi-permeable membrane.

The adhesive layer: facilitates patch adherence to the skin. It can be pressure sensitive, made from polyacrylates, polysobutylene or silicon.

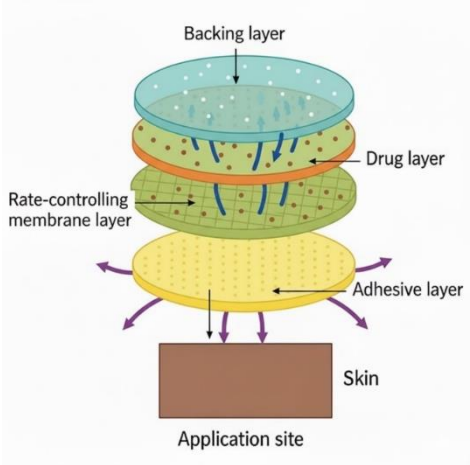

Fig. 1 – The main layers of a transdermal patch (AI generated image, 2025).

There are four main types of transdermal patches (Bird and Ravindra, 2020), described below.

1. Drug-in-adhesive system (DIA): the adhesive layer contains the active substance and releases it over a specific period.

2. Reservoir system: the drug is contained in a liquid compartment, separated from the liner and adhesive. It may be in the form of a suspension or solution and is released into circulation through a rate-controlling membrane.

3. Matrix system: the drug is dispersed in a solution containing various polymers. Its effectiveness is highly dependent on skin permeability, which makes it difficult to use.

4. Micro-reservoir system: this is a combination of matrix and reservoir systems. The drug is suspended in an aqueous solution of a water-soluble polymer and then dispersed in a lipophilic polymer to create multiple drug reservoirs.

Several factors play an important role in determining the efficiency of the transdermal patch: the active ingredient is affected by skin permeability, the area of the body where the patch is applied, and the metabolic activity of the skin. To achieve optimal absorption and skin penetration, the active substance should be lipophilic, have a molecular weight under 500 Daltons, and require a therapeutic dose of less than 10 mg per day.

Current and future directions in transdermal drug delivery

Although transdermal patches are a very convenient and patient-friendly alternative to conventional routes of administering treatment, there are still very few drugs that can be incorporated in a patch. The main problem lies in the difficulty of penetrating the outermost layer of the skin, the stratum corneum.
The skin is the largest organ in the human body and is the first protective barrier we have from harmful factors. It has three main layers: the epidermis, dermis and hypodermis. The hypodermis is made of fat cells, with multiple roles, especially in maintaining optimal body temperature. The dermis lies beneath de epidermis, and it is made of collagen and elastin. It provides elasticity and is highly vascularized. The epidermis is mainly formed of keratinocytes that are the basic part of the stratum corneum, a dense structure that prevents outer substances from penetrating the skin (Mishra *et al*., 2025).

In order to find the best way to penetrate the skin, *microneedle patches* were developed (Dillon *et al*., 2017). Nowadays, there are different types of microneedle patches available: coated microneedles, solid microneedles, hollow microneedles, dissolving microneedles, hydrogel-forming microneedles etc. (Khalid *et al*., 2023). They are being used and also considered for future research in: immunotherapy, vaccines, diabetes, cancer and genetic disorders (Al-Japairaia *et al*., 2020).

The use of biomaterials for transdermal drug delivery is a promising new approach in the medical field (Santos *et al*., 2018). Biomaterials are classified as

biodegradable, biocompatible, and biobased, and can be used in cancer therapy, cardiovascular and neurological diseases, and vaccines, as they offer personalised treatment for patients and few side effects (Lis Arias *et al*., 2018a, b).

Another innovation in the field of medical textiles is the development of *smart patches* embedded with microcapsules or various sensors that can be used to treat or monitor different diseases. They are used for diabetic patients or those who are unable to walk and suffer from various skin lesions (Thirunavukkarasu *et al*., 2022; Andrews *et al*., 2011).

3D patches are currently being researched for the development of personalised treatment and tissue regeneration (Norman *et al*., 2017; Trenfield *et al*., 2018; Zhang and Mao, 2017).

Continuous advancement and research are essential for patient outcomes in all medical fields, but especially in psychiatry, due to the unique patient profile. The need for a tolerable alternative of administrating treatment is essential to patient compliance. There are currently few patches available for psychiatric treatment, as summarized in Table 3 (Song *et al*., 2017; Suzuki *et al*., 2021; Cutler *et al*., 2022).

Table 3
Patches available on the market for psychiatric conditions

Substance	Pathology
ASENAPINE	Mania, Bipolar disorder, Schizophrenia
CLONIDINE	ADHD, Tourette syndrome, Anxiety
DEXTROAMPHETAMINE	ADHD
METHYLPHENIDATE	ADHD
NICOTINE	Smoking cessation
RIVASTIGMINE	Dementia
ROTIGOTINE	Parkinson's disease
SELEGILINE	Depression

3. Conclusions

Mental health problems place a significant burden on society, families, and the personal lives of patients. Considering that depressive disorders are the leading cause of disability, affecting 300 million people worldwide, and that the World Health Organization has stated that by 2030 depression will be the leading contributor to premature death and years lived with disability (YLWD – a measure reflecting the impact of an illness on quality of life and a disease severity index), there is an urgent need for research to develop more effective treatment methods.

Recent advances in transdermal drug delivery, such as 3D patches, smart patches with various sensors, and absorbable biodegradable patches, as well as

ongoing research, are especially needed in psychiatry, where patients require a viable alternative to oral medications; otherwise, they may refuse treatment.

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MATERIALE TEXTILE PENTRU TERAPIA TRANSDERMICĂ ÎN MEDICINĂ ȘI PSIHIATRIE

(Rezumat)

Dezvoltarea tehnologică, stilul nostru de viață marcat de stres constant și suprastimulare permanentă a dus la o creștere și o exacerbare a diverselor tulburări psihiatrice și psihologice, atât la adulți, cât și în rândul populației pediatrice. Tratamentul oral are o tolerabilitate și o complianță scăzută, deoarece nu poate fi folosit la anumite categorii de pacienți și, de asemenea, are numeroase efecte secundare. Textilele în medicină au înregistrat progrese semnificative de-a lungul timpului, ducând la îmbunătățiri și inovații remarcabile. Progresele recente în administrarea transdermică a medicamentelor (plasturi 3D, plasturi inteligenți cu diverși senzori, plasturi biodegradabili absorbabili) și cercetările continue sunt necesare, în special în domeniul psihiatric, unde pacienții au nevoie de o alternativă viabilă la medicamentele orale, altfel putând refuza tratamentul. Acest articol oferă o imagine de ansamblu asupra plasturilor medicali, ținând cont de tendința tot mai mare de utilizare a celor transdermici, ca soluție alternativă de administrare a medicamentelor prin țesutul cutanat.