RESEARCH ARTICLE

Development and Evaluation of Venlafaxine Hydrochloride Tablets for Oral Drug Delivery Technology

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ABSTRACT

Oral pills are the predominant, simple, and straightforward approach for administering drugs. The project's primary goal is to create a pharmaceutical product that is equal in terms of its medicinal properties. A controlled-release version of the antidepressant venlafaxine hydrochloride was created and compared to the formulation currently available on the market. The launch of the branded product was assessed through an innovator and prototype evaluation. In order to develop stable and bioavailable dosage forms, it is necessary to gather pertinent data through preformulation testing. In order to create stable and bioavailable dosage forms, preformulation testing must be performed to gather relevant information among the several mixes, high-performance polymer copolymer K100M, ethyl cellulose, and cross-linked polyvinyl pyrrolidone 0.45%. The precise release mechanism could be determined by conducting *in-vitro* solubility tests on the created formulations and analyzing the results with a number of exponential equations. We used fourier-transform infrared (FTIR) and differential scanning calorimetry (DSC) studies to check if the polymers were compatible with the medicine.

Keywords: Oral drug delivery, Venlafaxine hydrochloride, Dissolution testing, Analysis.

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INTRODUCTION

Oral pills are the most common, convenient, and straightforward means of administering medicine. A common method for making tablets is by compressing pharmaceutical granules with appropriate excipients; this allows for the quick absorption of the medicine into the bloodstream following ingestion. A limitation of traditional tablets is the challenge of achieving continuous drug release for treatments composed of numerous constituents. Various advanced methods for controlled drug release, including three-dimensional (3D), multilayer, matrix, dome-matrix based, and core-in-cup devices, have been created or are currently being studied to address the drawbacks of traditional tablets. Matrix tablets have been designed as a remedy for the difficulties linked to controlled medicine delivery in traditional tablets (Figure 1). Matrix tablets have several benefits, such as minimizing the occurrence of unpleasant effects caused by dosage spillage, reducing the frequency of dosing, and providing cost-effective treatment.[1-3] There are three separate categories for systems that are built on matrices: Osmotic pump; reservoir matrix; monolith matrix.

In osmotic pump systems, osmotic pressure is critical for controlling the release of medication *via* a semipermeable membrane containing a tiny opening. In reservoir matrix systems, a membrane regulates the drug's diffusion, whereas in monolith matrix systems, the drug's dispersion or encapsulation in a hydrophobic or hydrophilic system determines its release.

Multilayered tablets have an advantage over traditional tablets because they may release different drugs at different speeds. Examples of multilayered devices encompass bi, triple, and quadruple-layered systems. Typically, the drug core is encased in a layer of hydrophobic or hydrophilic polymer in multilayered tablets. Controlling the drug's absorption into the digestive tract is the job of this layer. Several complex tablets with several layers have been created, including the versa tab bilayered tablet, the geomatrix multilayer tablet, the Procise technology, the Chronotropic, and the CODES, among others.[4,5]

MATERIAL AND METHODS

Selection of Candidate Drug

A candidate medicine is chosen to develop a platform technology based on specific therapeutic requirements, focusing on achieving optimal therapeutic compliance and benefits. The choice of candidate medicine is determined based on its pharmacokinetic qualities, as well as its permeability and solubility criteria. In order to meet the specific drug and

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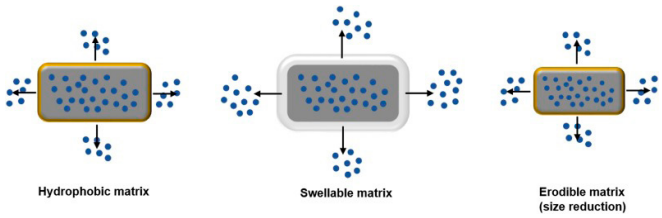

Figure 1: Drug release from matrix tablets

pharmacokinetic-pharmacodynamic (PK-PD) criteria, it is necessary to build a drug delivery platform technology. This technology may then be tested for other medications within the same Biopharmaceutics Classification System (BCS) class or therapeutic class, requiring only minimal adjustments to the formulation.[6]

Selection of Polymers

The materials used to regulate medication release encompass polymers derived from natural sources and chemically altered natural and synthetic substances. Polymers can be utilized alone or in combination to provide the required characteristics. The list is not exhaustive but functions as a first reference for development efforts.[7,8]

Design and Development of Platform Technology

Every medication has unique characteristics that necessitate particular considerations for that medication and its modalities of administration. The rational creation of controlled-release formulations requires the integration of a well-defined therapeutic rationale, the drug's biological features, and its physicochemical qualities. The fundamental therapeutic justification designed for a controlled-release product is that it must provide one or more benefits in terms of effectiveness, safety, and patient adherence. A medicine's pharmacokinetic properties and the required drug input rate dictate the design of its controlled-release product.[9]

Analytical Methodology

Preformulation

Preformulation data on the active ingredients are crucial for formulation scientists in the development of stable, safe, and efficient dosage forms. This knowledge may serve as a logical foundation for generating strategies, increasing the likelihood of successfully creating a satisfactory product and eventually maximizing the quality and performance of the product.[10]

Dissolution method development

Once a prototype formulation with suitable ranges of process and composition factors has been determined, it is necessary to investigate test variables. These variables encompass changes in pH, the impact of surfactants, agitation, ionic strength, and so on. The crucial factors to consider during the dissolution evaluation are (a) ensuring the method can be reproduced accurately, (b) maintaining sink conditions, (c) achieving a dissolution profile that adheres to a strict one-hour specification to prevent dose dumping, and (d) ensuring that at least 75% of the drug is released during the final sampling interval to guarantee complete release.

In-vitro Evaluation of Drug Delivery System

Physico-chemical parameters

Physical properties of dosage form, like appearance, dimensions, thickness, breadth, length, hardness, friability, and size distribution, need to be assessed. Furthermore, the estimation of aquatic moisture level can be done by utilizing loss on drying or water content analysis using a Karl-Fischer titrator.[11]

Dissolution studies

In vivo experimentation is crucial for the advancement and assessment of dose formulations. Dissolution testing is serious a procedure used to assess the effectiveness of solid oral dosage forms, specifically those that need drug absorption to provide a therapeutic effect. Evaluating the *in-vitro* properties and quality of the product is also essential.[12]

RESULTS AND DISCUSSION

Selection of Candidate Drug

Drug solubility is a crucial molecular characteristic. It has a crucial influence on their capacity to be absorbed and significantly affects their bioavailability as a result. Polymorphism significantly impacts solubility data, which corresponds to the physical state of a solid substance. Many medical solids exhibit polymorphism, meaning that a chemical can exist in multiple crystalline forms. These forms feature distinct groupings and/or conformations of the molecules in the crystal lattice. A solid, white or off-white material, venlafaxine hydrochloride, looks like this. By increasing the ionic strength of the water to 0.2 M using sodium chloride, it can dissolve in water at a concentration of 572 mg/mL.

Selection of Polymers

Initial characterization was done for the selected excipients and the results[13,14] were as follows:

Colloidal silicon dioxide

Insoluble in water. LoD is 1.5% w/w, and bulk density is 0.035 g/mL.

Croscarmellose sodium

Insoluble in water. LoD is 7.0% w/w, and bulk density is 0.529 g/mL.

Crospovidone

Insoluble in water. LoD is 3.5% w/w, and bulk density is 0.30 g/mL.

Ethylcellulose

4 cps & 7 cps: Insoluble in water, soluble in isopropyl alcohol. LoD is 2.4, 2.1% w/w and bulk density is 0.4, 0.38 g/mL, respectively.

Glyceryl monostearate

Insoluble in water. Meting point is 56°C.

Hydroxypropyl cellulose

Soluble in water (1 in 2), 95% ethanol (1 in 2.5), methanol (1 in 2), dichloromethane (1 in 10). pH is 7.2 for 1% w/w aqueous solution. LoD is 2.3% w/w. Bulk density is 0.5 g/mL.

Hypromellose

5 cps: Soluble in water. pH for a 1% w/w aqueous solution is 6.5, LoD is 5.0% w/w. Bulk density is 0.341 g/mL.

Lactose monohydrate

Soluble in water (1 in 5.24). LoD is 0.5% w/w, and bulk density is 0.57 g/mL.

Analytical Methodology

Preformulation study

Preparing an enduring, safe, and efficient dosage form relies heavily on excipients. A natural polymer made of lyophilized *Lapidium sativum* powder was used in an effort to produce a co-processed excipient. The drug excipient compatibility investigation was conducted after the initial drug identification and preformulation process development. Various methods, including as differential scanning calorimetry (DSC), fourier-transform infrared (FTIR), and X-ray diffraction (XRD) were used for this purpose. Preformulation testing is an initial stage in the logical creation of pharmacological dosage forms. Pharmaceutical biotechnology applies scientific concepts to the to physicochemical properties of medicine to create an efficient drug delivery system that is both stable and capable of being manufactured on a large scale (Table 1).

Determination of drug-polymer compatibility

Researchers used techniques like DSC and FTIR to determine the drug's and polymers' physicochemical compatibility and interaction. These methods are useful for foretelling how the drug and polymers will interact. Medication amounts that are close to what will be in the final dosage form were matched for each polymer used in the formulations. The drug was extensively mixed with each polymer to enhance the molecular interactions between the drug and polymer, perhaps speeding up the processes.

- *FTIR study*

The compatibility of the medicine with the excipients was assessed using FTIR spectroscopy, specifically the Perkin Elmer Spectrum-RX1 FTIR Spectrophotometer. Using a sample-to-KBr ratio of 1:100, pellets were manufactured at high compaction pressure with KBr. Analysis of manufactured pellets involved comparing original spectra to those of medicine and other compounds included in formulations. Figure 2 shows the usual absorption peaks detected in the FTIR spectra of venlafaxine, which confirms its stable and pure pharmacological profile. Figures 3-5 show FTIR of venlafaxine hydrochloride and different polymers that were used in the formulation.

- *DSC thermogram*

A differential scanning calorimeter is employed to quantify the specific heat and enthalpies associated with transitions. A

Table 1: Organoleptic properties of VF

Parameter	*Description*	*Results*
		Venlafaxine HCl
Organoleptic properties	Appearance	crystalline white powder
	Taste	Bitter
	Odor	Characteristic
Saturation solubility (mg/L)	Distilled water	520.12 ± 2.15
pH solubility profile (mg/L)	pH 1.2 buffer	557.59 ± 18.99
	pH 4.5 buffer	501.89 ± 21.59
	pH 6.8 buffer	554.88 ± 16.89
	pH 7.4 buffer	492.59 ± 17.18
Intrinsic dissolution rate (IDR)	mg/min/cm^2	0.527 ± 0.0017
Partition coefficient	Octanol/Water	3.2
Assay (Purity)	%	99.98 ± 2.78
Melting point	°C	213-216
Micromeritical properties	Average particle size	212.59 ± 24.89
	Tapped density	0.577 ± 0.01
	Bulk density	0.427 ± 0.19
	Carr's index	25.99
	Hausner's ratio	1.35

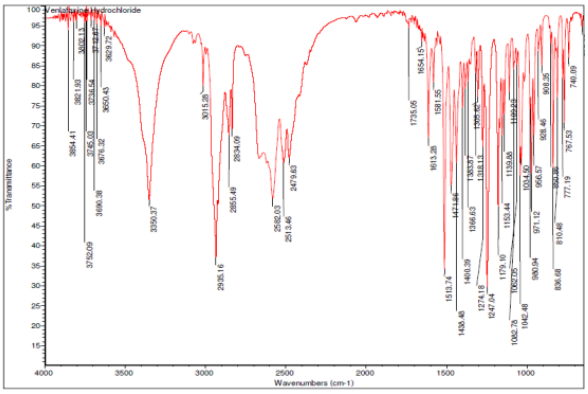

Figure 2: FTIR spectrum of pure VFH

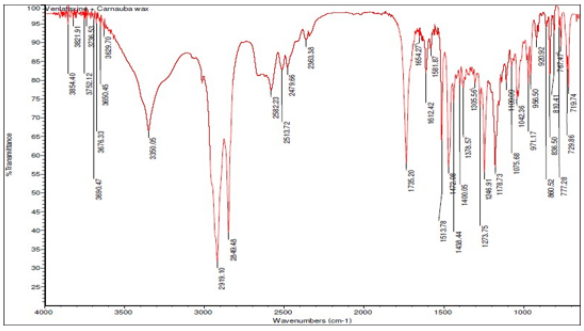

Figure 3: FTIR of venlafaxine hydrochloride with carnauba wax

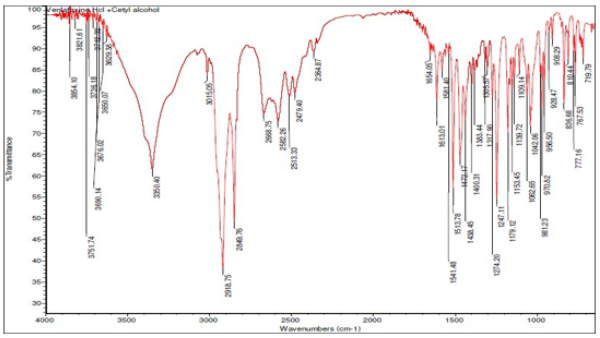

Figure 4: FTIR of venlafaxine hydrochloride with cetyl alcohol

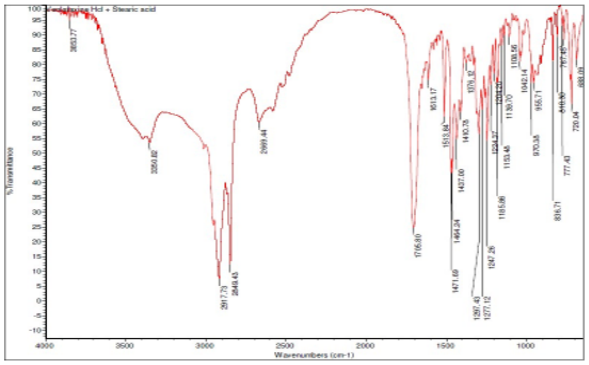

Figure 5: FTIR of venlafaxine hydrochloride with stearic acid

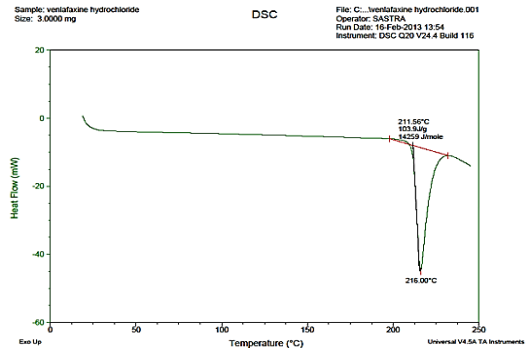

Figure 6: DSC of VFH

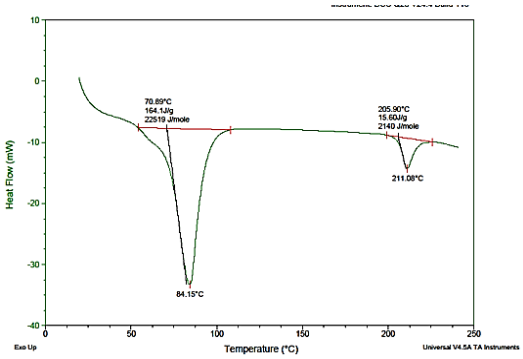

Figure 7: Thermogravimetric study of the combination of venlafaxine hydrochloride and carnauba wax

thermogram is obtained when a sample experiences a thermal transition, and the power supplied to the heater is changed to maintain the temperature. The thermogram is a plot of the power differential, signed proportionally, on the second axis of the recorder. The integral of the curve represents the precise measurement of the heat of transition. Thermograms were acquired using a differential scanning calorimeter with a heating rate of 10ºC/min, spanning a temperature assortment from 30 to 300°C. The specimen was airtight and enclosed within an aluminum crucible. Nitrogen gas was evacuated at a flow rate of 40 mL/min. Used to preserve inert atmospheres.[15] Figure 6 displays the DSC thermogram of venlafaxine. The Thermogram of Venlafaxine shows an endothermic peak at a temperature of 207.68°C.

Figure 7 shows that the DSC thermogram showed no significant difference between the pure medicine thermogram and the other thermograms in terms of starting temperature and maximum temperature. Hence, this suggests no incompatibility was seen between the medication and the polymer used in the optimal formulation.

Design and Development of Platform Technology

All the chemicals were pre-measured and filtered through mesh #80 to ensure the drug's passage. The waxes were in a liquid state, and then a measured amount of medicine was gradually introduced into the liquid wax. Following the chilling process, the bulk underwent granulation by being passed over mesh #16. To evaluate the flow characteristics, the granules were mixed with talc and lactose (Table 2).

In-vitro Evaluation of Drug Delivery System

Evaluation of pre-compression granules

- *Angle of repose*

Between 21.31° ± 0.05 and 23.27° ± 0.43, the angles of repose were measured. The blend was determined to have great flowability because the readings were less than 25 degrees.

- *Loose bulk density and tapped bulk density*

The compressibility index can be calculated using either the bulk or tapped densities. Between 0.454 ± 0.00 and 0.476 ± 0.00 g/mL was the range for the LBD, whereas the TBD was between 0.526 ± 0.00 and 0.555 ± 0.00 g/mL.

- *Compressibility index (Carr's index)*

From 13.68 ± 0.44 to 14.28 ± 0.62, the compressibility index (%) varied. The results showed that the blend had outstanding flowing properties, with a percentage below 15%.

- *Hausner ratio*

Between 1.15 ± 0.00 and 1.16 ± 0.01 was the range of the Hausner ratio. This finding provides evidence that the powders are free-flowing.

Evaluation of sustained-release matrix tablets

- *Appearance*

After visually inspecting the tablets and found no signs of surface flaws such as capping, chipping, or lamination.

Table 2: Venlafaxine hydrochloride SR matrix tablets composition

Ingredients	*Venlafaxine hydrochloride*	*Carnauba wax*	*Cetyl alcohol*	*Stearic acid*	*Lactose*	*Talc*	*Total weight*
VF1	75	53	-	-	204	18	350
VF2	75	106	-	-	151	18	350
VF3	75	159	-	-	98	18	350
VF4	75	-	53	-	204	18	350
VF5	75	-	106	-	151	18	350
VF6	75	-	159	-	98	18	350
VF7	75	-	-	53	204	18	350
VF8	75	-	-	106	151	18	350
VF9	75	-	-	159	98	18	350

- *Physico-chemical characteristics*

It was found that the venlafaxine hydrochloride matrix tablets (VF1–VF9) have the following physical properties: thickness, diameter, hardness, friability, weight fluctuation, and drug content.

- *Dimension (Thickness and Diameter)*

The tablets' sizes ranged from 11.15 ± 0.02 to 11.19 ± 0.02 mm in diameter and from 4.44 ± 0.01 to 4.53 ± 0.01 mm in thickness.

- *Tablet hardness*

A range of 6.05 ± 0.05 to 7.10 ± 0.02 kg/cm^2 was determined for the hardness of the tablets. This proves that the tablet has a high mechanical strength.

- *Percent friability*

All of the formulations were determined to have percentage friability ranging from 0.085 to 0.20%. This proves that the constructed matrix tablet has excellent handling characteristics.

- *Drug content*

All of the formulations' drug content fell within the allowed range of 99.24 ± 0.41 to 100.38 ± 0.26% w/w, according to IP 2007.

CONCLUSION

This research was conducted with the intention of developing a matrix-based oral dosage form of venlafaxine hydrochloride as the focus of the investigation. The findings of the experiments suggested that cross-linked polyvinyl chloride (PVP) 0.45% is an appropriate polymer for limiting the release of venlafaxine hydrochloride (HCl). According to the conclusions of study, it is recommended to perform an *in-vivo* evaluation of the improved formula to evaluate various pharmacokinetic characteristics. Among the antidepressants that are available for oral administration, venlafaxine hydrochloride is a structurally new medication. A short half-life is associated with venlafaxine hydrochloride, which is a disadvantage. Patient compliance is the most difficult thing to obtain when it comes to administering doses for long-term therapy that involves a multidose schedule. In order to lessen the frequency of dose, it was decided that sustained-release tablets of venlafaxine hydrochloride that were easy to use and less expensive would be the best option for the development.

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