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A REVIEW OF ANALYTICAL METHODS FOR ESTIMATION OF VINCA ALKALOIDS FROM CATHARANTHUS ROSEUS

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ABSTRACT

Catharanthus roseus, also known as Madagascar Periwinkle is a pretty ornamental plant of Vinca rosea (C. roseus), is a member of the Apocynaceae family. Cancer, one of the leading illness, and public health burden in developed and developing country. A phytochemical investigation of the plant has demonstrated that a number of alkaloidal substances can be obtained with antitumor activity. Among the numerous natural products, acting via different mechanisms of action, microtubule-targeting agents (MTAs) have a high therapeutic potential, since they disrupt the abnormal cancer cell growth, interfering with the continuous mitotic division. Vinca alkaloids are the earliest developed MTAs. There major vinca alkaloids in clinical use are vincristine (VCR), vinblastine (VBL), vinorelbine (VRL), and vindesine (VDS) and vinflunine. The present review is about the various analytical techniques employed for the estimation of Vinca alkaloids.

KEYWORDS: Analytical techniques, validation, High performance liquid chromatography, Ultra-high performance liquid chromatography, High performance thin layer chromatography.

INTRODUCTION

Catharanthus roseus, also known as Madagascar Periwinkle is a pretty ornamental plant of Vinca rosea (C. roseus), is a member of the Apocynaceae family. Cancer, one of the leading illness, and public health burden in developed and developing country. Vinca alkaloids, derived from Catharanthus species, are a group of indole alkaloids with significant medicinal properties. These alkaloids, including vinblastine, vincristine, and catharanthine, possess anti-

cancer, anti-inflammatory, and anti-microbial activities, making them valuable compounds in the pharmaceutical industry.[1,2] The Catharanthus species, primarily C. roseus, species, are the primary sources of these alkaloids, and their cultivation and processing have become an essential part of the herbal medicine industry.[3,4]

Figure 1: Catharanthus roseus.

CHEMISTRY OF VINCA ALKALOIDS

Vinca alkaloids are a complex group of compounds, with similar chemical structures and properties. They are characterized by the presence of an indole ring, a vinyl group, and a methoxy group.[5] The similarity in chemical properties makes their analysis challenging, and the development of sensitive, specific, and accurate analytical methods is essential for their reliable quantification.

Analytical Methods

Various analytical methods have been developed and employed for the quantification of vinca alkaloids, including:

- High-Performance Liquid Chromatography (HPLC): widely used for the separation, identification, and quantification of vinca alkaloids.[6]
- Gas Chromatography (GC): employed for the analysis of volatile vinca alkaloids.[7]
- Thin-Layer Chromatography (TLC): used for preliminary screening and identification of vinca alkaloid.[8]

- Nuclear Magnetic Resonance (NMR) Spectroscopy: provides structural information and confirms the identity of vinca alkaloid.[9]
- Mass Spectrometry (MS): used for the identification and quantification of vinca alkaloids.[10]

Recent Advances

Recent advances in analytical techniques have improved the sensitivity, selectivity, and accuracy of vinca alkaloid quantification. These include:

- Ultra-High-Performance Liquid Chromatography (UHPLC): offers improved resolution and sensitivity.[11]
- Supercritical Fluid Chromatography (SFC): provides improved separation and quantification.[12]
- Chemometric Techniques: enable the simultaneous analysis of multiple alkaloids and provide valuable insights into their chemical properties and relationships.[13]

Table 1: The Analytical Techniques Used For The Quantification of Vinca Alkaloids From Catharanthus Roseus By Hplc And Uhplc-Ms.

S.no:	Plant name	Extraction solvent	Techniques	Instrumentation	Column	Condition	Mobile phase	Ms	Ref
1	*Catharanthus roseus*	MeOH	HPLC-MS	Agilent 1050 HPLC system with UV detector	Phenomenex Gemini C18 column (150 ×2.0 mm, 5µm).	Flow rate: 0.3 mL/min; injection volume: 5 µL; UV: 214nm	A:10 mM $C_2H_7NO_2$ buffer (pH 5.0) B: ACN C: MeOH	ESI	14
2	*Catharanthus roseus*	70% MeOH	UPLC-MS	Waters Acquity UPLC system, with PDA detector	C18 column (2.1×50mm, 1.7 µm)	Column temperature: 45°C; flow rate: 0.4 mL/min; injection volume: 1.5 µL	A: water containing 0.1% CH_2O_2 and 10 mM NH4HCO2 B: ACN	ESI	15
3	*Catharanthus roseus*	C4H8O2		Agilent 1100 series HPLC	C18 column (Agilent Eclipse C18, 4.6 × 150 mm, 5 µm)	Flow rate: 1.0 mL/min; injection volume: 5 µL	MeOH: 15 mmol/L $C_2H_7NO_2$ containing 0.02% CH_2O_2 (65:35, V/V).	ESI	16
4	*Catharanthus roseus*	Methanol	HPLC	Agilent 1260 Infinity HPLC system	Zorbax Eclipse XDB-C18 (4.6 x 150 mm, 5 µm)	25°C, flow rate 1 mL/min	Water-acetonitrile (60:40, v/v) with 0.1% formic acid	ESI	17
5	*Catharanthus roseus*	Ethanol	UHPLC	Waters Acquity UPLC system	Acquity UPLC BEH C18 (2.1 x 100 mm, 1.7 µm)	30°C, flow rate 0.4 mL/min	Water-methanol (50:50, v/v) with 0.1% formic acid	ESI	18
6	*Catharanthus roseus*	Chloroform	HPTLC	CAMAG HPTLC system	Silica gel 60 F254 (20 x 20 cm)	25°C, development distance 70 mm	Toluene-ethyl acetate-methanol (40:30:30, v/v/v)	ESI	19
7	*Catharanthus roseus*	Methanol-water (80:20, v/v)	HPLC	Shimadzu LC-20AT HPLC system	Inertsil ODS-3V (4.6 x 150 mm, 5 µm)	25°C, flow rate 1.2 mL/min	Water-acetonitrile (60:40, v/v) with 0.1% trifluoroacetic acid	ESI	20
8	*Catharanthus roseus*	Ethanol-water	HPLC	Agilent 1200 Series HPLC	Zorbax Eclipse XDB-C18 (4.6 x 150 mm, 5	25°C, flow rate 1.5 mL/min	Water-methanol (50:50, v/v) with 0.1% formic	ESI	21

		(70:30, v/v)		system	µm)		acid		
9	*Catharanthus roseus*	Methanol	UHPLC	Waters Acquity UPLC system	Acquity UPLC BEH C18 (2.1 x 100 mm, 1.7 µm)	30°C, flow rate 0.3 mL/min	Water-acetonitrile (40:60, v/v) with 0.1% formic acid	ESI	22

Table 2: Validation Parameters For The Analytical Methods For Quantification of Vinca Alkaloids From Catharanthus Roseus By Hplc And Uhplc-Ms.

No	Plant name	Technique Used	Alkaloids	Linearity R^2	Lod (ng/ml)	Loq (ng/ml)	Precision (Intraday %Rsd)	Precision (interday %Rsd)	Accuracy/ Recovery	Ref.
1	*Catharanthus roseus*	UHPLC-MS	Vincristine Vinblastine Vindoline	0.9988 0.9993 0.9998	0.048 ng/mL 0.388 ng/mL 0.254 ng/mL	0.147 ng/mL 1.178 ng/mL 0.771 ng/mL	0.74 1.73 0.51	0.58 1.39 0.41	99.70±1. 86% 101.24±0 .68% 99.63±0. 22%	23
2	*Catharanthus roseus*	UHPLC-MS	Vincristine Vindoline Vinblastine	0.9990 0.9997 0.9998	10 ng/mL 1 ng/mL 10 ng/mL	30 ng/mL 3 ng/mL 20 ng/mL	2.1 0.9 2.3	2.6 1.6 3.1	101.4 % 100.9% 92.8%	24
3	*Catharanthus roseus*	HPLC	Vinblastine	0.9990	0.0230 µg/mL	0.0698µg/mL	0.41	2.22	95.0 ±1.28	25
4	*Catharanthus roseus*	HPLC-MS	Vinblastine Vincristine Vinleurosine Vindoline	0.999 5 0.9980 0.9979 0.9953	0.75 ng/mL 0.75 ng/mL 0.75 ng/mL 1.5 ng/mL	1.5 ng/mL 1.5 ng/mL 1.5 ng/mL 3.1 ng/mL	4.5 3.3 1.5 8.4	4.5 5.1 1.4 5.2	± 10.9% ± 10.9% ± 10.9% ± 10.9%	26
5	*Catharanthus roseus*	HPLC-MS	Vindoline Vinblastine Vincristine	≥0.9990 ≥0.9990 ≥0.9990	0.15 mcg/mL 0.1 mcg/mL 0.08mcg/mL	2.0 mcg/mL 1.3 mcg/mL 1.1 mcg/mL	NA	NA	NA	27
6	*Catharanthus roseus*	HPLC-MS	Vinblastine Vincristine	0.999 0.999	0.5	1.5	2.1	3.5	95-105%	28
7	*Catharanthus roseus*	UHPLC-MS	Vincristine Vinblastine	0.998	0.2	0.6	1.8	2.9	98-102%	29
8	*Catharanthus roseus*	HPLC-DAD	Vincristine Vinblastine	0.996	2.0	6.0	4.5	5.8	85-95%	30

METHOS USED IN ANALYTICAL TECHNIQUE OF VINCA ALKALOIDS IN THIS ARTICLE

High-Performance Liquid Chromatography (HPLC)

HPLC is a powerful analytical technique used for separating, identifying, and quantifying the components of a mixture.[31] It is widely used in pharmaceutical analysis for the quantification of vinca alkaloids.[32]

Principle

HPLC works on the principle of chromatography, where the components of a mixture are separated based on their interactions with the stationary phase and the mobile phase.[33]

Instrumentation

An HPLC system consists of a solvent reservoir, a pump, an injector, a column, and a detector.[34] The pump delivers the mobile phase at high pressure, allowing for efficient separation of the components.[35]

Columns

HPLC columns are typically made of stainless steel or silica and are packed with a stationary phase.[36] The choice of column depends on the type of analysis being performed.[37]

Detectors

HPLC detectors measure the absorbance or fluorescence of the components as they elute from the column.[38] Common detectors include UV-Vis, fluorescence, and mass spectrometry (MS) detectors.[39]

Method Development

HPLC method development involves optimizing the mobile phase, column, and detector settings to achieve efficient separation and quantification of the components.[40]

Validation

HPLC methods must be validated to ensure accuracy, precision, and reliability.[41] Validation parameters include linearity, LOD, LOQ, intraday and interday precision, and accuracy.[42]

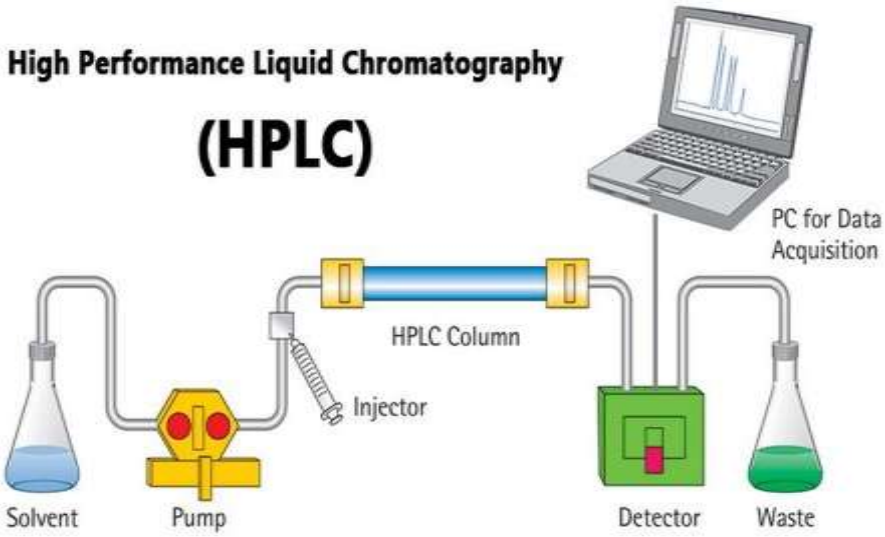

Figure 2. High performqance Liquid Chromatography (hplc).

Ultra-High Performance Liquid Chromatography (UHPLC)

UHPLC is a advanced chromatographic technique that offers faster and more efficient separations compared to traditional HPLC.[43] It is widely used in pharmaceutical analysis for the quantification of vinca alkaloids.[44]

Principle

UHPLC works on the same principle as HPLC, but uses smaller particle size stationary phases and higher pressures to achieve faster separations.[45]

Instrumentation

UHPLC systems are similar to HPLC systems, but require more advanced pumps and columns to handle the higher pressures.[46] The use of smaller particle size columns allows for faster separations and improved resolution.[47]

Columns

UHPLC columns are typically made of silica or hybrid materials and are packed with sub-2 µm particles.[48] These columns offer improved efficiency and resolution compared to traditional HPLC columns.[49]

Detectors

UHPLC detectors are similar to HPLC detectors, but may require more advanced technology to handle the faster separations.[50] Mass spectrometry (MS) detectors are commonly used in UHPLC for their high sensitivity and selectivity.[51]

Method Development

UHPLC method development involves optimizing the mobile phase, column, and detector settings to achieve efficient separation and quantification of the components.[52] The use of design of experiments (DoE) and quality by design (QbD) approaches can improve method development efficiency.[53]

Validation

UHPLC methods must be validated to ensure accuracy, precision, and reliability.[54] Validation parameters include linearity, LOD, LOQ, intraday and interday precision, and accuracy.[55]

Figure 3: Ultra High Performance Liquid Chromatography (Uhplc).

High-Performance Thin-Layer Chromatography (HPTLC)

HPTLC is a sophisticated variant of thin-layer chromatography (TLC) that offers improved resolution, sensitivity, and reproducibility.[56] It is widely used in pharmaceutical analysis for the quantification of vinca alkaloids.[57]

Principle

HPTLC works on the principle of chromatography, where the components of a mixture are separated based on their interactions with the stationary phase and the mobile phase.[58]

Instrumentation

HPTLC instrumentation includes a sample applicator, a chromatography chamber, and a

densitometer.[59] The use of advanced instrumentation allows for automated sample application, development, and detection.[60]

Plates

HPTLC plates are coated with a thin layer of silica or other stationary phases.[61] The plates are available in various sizes and thicknesses, allowing for flexibility in method development.[62]

Method Development

HPTLC method development involves optimizing the mobile phase, plate selection, and detection settings to achieve efficient separation and quantification of the component.[63] The use of design of experiments (DoE) and quality by design (QbD) approaches can improve method development efficiency.[64]

Validation

HPTLC methods must be validated to ensure accuracy, precision, and reliability.[65] Validation parameters include linearity, LOD, LOQ, intraday and interday precision, and accuracy.[66]

Applications

HPTLC has various applications in pharmaceutical analysis, including the quantification of vinca alkaloids, identification of impurities, and determination of drug stability.[67]

Figure 4: High Performance Thin Layer Chromatography (Hptlc).

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