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FORMULATION AND EVALUATION OF DULOXETINE HYDROCHLORIDE TRANSDERMAL PATCHES

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ABSTRACT

Transdermal patches are a non-invasive method of drug administration. It is an adhesive patch designed to deliver a specific dose of medication through the skin and into the blood stream throughout the body**.** Transdermal drug delivery system is an advanced drug administration technique. It represents a significant advancement in the field of novel drug delivery offering an alternative to traditional methods such as oral tablets, injections and topical formulations. Transdermal patches of duloxetine hydrochloride (HCl) are being developed as a controlled-release, non-invasive alternative to oral administration for treating depression and chronic pain. These patches improve bioavailability, reduce dosing frequency, and avoid gastrointestinal side effects like nausea or toxic metabolites, often using drug-in-adhesive or polymeric matrix systems. Transdermal patches were prepared by using solvent casting method using polymers such as hydroxypropyl methyl cellulose (HPMC) patch forming agent and PEG 400 (polyethylene glycol) used as plasticizer to enhance skin flexibility. the patches were evaluated includes peel test, tack test, tensile strength, in-vitro drug release, skin irritation studies. The results that duloxetine hydrochloride patches suggest excellent quality and uniformity patch characteristics. The patch showed effective dose for 24 hours, improve patient compliance for effective depression management.

KEYWORDS: Duloxetine hydrochloride, solvent casting method, transdermal drug delivery, HPMC, in- vitro drug release, control release.

INTRODUCTION

Patch is a thin, flexible medicated device designed for application to the skin. It contains a drug reservoir or matrix that releases medication in a controlled manner. The drug diffuses through the skin either for local or systemic therapeutic action. They improve patient compliance by offering a simple, painless and sustained release method. Transdermal patches are a non-invasive method of drug administration. It is an adhesive patch designed to deliver a specific dose of medication through the skin and into the blood stream throughout the body.

History of Transdermal patch

The first transdermal patch was approved in 1981 to prevent the nausea and vomiting associated with motion sickness. The FDA has approved, till 2003, more than 35 transdermal patch products, spanning 18 molecules. Two now recently approved transdermal patch products Estradiol and orelgestromin and a patch to treat overactive bladder containing oxybutyninn.

Fig. 1: Transdermal Patch.

SKIN ANATOMY AND PHYSIOLOGY OF SKIN

Skin is composed of

1. Epidermis Dermis
2. Dermis
3. Hypodermis

Epidermis: The epidermis is the outermost layer of the skin and plays a crucial role in transdermal drug delivery. It is composed of several layers, among which the stratum corneum serves as the principal barrier to drug permeation. This layer consists of dead; keratinized cells embedded in a lipid matrix that markedly restricts the diffusion of drug molecules.

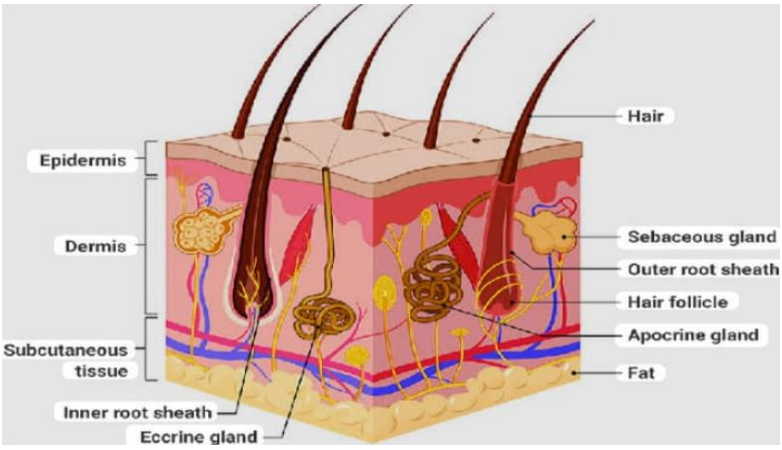


Fig. 2: Structure of skin.

Dermis: The dermis is the thick, vascular rich in capillaries, and the deeper reticular dermis, which consists of dense connective tissue containing collagen fibers, elastic fibers, and reticular fibers. The dermis houses essential components such as blood vessels, lymphatic vessels, nerve endings, hair follicles, sweat glands, and sebaceous glands, all of which influence drug absorption.

Hypodermis: It is also called the subcutaneous tissue; is the deepest layer of the skin located below the dermis and is composed mainly of loose connective tissue and adipose (fat) cells. In transdermal drug delivery systems, the hypodermis plays an important role as a drug uptake and distribution layer rather than a barrier. After a drug permeates through the stratum corneum, viable epidermis, and dermis, it reaches the hypodermis, where the rich network of blood vessels.

Types of transdermal patches

1. Reservoir patch.
2. Matrix patch.
3. Drug- in -adhesive patch.
4. Multi laminate patch.
5. Microreservior patch.

Reservoir patch

Drug is stored in a liquid or gel reservoir. A rate-controlling membrane regulates drug release to the skin. Provide zero order release in many cases.
Ex: Nitro- glycerin reservoir patch.

Matrix Patch

Drug is uniformly dispersed in a polymer matrix. Drug diffuses from the matrix directly into the skin. Simpler design and safer than reservoir systems. Release follows diffusion-controlled kinetics.
Ex: Nicotine matrix patch.

Drug-in-Adhesive Patch

Drug is incorporated directly into the adhesive Laye Adhesive acts as both drug reservoir and skin-contact layer. Thin, flexible, and comfortable. Most commercially popular system.
Ex: Fentanyl, Estradiol patch.

Multi-Laminate Patch

Contains multiple drug-loaded layers (immediate + controlled release). Allows biphasic or programmed drug delivery. Useful for maintaining plasma drug levels. Complex design compared to single-layer patches.

Microreservior Patch

Combines features of reservoir and matrix systems. Drug is suspended in microscopic reservoirs within a polymer matrix. Provides controlled and prolonged release. Lower risk of dose dumping than reservoir patches.

MATERIALS AND METHODS

Chemicals: Duloxetine hydrochloride, hydroxy propyl methyl cellulose (HPMC), ethyl cellulose, poly ethylene glycol (PEG 400), methanol, ethanol, oleic acid, aluminum foil.

Solvent Casting Method

Step 1: Preparation of Polymer Solution

Weigh the required amount of polymer(s). Dissolve the polymer in a suitable volatile solvent (methanol, ethanol, or water–alcohol mixture). Stir the solution continuously using a magnetic stirrer until a clear, homogeneous polymer solution is obtained.

Step 2: Incorporation of Drug

Accurately weigh the required amount of Duloxetine hydrochloride. Dissolve the drug in a small volume of the same solvent used for polymer solution or in a compatible co-solvent. Add the drug solution slowly to

the polymer solution under continuous stirring to ensure uniform distribution.

Step 3: Addition of Plasticizer
Add the plasticizer (e.g., 10–20% w/w of polymer) to the mixture to enhance flexibility and prevent brittleness. Stir the mixture thoroughly for 30–60 minutes to achieve a uniform casting solution.

Step 4: Degassing
Allow the prepared solution to stand or sonicate gently to remove air bubbles that could cause imperfections in the patch.

Step 5: Casting
Pour the solution onto a clean, levelled glass or Teflon plate or the backing membrane. Spread the solution evenly using a glass rod, doctor blade, or spreader to obtain uniform thickness.

Step 6: Solvent Evaporation
Allow the solvent to evaporate at room temperature or under controlled conditions (e.g., 40–50°C in a hot air oven). Complete drying ensures formation of a uniform, flexible, and drug-loaded film.

Step 7: Film Removal and Cutting
Carefully peel the dried patch from the casting surface. Cut into desired sizes (e.g., 2×2 cm^2 or 4×4 cm^2).

Drug–Polymer Compatibility Studies of Duloxetine Hydrochloride Using FTIR
FTIR studies were carried out to evaluate the compatibility of Duloxetine with selected polymers used in transdermal patch formulation. FTIR spectra of pure Duloxetine, individual polymers, and physical mixtures of Duloxetine with polymers (1:1 ratio) were recorded using the KBr pellet method over a scanning range of 4000–400 cm^{-1}. Characteristic peaks of Duloxetine such as N–H stretching, aromatic C–H stretching, and C–O stretching were analyzed. The presence of all characteristic peaks without significant shifts or disappearance indicated that Duloxetine hydrochloride was compatible with the selected polymers.

PHYSICAL CHARACTERIZATION OF TRANSDERMAL PATCHES
Visual inspection
All the formulated transdermal patches are visually checked for its color, flatness and elasticity.

Thickness
It directly reflects the uniformity of the polymeric film and ensures consistent drug distribution and release. Uniform thickness indicates proper mixing of the drug with polymers and reproducible casting during formulation, while variations in thickness can lead to dose variability and inconsistent permeation through the skin. For duloxetine transdermal patches, thickness is usually maintained within a narrow range, confirming good film-forming properties and mechanical stability of the formulation.

Weight variation
After complete drying, duloxetine transdermal patches are cut into identical sizes (commonly 1–4 cm^2). Each patch is individually weighed using a calibrated analytical balance. The weights of at least three to five patches are recorded, and the average weight is calculated. The individual weights are then compared with the mean value to determine weight variation.

Folding endurance
A strip of specific area (e.g.,2cm x 2cm) is cut and repeatedly folded at the same location until it breaks or shows signs of failure. This test ensures the physical integrity of the patch during storage and while adhered to the skin. A value greater than 200 is generally considered optimal, indicating the patch is stable, flexible and can with stand skin movement without breaking.

Moisture content
Moisture loss is an important post-compression evaluation parameter for duloxetine hydrochloride transdermal patches, as it indicates the stability of the patch and its ability to retain moisture during storage. Excessive moisture loss can make the patch brittle and reduce flexibility, while very low moisture loss suggests good film integrity and effective plasticization.

Tensile strength
Tensile strength is an important evaluation parameter for transdermal patches as it indicates the mechanical strength and elasticity of the patch. It measures the force required to break the patch when it is stretched and ensures that the patch can withstand handling, packaging, transportation, and application on the skin without tearing or breaking. A transdermal patch with optimal tensile strength remains flexible, maintains integrity during use, and provides better patient compliance and product quality.

Surface PH
surface pH of a transdermal patch should be close to the normal, typically in the range of 5.5 to 7.0. Maintaining an appropriate surface pH improves patient comfort, safety, and acceptance of the transdermal drug delivery system.

Peel adhesion test
Peel adhesion test is an evaluation method used for transdermal patches to determine the adhesive strength between the patch and the skin or a standard substrate. It measures the force required to peel the patch from a surface at a specified angle, commonly 180° or 90°, and at a constant rate. The patch is then peeled off using a tensile strength tester or texture analyzer, and the peel force is recorded. This test ensures that the transdermal patch has sufficient adhesion to remain attached during

the dosing period without causing discomfort or skin damage upon.

***In Vitro* Drug Release Studies**

The transdermal patches prepared are cut into piece of 1 ×1 cm for all the formulations made and are placed in the middle of the egg membrane and it is tied to the inverted test tube. The test tube is touched to the superficial layer of the distilled water (50 ml) taken in a beaker. The beaker is magnetically stirred on magnetic stirrer. The samples of 5ml were withdrawn at time interval of 1, 2, 3, 4, 5, 6, 7, 8, up to 24h, analyzed for drug content spectrophotometrically at 289 nm against blank. Then it is exchanged with the equal quantity of distilled water at every time of sample withdrawal.

FORMULATION OF DULOXETINE HYDROCHLORIDE PATCHES

Table 1: Formulation of duloxetine hydrochloride patches.

INGREDIENTS	F1	F2	F3	F4	F5	F6
DULOXETINE HYDROCHLORIDE	20	20	20	20	20	20
HYDROXYPROPYL METHYL CELLULOSE (HPMC E5)	130	125	120	115	110	105
POLYVINYL PY RROLIDONE (PVP K30)	30	35	40	45	50	55
POLYETHYLGLYCOL(PEG400)	15	15	15	15	15	15
PROPYLENE GLYCOL	5	5	5	5	5	5
ETHANOL: CHLOROFORM	5	5	5	5	5	5
GLYCERINE	5	5	5	5	5	5

RESULTS AND DISCUSSION

Solubility of Duloxetine Hydrochloride

The solubility of Duloxetine Hydrochloride was studied in different solvents. The drug was sparingly soluble in water, while it was freely soluble in methanol and DMSO. It was also soluble in phosphate buffer solutions of pH 5.8, 6.8, and 7.4. These results indicate that duloxetine hydrochloride shows better solubility in organic solvents and buffer solutions than in water.

Solubility of Duloxetine Hydrochloride in various media

Table 2: Solubility.

Solvent	SolubilityU1HofU1HDuloxetine U1H
Water	Sparingly soluble
Methanol	Freely soluble
DMSO	Freely soluble
Phosphate 6.8 buffer	soluble
Phosphate 7.4 buffer	soluble
Phosphate 5.8 buffer	soluble

PRE-FORMULATION STUDIES

Organoleptic properties

The organoleptic properties of duloxetine Hydrochloride were evaluated based on sensory observations such

Colour: off white

Odor: odourless

Taste: Bitter

Texture: crystalline

Melting point of Determination

Melting point of duloxetine was determined using a melting point apparatus and was found to be 163 °C. This value is close to the reported melting point, indicating that the sample is pure and free from significant impurities.

DETERMINATION OF λ MAX

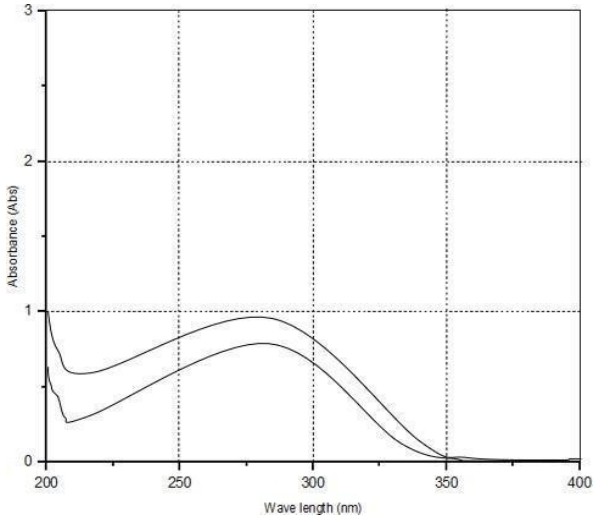


Fig. 3: Determination of λ max.

The UV spectrum of duloxetine was recorded using a UV–spectrophotometer in the wavelength range of 200–400 nm. The spectrum shows a maximum absorbance (λmax) around 285 nm, which corresponds to electronic transitions in the aromatic structure of the drug. The absorbance decreases beyond 300 nm, indicating that duloxetine absorbs mainly in the UV region.

CALIBRATION OF DULOXETINE HYDROCHLORIDE

The standard solutions of Duloxetine Hydrochloride were prepared in 0.1 N HCl with concentrations ranging from 2–10 µg/mL. The absorbance of each solution was measured at 288 nm using a UV–Visible spectrophotometer. The observed absorbance values corresponding to each concentration are presented in the table. The data show a gradual increase in absorbance with increase in concentration, indicating proportionality between concentration and absorbance.

Table 3: calibration curve of duloxetine Hydrochloride.

S.No	Concentration(U1Hμg/ml)	Absorbance
1.	2	0.173
2.	4	0.363
3.	6	0.551
4.	8	0.756
5.	10	0.931

A calibration curve of Duloxetine Hydrochloride in 0.1 N HCl was constructed by plotting concentration (µg/mL) on the X-axis against absorbance on the Y-axis at 288 nm. The plotted data exhibited a linear relationship over the concentration range of 2–10 µg/mL. The regression equation obtained was y = 0.095x − 0.017 with a correlation coefficient (R^2) of 0.999, demonstrating excellent linearity. The results confirm that Duloxetine Hydrochloride follows Beer–Lambert's law within the studied concentration range and the calibration curve can be used for quantitative estimation of the Calibration curve of Duloxetine Hydrochloride.

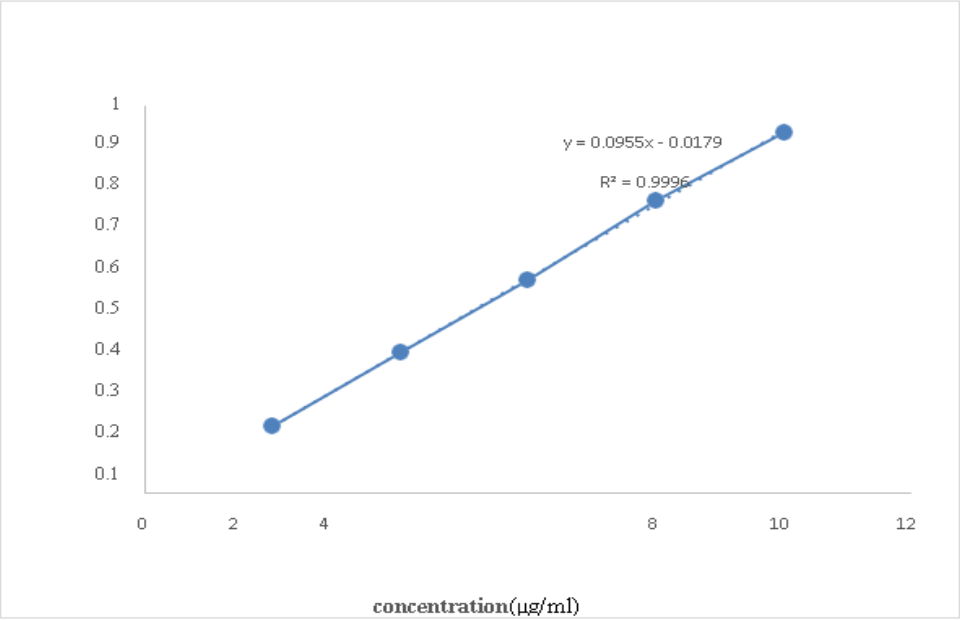


Fig. 3: Formulation of duloxetine hydrochloride patches.

FTIR Study of Duloxetine

Pure Duloxetine Hydrochloride was used in this work, and its IR spectra reveals distinctive absorption bands at 3366 (N-H Stretching), 2980 (Aromatic C-H Stretching), 2945 (C-H Stretching of $CH_{2&}$ CH_3 Groups), 1688 (C=O Stretching), 1642 (N-H Bending), 1620 (C=C Ring Stretching), 1494 (C=C Ring Stretching), 1461 (C=C Ring Stretching), 1096 (C-O-C stretching), 726, 801 (Substituted benzene ring), 564 (Cl stretching) cm-1 respectively. In the drug–excipient compatibility study, the FTIR spectra of the drug with excipients showed no significant shift or disappearance of characteristic peaks, indicating no chemical interaction between the drug and excipients and confirming good compatibility.

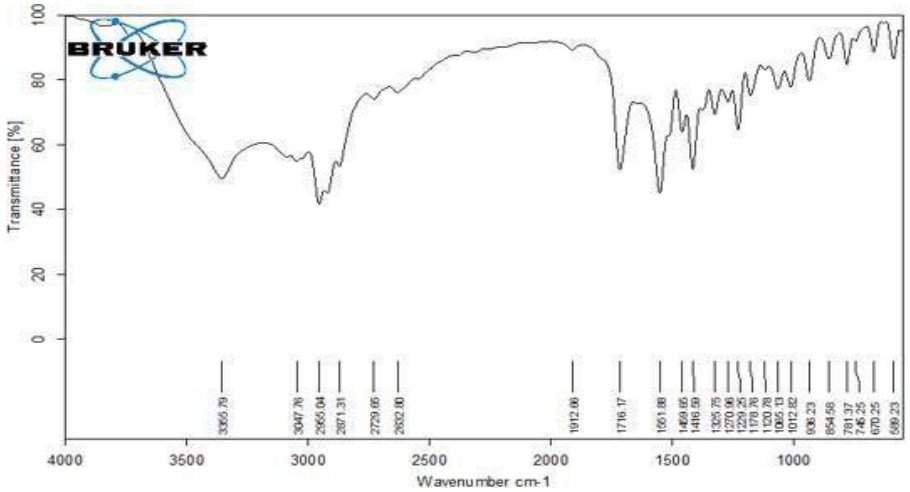


Fig. 4: FTIR of optimized Duloxetine Hydrochloride transdermal patches.

Differential Scanning Calorimetry Study of Duloxetine hydrochloride

DSC study for duloxetine exhibited a sharp endothermic peak at 143.6^{o}C. With on set and end set temperature of 139.8^{o}C &144.38^{0}C respectively. The sharp Melting point suggests that duloxetine is a crystalline drug.

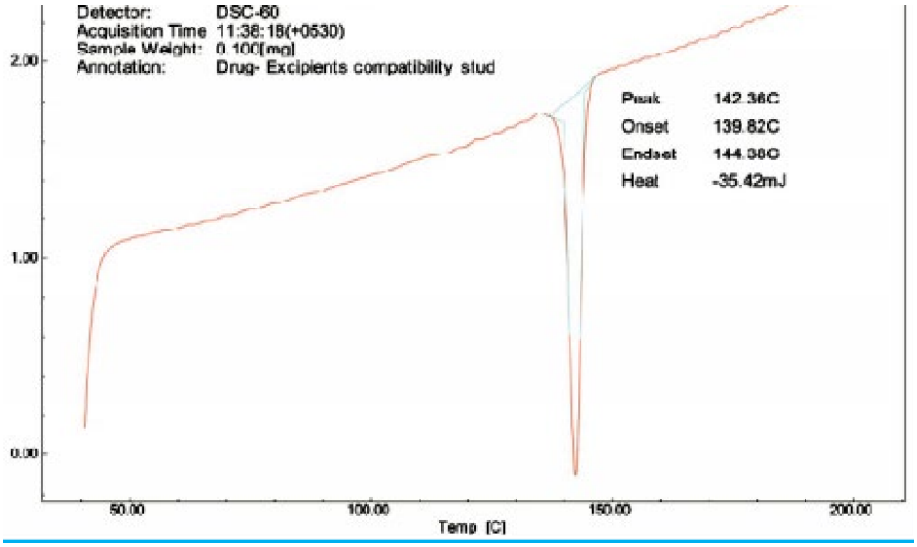
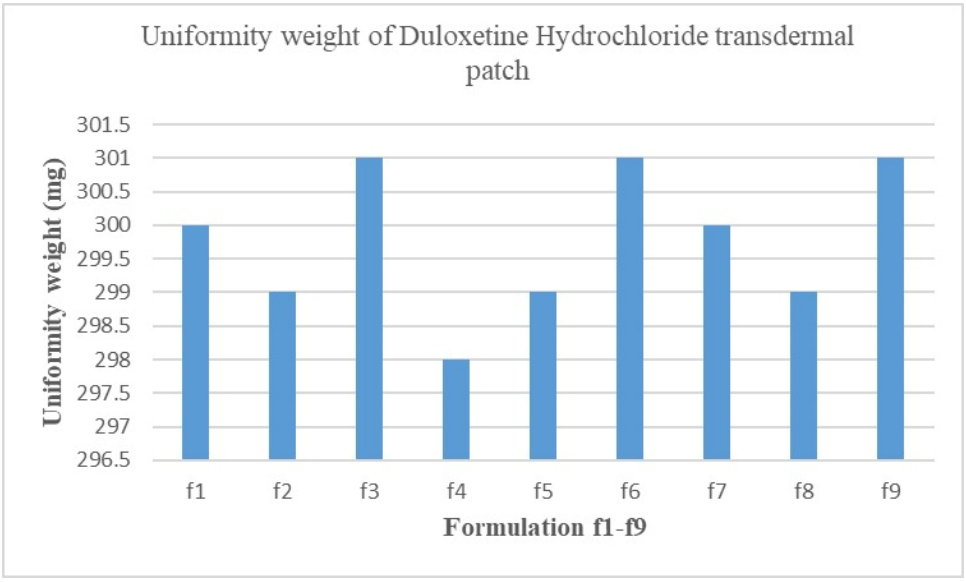


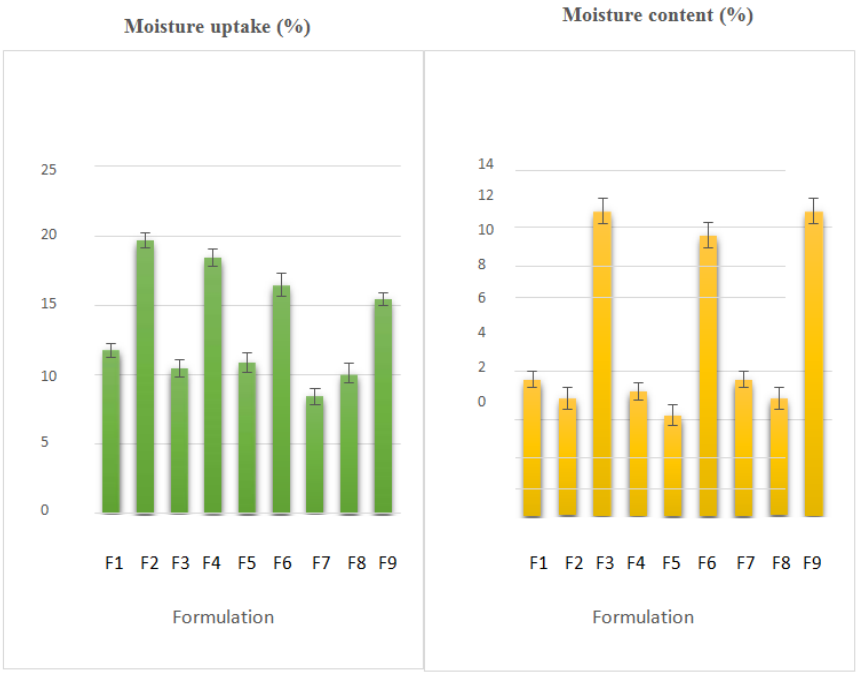
Fig. 5: DSC of Pure Duloxetine Hydrochloride.

Evaluation of the Transdermal Patches of duloxetine Hydrochloride (F1 to F9)

Table 4: Evaluation of the Transdermal Patches of duloxetine Hydrochloride.

Formulation	Thickness (mm)	Folding endurance	Moisture uptake (%)	Moisture content (%)	Uniformity Weight(mg)
F1	0.5169±0.11	298±1.19	11.73±0.49	5.66±0.34	300±1.11
F2	0.4210±0.22	218±1.09	19.65±0.51	4.87±0.44	299±1.16
F3	0.5470±0.31	262±1.10	9.42±0.62	12.67±0.53	301±1.17
F4	0.5496±0.62	287±1.07	8.42±0.62	5.16±0.34	298±1.16
F5	0.4460±0.42	232±1.18	10.87±0.71	4.17±0.44	299±1.14
F6	0.4517±0.51	211±1.09	16.44±0.81	11.67±0.53	301±1.16
F7	0.4108±0.69	203±1.19	9.42±0.62	5.66±0.34	300±1.10
F8	0.4437±0.62	229±1.09	10.07±0.71	4.87±0.44	299±1.19
F9	0.4903±0.78	198±1.11	15.44±0.81	12.67±0.53	301±1.18





Percentage drug content of Duloxetine Hydrochloride in unit dosage form of Patch

Drug content

Transdermal patches, designated CTP1 through CTP9, contain between 85±0.21percent and 99±0.61percent of their respective drugs. The displays the compiled results.

Drug content Percentage of DUL

Table 5: Percentage drug content.

Formulation	Percentage of D content
F1	95±0.11
F2	85±0.21
F3	97±0.31
F4	90±0.44
F5	97±0.32
F6	92±0.54
F7	99±0.61
F8	85±0.69
F9	95±0.74

Among formulations F1–F9, F7 showed the highest drug content (99 ± 0.61%), indicating better drug uniformity and formulation efficiency, so F7 can be considered the best formulation based on drug content.

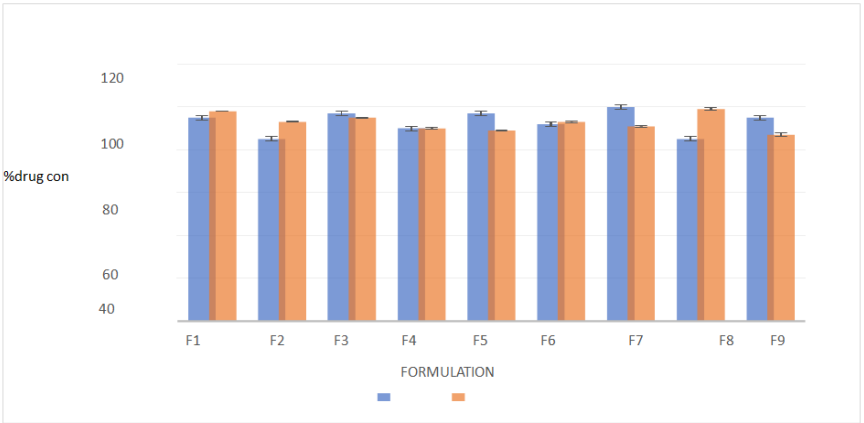


Fig. 6: Percentage drug content of Duloxetine hydrochloride.

Percentage Cumulative Drug release of DUL from transdermal patch

The cumulative drug release of DUL from the transdermal patch was studied for 24 hours. The results showed a gradual and sustained increase in drug release over time. At 2 hours, the drug release was around 18–22%, which increased progressively at 4, 6, 8, and 12 hours. By 24 hours, the formulations exhibited a high level of drug release ranging from approximately 75% to 98%. The findings indicate that the transdermal patches provided effective and controlled drug release throughout the 24-hour period.

Cumulative Drug release percentage of Duloxetine hydrochloride transdermal patch

Table 6: Cumulative Drug release percentage of Duloxetine hydrochloride transdermal patch.

Time (Hr)	F1	F2	F3	F4	F5	F6	F7	F8	F9
2	20.12±1.11	19.81±1.10	21.98±1.12	20.12±1.15	21.12±1.17	18.32±1.16	21.42±1.19	22.42±1.20	21.12±1.22
4	32.12±1.14	33.32±1.12	37.11±1.15	35.77±1.16	35.02±1.21	36.65±1.22	46.65±1.25	45.65±1.29	35.02±1.26
6	52.16±1.5	45.12±1.15	44.11±1.13	49.12±1.20	62.16±1.25	51.12±1.26	61.12±1.30	65.22±1.33	52.16±1.30
8	67.76±1.20	51.32±1.18	49.32±1.13	53.98±1.19	77.76±1.30	78.79±1.33	79.33±1.33	78.03±1.35	73.76±1.31
12	72.11±1.25	67.31±1.21	71.32±1.24	69.01±1.20	82.11±1.35	89.12±1.29	89.12±1.38	86.12±1.37	81.11±1.36
24	79.21±1.30	75.77±1.24	82.09±1.25	86.12±1.30	89.21±1.39	92.12±1.35	98.82±1.41	97.32±1.39	89.21±1.42

Percentage of cumulative drug release Duloxetine Hydrochloride transdermal patch

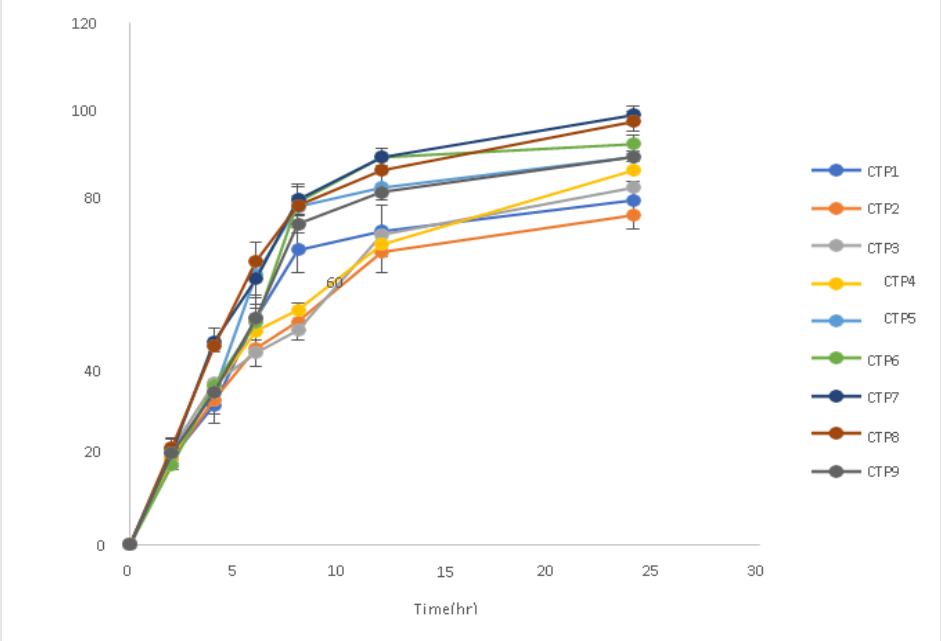


Fig. 7: Percentage of Cumulative Drug release of Duloxetine Hydrochloride transdermal patch.

FORMULATION AND EVALUATION OF DULOXETINE HYDROCHLORIDE TRANSDERMAL PATCHES

Table 7: Formulation and evaluation of duloxetine hydrochloride transdermal patches.

S.NO	List of Ingredient	CTP1	CTP2	CTP3	CTP4	CTP5	CTP6	CTP7	CTP8	CTP9
1.	**Duloxetine**	20	20	20	20	20	20	20	20	20
2.	**HPMCE-5**	130	125	120	115	110	105	100	95	90
3.	**PVPK-30**	30	35	40	45	50	55	60	65	70
4.	**PEG-400**	15	15	15	15	15	15	15	15	15
5.	**Propylene Glycol**	5	5	5	5	5	5	5	5	5
6.	**Ethanol: Chloroform (1:1)**	5	5	5	5	5	5	5	5	5
7.	**Ultrapure Water**	QS	QS	QS	QS	QS	QS	QS	QS	QS
8.	**Glycerine**	5	5	5	5	5	5	5	5	5

Stability studies

Stability studies were carried out to evaluate the physical and chemical stability of the optimized transdermal patch formulation of duloxetine hydrochloride during storage. The study was performed according to the guidelines recommended by the International Council for Harmonisation (ICH). The optimized formulation (F7) was packed in aluminium foil and stored under accelerated stability conditions at 40 ± 2°C and 75 ± 5% relative humidity for a period of three months. Samples were withdrawn at predetermined time intervals of 0, 30, 60, and 90 days and evaluated for parameters such as physical appearance, folding endurance, drug content, and in-vitro drug release. The results indicated that there were no significant changes in the physical characteristics of the patches, and the drug content remained within acceptable limits throughout the study period. The folding endurance values also remained nearly constant, indicating that the mechanical strength of the patches was maintained during storage. In addition, the in-vitro drug release profile showed only minor variations, confirming that the release characteristics of the formulation were not affected by storage conditions. These findings suggest that the optimized duloxetine hydrochloride transdermal patch formulation remained stable under accelerated stability conditions, demonstrating good stability and suitability for long-term storage.

DISCUSSION

The pre-formulation studies of Duloxetine Hydrochloride confirmed the suitability of the drug for development of transdermal patches. The solubility study showed that duloxetine hydrochloride is sparingly soluble in water but freely soluble in methanol and DMSO, while it exhibited good solubility in buffer solutions of pH 5.8, 6.8, and 7.4. These results indicate that the drug possesses adequate solubility characteristics for formulation development. The organoleptic evaluation revealed that duloxetine hydrochloride is a white to off-white crystalline powder with a faint odour and slightly bitter taste. The melting point was found to be 163 °C, which is close to the reported value, confirming the purity of the drug sample. UV spectrophotometric analysis showed a maximum absorbance (λmax) at 285–288 nm. The calibration curve in 0.1 N HCl followed Beer–Lambert's law in the concentration range of 2–10 µg/mL with a high correlation coefficient (R^2 = 0.999), indicating good linearity and reliability for drug estimation. FTIR analysis confirmed the presence of characteristic functional groups such as N–H stretching, C=O stretching, aromatic C–H stretching, and C–O–C stretching, indicating the structural integrity of the drug. DSC analysis showed a sharp endothermic peak around 143.6 °C, confirming the crystalline nature of duloxetine hydrochloride. The prepared transdermal patches (F1–F9) were evaluated for physicochemical parameters including thickness, folding endurance, moisture uptake, moisture content, and weight uniformity. The results indicated uniform thickness and acceptable mechanical strength for all formulations. Drug content analysis showed values between 85% and 99%, confirming uniform distribution of the drug within the patches. *In vitro* drug release studies demonstrated a gradual and sustained release pattern over 24 hours. Among all formulations, F7 exhibited the highest cumulative drug release (98.82%), indicating better drug diffusion and controlled release characteristics. Overall, the results suggest that the developed transdermal patches of duloxetine hydrochloride provide effective and sustained drug delivery for an extended period.

SUMMARY

The in-vitro drug release study of duloxetine transdermal patches (F1–F9) was performed for a period of 24 hours to evaluate the release pattern of the drug from different formulations. The results indicated that all formulations showed a gradual and sustained drug release profile, confirming the suitability of the prepared patches for controlled drug delivery. In the initial stage (2 hours), the cumulative drug release ranged from 18.32% to 22.42%, indicating a moderate initial release of the drug. As time progressed, the drug release increased steadily, reaching 32.12% to 46.65% at 4 hours and 44.11% to 65.22% at 6 hours, which indicates continuous diffusion of the drug from the polymer matrix. Further increase in drug release was observed at 8 hours, where the cumulative release ranged from 49.32% to 79.33%, and at 12 hours, where the values ranged between 67.31% and 89.12%. This pattern demonstrates the sustained release behaviour of duloxetine from the transdermal patches. At the end of 24 hours, the cumulative drug release ranged from 75.77% to 98.82% for all formulations. Among the formulations, F7 showed the highest drug release (98.82%), followed by F8 (97.32%) and F6 (92.12%), indicating better drug release and diffusion properties. On the other hand, F2 showed the lowest drug release (75.77%). Overall, the results suggest that the prepared transdermal patches were capable of providing controlled and prolonged release of duloxetine for 24 hours. Among all the formulations, F7 was considered the optimized formulation due to its highest cumulative drug release and consistent release profile.

CONCLUSION

The present research work was carried out to formulate and evaluate transdermal patches of Duloxetine Hydrochloride for sustained drug delivery. Pre-formulation studies such as organoleptic properties, melting point determination, UV spectrophotometric analysis, solubility studies, FTIR and DSC were performed to characterize the drug. Duloxetine Hydrochloride was found to be a white to off-white crystalline powder with a melting point close to the reported value, indicating purity of the sample. The UV analysis showed a λmax at 288 nm, and the calibration curve exhibited excellent linearity within the concentration range of 2–10 µg/mL, confirming compliance with Beer–Lambert's law. FTIR studies confirmed the presence of characteristic functional

groups, while DSC analysis indicated the crystalline nature of the drug. Transdermal patches (F1–F9) were prepared and evaluated for various physicochemical parameters such as thickness, folding endurance, moisture uptake, moisture content, weight uniformity, and drug content.

All the formulations showed acceptable physical characteristics and good flexibility. The drug content ranged from 85% to 99%, indicating uniform distribution of the drug in the patches. The in-vitro drug release study revealed a gradual and sustained release pattern of duloxetine from the prepared transdermal patches over 24 hours. Among the formulations, F7 showed the highest cumulative drug release (98.82%), along with satisfactory physicochemical properties, indicating better performance compared to other formulations. Therefore, it can be concluded that duloxetine can be successfully formulated into transdermal patches to provide controlled and prolonged drug release. The optimized formulation (F7) demonstrated promising characteristics and may serve as a potential transdermal drug delivery system for improving therapeutic effectiveness and patient compliance.

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