

Pressure sensitive adhesives in transdermal drug delivery system

Onkar B. Patil¹, Swarupa N. Shirke², Arehalli S. Manjappa¹, Popat S. Kumbhar¹
John I. Disouza¹

¹Tatyasaheb Kore College of Pharmacy, Warananagar, Tal: Panhala, Dist. Kolhapur, Maharashtra-416113, India

²Shree Santkrupa College of Pharmacy, Shivajinagar, Ghogaon, Maharashtra, India.

✉ Corresponding author: obpatil.tkcp@gmail.com

Received: July 11, 2022 / Revised: Aug 18, 2022 / Accepted: Aug 20, 2022

Abstract

Transdermal drug delivery systems (TDDS) are used to transfer medicines into the systemic circulation through the skin. (Trans)dermal patches are well-known pharmacological formulations that are applied to the skin's surface for a variety of reasons, ranging from treating cutaneous diseases to achieving a systemic impact. Transdermal drug delivery (TDD) devices rely heavily on adhesives. In addition to the normal functional adhesive qualities, adhesives for TDD applications must be biocompatible with the skin, chemically compatible with the medication, and enable consistent, efficient drug administration. One of the most important components of a TDDS is the pressure-sensitive adhesive (PSA). PSA's primary role is to aid patch adherence to the skin, but it also serves as a matrix for the medication and other excipients. As a result, PSA impacts other important quality aspects of the TDDS, such as drug distribution, flux through skin, and physical and chemical stability of the completed product, in addition to patch adherence. This article addresses transdermal drug delivery systems, their benefits and drawbacks, and their uses in pharmaceuticals, as well as providing detailed information on pressure sensitive adhesives.

Keywords Transdermal drug delivery; Adhesives; Pressure sensitive adhesives; pharmaceutical applications

Introduction

Transdermal drug delivery systems (TDDSs) make it easier for therapeutic amounts of pharmacological compounds to pass through the skin and into the bloodstream for systemic effects (Cilurzo, et al., 2014). Stoughton was the first to think about medication absorption through the skin in 1965. The Food and Drug Administration (FDA) authorized the first transdermal system, Transderm Scop (Baxter), in 1979 for the prevention of nausea and vomiting associated with travel, particularly at sea. Transdermal patches are pharmacological preparations that distribute a medication over the skin in a regulated and sustained manner for a variety of purposes. Adhesive matrices are soft thermoplastic polymeric materials that attach to a substrate with minimal pressure and leave no trace on the skin's surface when removed. In 1979, the United States Food and Drug Administration (FDA) authorized the first transdermal drug delivery system (TDDS), which was a scopolamine patch for the treatment of motion sickness. Other medications include estrogen (for menopause and to prevent osteoporosis after menopause), nicotine (for stopping

smoking), lidocaine (for shingles pain relief), and nitroglycerin (to ease the agony of shingles) (for angina).

Advantages of TDDS

The most important benefits of TDDS are that it provides a longer period of administration and keeps drug levels within the therapeutic window, improves patient compliance, reduces side effects, improves bioavailability, more uniform plasma level, hepatic first pass metabolism, and improves therapeutic efficacy (Tan, 1999).

Disadvantages of TDDS

Some individuals develop contact dermatitis, and medications that need high blood levels are expensive and not appropriate for all patients.

Components of TDDS

Components of transdermal drug delivery systems are summarized as below (Tan, 1999):

- **Polymer Matrix-** An essential and vital component of TDDS. Cross-linked polymers, polymer blends, and plasticizers are all used to change the characteristics of polymers.
- **Drug substance** refers to a drug that has been dissolved or distributed in a matrix.
 - mol. wt.1000 Daltons; mol.
 - Adequate lipid and water solubility (1 mg/ml).
 - For effective therapeutic activity, an optimal partition coefficient is necessary.
 - It should have a low melting point (below 200 degrees Fahrenheit).
 - pH ranges from 5 to 9.
 - Short half-life, high potency (25mg dosage)
 - It should be allergy-free, irritant-free, and intolerable
- **Penetration enhancers-** increases skin permeability by changing the barrier to desired penetration flux. Alcohols, surfactants, water, fatty acids, and so forth.
- **Drug Reservoir Components-**Components of the drug reservoir should be compatible and allow for drug transfer at the required pace. It should have the viscosity, adhesiveness, and cohesiveness that you want. Mineral oils, polyisobutylene, HPC, colloidal silica, and other materials are examples.
- **Backing Membrane-** The backing membrane's principal role is to give support and prevent medication from escaping through the top of the dosage form. Low moisture and vapor transfer rates, as well as optimum elasticity, flexibility, and tensile strength are all desirable.
- **Adhesives-**Adhesives serve to hold the patch's components together as well as attach the patch to the skin, enhancing medication release. Silicone adhesives, polyisobutylene, polyacrylates, and other similar materials are examples.
- **Rate-controlling membrane-** Drug release from the dosage form is controlled by the rate-controlling membrane. Chitosan, ethylene vinyl acetate (EVA), poly-2-hydroxyethylmethacrylate (PHEMA), and other similar materials are examples.
- **Release liner-** Before applying the patch, the release liner must be removed. It guards against the loss of medicine that has moved into the adhesive layer during storage, as well as the contamination of medications. PVC, PG, PEG, and other similar materials are examples. (Fig. 1)

Technologies for Developing TDDS

Pressure sensitive adhesives (PSAs)

PSAs are materials that attach to a substrate with minimal pressure and leave no adhesive residue when removed. PSAs, which are described as adhesives capable of attaching to a surface with the application of mild pressure, are used to achieve transdermal delivery system (TDS) skin adherence. In addition to performing their adhesion role, PSAs are utilized as a matrix to retain the medication and manage its

release rate. Acrylic PSAs have been used in TDDS for decades and have played a key role in TDDS development in order to achieve the appropriate drug release profile in drug-in-adhesive patches. PSAs are a key excipient in transdermal patches, where various interactions with the medication govern the drug release profile. PSAs can have a direct impact on the system's permeation, release, and performance. Appropriate tack, skin adherence, and cohesive strength are all functional characteristics of PSAs (Barnhart, 1998; Benedek and Heymans, 1997; Musolf, 1987; Peterson et al., 1997; Banerjee et al., 2014). (Fig. 3)

Polyisobutylene's (PIBs)

The elastomeric polymers utilized as major base polymers and tackifiers are isobutylene homopolymers. This polymer has a glass transition temperature (T_g) of around -70 °C, which gives it flexibility and tack (Higgins et al., 1989; Pfister et al., 1992). Polymer permeability diminishes as the molecular weight of the polymer rises. The backbone is made up of C-H. PIB formulations include a variety of adhesives such as fillers and tackifiers. Tackifiers include polybutene, resin, and polyterpenes; plasticizers include mineral oil, diethyl phthalate, and adipates; and fillers include silicon, clay, microcrystalline cellulose, and other materials.

Silicones

Silicon polymer and silicate resin are the two components. Poly-dimethyl siloxane is a polymer with a residual silanol group at the end. Poly-dimethyl siloxane provides excellent diffusivity to a range of medicinal compounds because to their low glass transition temperature (T_g) of -127 °C and large void volume. Silicone polymer and resin were mixed in the same solvent during the formulation process, followed by a condensation reaction, resulting in silicone pressure sensitive adhesives. During the production of TDDS for this type of adhesive, no further additives are necessary. The end capping trimethylation process with methyl group can improve adhesive stability (Lobo et al., 2016)

Acrylic adhesives/Acrylates

These PSAs are biocompatible, have high adhesion, and may be used with a variety of medicinal compounds and excipients. TDDS does not require any additional additives throughout the manufacturing process. CH₂=CH-COOR is the general formula for this PSA. Primary monomer, modifying monomer, and functional group monomer are the three types of monomers found in it. About 50-90 percent of the overall composition is made up of primary monomers. Tack and flexibility are imparted by alkyl and methacrylate monomers, and tack and flexibility rose as monomer length increased. 2-ethylhexyl acrylate, butyl, ethyl, and iso-octyl acrylates are only a few examples (Temin, 1990). The mechanical and physical characteristics of acrylates can be improved by modifying monomers (Satas, 1989). For example, methacrylic acid, Vinyl acetates etc.

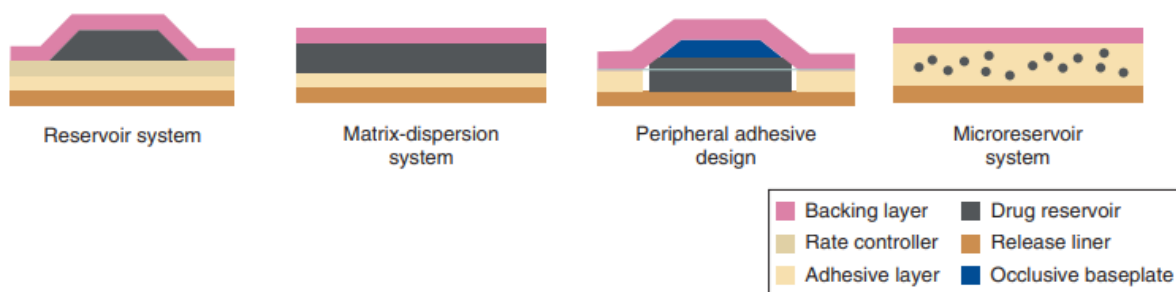


Fig 1. Types of TDDS

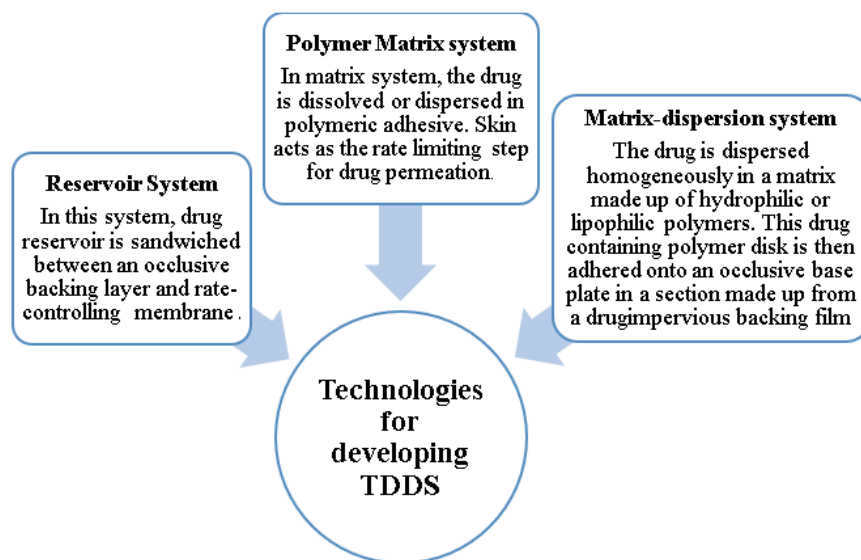


Fig 2. Technologies for developing TDDS

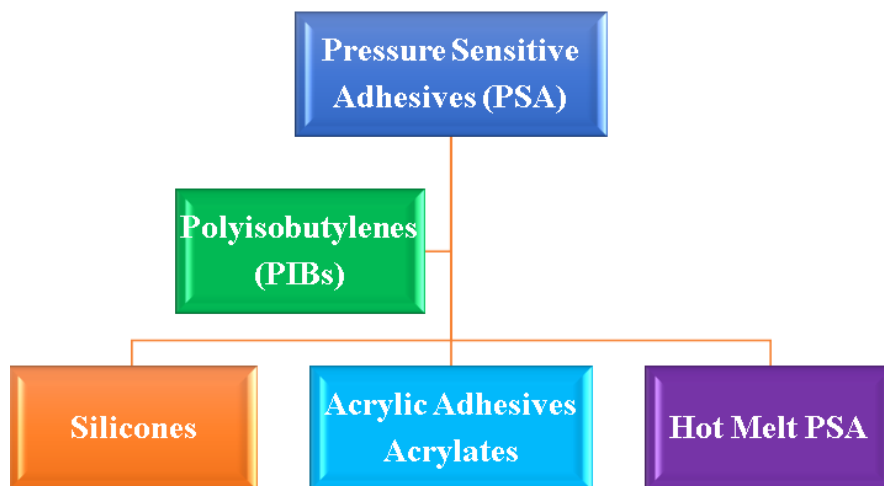


Figure 3. Types of Pressure Sensitive Adhesives (PSA)

Table 1. PSAs used in various TDDS

Type of PSA used	Drug	Indications
Acrylate	Oxybutynin	Overactive bladder
	Selegiline	Major Depressive Disorder
	Granisetron	Chemo-induced emesis
	Buprenorphine	Chronic Pain
	Sumatriptan	Migraine
	Estradiol and levonorgestrel	Menopausal Symptoms
	Propranolol	Antihypertension
	galantamine	Alzheimer's disease
PIB	Fentanyl HCl	Attention deficit/ hyperactivity disorder
	Ethinyl estradiol	Contraception
	4-benzylpiperidine	Attention deficit/hyperactivity disorder
Silicone	Rotigotine	Parkinson's disease
	Capsaicin	Neuropathy pain
	Lidocaine	Chronic pain
Hot melt PSA	ketoprofen or nicotine	Acute and Chronic Pain

Hot melt pressure sensitive adhesives (HMPSAs)

Polymers are melted into a flowable viscosity in this PSA, which allows for easy coating at room temperature. During the preparation, there is no need to add any additional organic solvent. HMPSA is frequently used as ethyl vinyl acetate. To increase both physical and mechanical characteristics, plasticizers, fillers, and antioxidants must be added.

Applications of PSAs in TDDS

Pressure sensitive adhesives can be utilized in a variety of TDDS to improve characteristics such as tackiness, medication release control, and surface (skin) contact. Some of the PSAs that are utilized in TDDS are given in Table 1. (Ganti et al., 2016; Yang et al., 2018; Ameena and Michniak-Kohn, 2019; Musazzi et al., 2020)

Abbreviations

TDDS- Transdermal Drug Delivery System; PSA- Pressure Sensitive Adhesives; HMPSAs- Hot Melt Pressure Sensitive Adhesives; PIBs-Polyisobutylene's; TDS- Transdermal Delivery System; PVC- Polyvinyl Chloride; PG- Polythene glycol; PEG- Polyethylene Glycol; EVA- Ethyl Vinyl Acetate

Acknowledgements

We are greatly thankful to our Head of Institute and Institute Management for supporting this review project.

Conflict of Interest

The author hereby declares no conflict of interest.

Funding support

The author declares that they have no funding support for this study

References

- Ameena, D., Michniak-Kohn, B. (2019). Development and in vitro evaluation of pressure sensitive adhesive patch for the transdermal delivery of galantamine: Effect of penetration enhancers and crystallization inhibition. *European Journal of Pharmaceutics and Biopharmaceutics*, 139, 262–271.
- Banerjee, S., Chattopadhyay, P., Ghosh, A., Datta, P., & Veer, V. (2014). Aspect of adhesives in transdermal drug delivery systems. *International Journal of Adhesion and Adhesives*, 50, 70-84.
- Barnhart, S. (1998). Critical Role of PSA in Transdermal Drug Delivery. Adhesives and Sealants Industry, MI, USA 1–6.
- Benedek, I., Heymans, L.J. (1997) Pressure Sensitive Adhesive Technology. Marcel Dekker, NY, USA.
- Cilurzo, F., Selmin, F., Gennari, C. G., Montanari, L., & Minghetti, P. (2014). Application of methyl methacrylate copolymers to the development of transdermal or loco-regional drug delivery systems. *Expert opinion on drug delivery*, 11(7), 1033-1045.
- Dasht Bozorg, B., & Banga, A. K. (2020). Effect of different pressure-sensitive adhesives on performance parameters of matrix-type transdermal delivery systems. *Pharmaceutics*, 12(3), 209.
- Ganti, S. S., Bhattacharjee, S. A., Murnane, K. S., Blough, B. E., & Banga, A. K. (2018). Formulation and evaluation of 4-benzylpiperidine drug-in-adhesive matrix type transdermal patch. *International journal of pharmaceutics*, 550(1-2), 71-78.
- Higgins, J.J., Jagisch, F.C., Stucker, N.E. (1989) Handbook of Pressure Sensitive Adhesive Technology. Van Nostrand Reinhold, NY, USA.
- Lobo, S., Sachdeva, S., & Goswami, T. (2016). Role of pressure-sensitive adhesives in transdermal drug delivery systems. *Therapeutic delivery*, 7(1), 33-48.
- Musazzi, U. M., Orteni, M. A., Gennari, C. G., Casiraghi, A., Minghetti, P., & Cilurzo, F. (2020). Design of pressure-sensitive adhesive suitable for the preparation of transdermal patches by hot-melt printing. *International Journal of Pharmaceutics*, 586, 119607.
- Musolf, MC. (1987). Transdermal Controlled Systemic Medications. Marcel Dekker, NY, USA (1987).

- Peterson, T.A., Wick, S.M., Ko, C. (1997). Transdermal and Topical drugdelivery systems. Interpharm Press,IL, USA.
- Pfister, W. R., Woodard, J. T., & Grigoras, S. (1992). Developing drug-compatible adhesives for transdermal drug delivery devices. *Pharmaceutical technology*, 16(1).
- Satas, D. (1989). Handbook of Pressure Sensitive Adhesive Technology. Van Nostrand Reinhold, NY, USA.
- Tan, H. S., & Pfister, W. R. (1999). Pressure-sensitive adhesives for transdermal drug delivery systems. *Pharmaceutical Science & Technology Today*, 2(2), 60-69.
- Temin, S.C. (1990) Handbook of Adhesives (3rd Edition). Van Nostrand Reinhold, NY, USA.
- Yang, D., Wan, X., Quan, P., Liu, C., & Fang, L. (2018). The role of carboxyl group of pressure sensitive adhesive in controlled release of propranolol in transdermal patch: Quantitative determination of ionic interaction and molecular mechanism characterization. *European Journal of Pharmaceutical Sciences*, 115, 330-338.

How to cite this article

Patil, O.P., Shirke, S.N., Manjappa, A.S., Kumbhar, P.S. and Disouza, J.I. (2022). Pressure sensitive adhesives in transdermal drug delivery system *Chemical and Environmental Science Archives*, Vol. 2 (3), 17-21. <http://dx.doi.org/10.47587/CESA.2022.2301>

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)



Publisher's Note: MD International Publishing stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.