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Research Paper

UV Method Development Using Multicomponent Analysis

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ABSTRACT

The present study describes the development of a simple, accurate, precise, and economical UV spectrophotometric method for the simultaneous estimation of Paracetamol (PCM) and Ibuprofen (IBU) in Combiflam tablet dosage form. Ethanol was selected as the solvent system. The analytical wavelengths selected were 245 nm and 220 nm for PCM and IBU respectively, based on their absorption maxima determined by spectral scanning in the range 200–400 nm. Vierordt's simultaneous equation method and Isobestic point method were applied for the quantitative estimation of both drugs in their combined formulation.The developed method demonstrated good linearity over the working concentration range for both analytes. Absorptivity coefficients were determined. The UV spectral overlay graphs for standard solutions, marketed formulations, and drug mixtures are presented and discussed. The results obtained from the analysis of the marketed Combiflam tablet formulation were found to be within acceptable limits, confirming the suitability of the method for routine quality control analysis.

INTRODUCTION

1.1 Analytical Chemistry

Analytical chemistry is a scientific discipline that develops methods, instruments, and strategies to obtain information on the composition and nature of matter. Unlike other major sub-disciplines of chemistry such as inorganic and organic chemistry, analytical chemistry is not restricted to any particular type of chemical compound or reaction. An analytical method is a specific application of technique to solve an analytical problem.The use of instrumentation is an exciting and fascinating part of chemical analysis that interacts with all areas of chemistry and with many other areas of pure and applied science. Analytical instruments play an important role in production and evaluation of new products and in the protection of consumers and the environment. Pharmaceutical analysis deals with qualitative and quantitative analysis of drugs in bulk, dosage forms, and in biological samples.

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1.2 Classification of Analytical Methods

Common techniques indispensable to analytical chemistry are categorised as follows:

Category	Methods
Classical Methods	Gravimetric Analysis, Titrimetric Analysis, Volumetric Analysis
Instrumental Methods	Electro-analytical, Spectroscopic, Chromatographic & Electrophoresis methods
Non-destructive Methods	Electro probe micro analysis, X-ray fluorescence
Radioactive Methods	Radiotracer techniques, Activation analysis
Special Methods	Optical methods, Kinetic methods
Hyphenated Techniques	GC-MS (Gas Chromatography–Mass Spectrometry), ICP-MS (Inductively Coupled Plasma–MS)

2. UV-VISIBLE SPECTROSCOPY

Ultraviolet–Visible (UV–Visible) Spectroscopy is one of the most powerful, widely used, and fundamental analytical techniques in modern chemistry and related scientific fields. It is based on the measurement of the absorption of ultraviolet (200–400 nm) and visible (400–800 nm) electromagnetic radiation by molecules or ions. When a molecule absorbs light in this region, it undergoes electronic excitation, where electrons are promoted from a lower-energy orbital to a higher-energy orbital.These transitions provide valuable information about the electronic structure of the molecule, the presence of chromophores, and the molecular environment. Because of its ability to generate rapid, reliable, and non-destructive analytical data, UV–Visible spectroscopy has become an essential tool in both research and industrial laboratories.

2.1 Principle

The principle of UV–Visible spectroscopy is dependent on absorption of polychromatic light or visible light by a sample which gives spectra. When the sample absorbs radiation, the sample molecule moves from the ground state to the singlet excited state. There are three possible categories of ground state orbital involved:

- sigma (σ) bonding molecular orbital
- pi (π) bonding molecular orbital
- n (non-bonding) atomic orbital

In addition, two classes of antibonding orbitals may be involved in the transition process: σ* (sigma star) orbital and π* (pi star) orbital. Electronic transitions can take place by absorbing ultraviolet and visible light.

2.2 Electronic Transitions

When a beam of light moves through a material, some wavelengths are absorbed because the substance takes in part of the light. This occurs when electrons inside the molecules gain energy from the incoming photons, causing them to jump from their ground states to higher-energy levels.

Key transition types include:

π → π* Transitions: Often seen in conjugated organic molecules, where electrons in a π-bond system absorb energy and move into a π* (anti-bonding) orbital.

n → π* Transitions: Involves non-bonding electrons getting excited into a π* anti-bonding orbital.

σ → σ* Transitions: High-energy transitions in sigma bonds, typically occurring below 200 nm.

2.3 Beer–Lambert Law

The Beer–Lambert Law is one of the fundamental foundations of UV–Visible spectroscopy. It clarifies how the quantity of light absorbed by a solution is related to the concentration of the absorbing species and the path length.

$A = \log_{10}(I_0/I) = \varepsilon \cdot c \cdot l$

Symbol	Parameter	Description
A	Absorbance	The measure of light absorbed by the solution (dimensionless)
I_0	Incident Intensity	Intensity of light entering the sample
I	Transmitted Intensity	Intensity of light exiting the sample
ε	Molar Absorptivity	Constant indicating how strongly the substance absorbs light at a given wavelength
c	Concentration	Molar concentration of the analyte in solution (mol/L)
l	Path Length	Length of the light path through the sample (cm)

2.4 Advantages and Disadvantages of UV–Visible Spectroscopy

Advantages	Disadvantages
• Cost-effective equipment • Simple operation and rapid results • Non-destructive analysis • Minimal sample preparation • High quantitative accuracy • Wide range of applications • Real-time monitoring capability • Qualitative identification possible	• Limited selectivity (spectral interference) • Primarily suited for liquid samples • Stray light errors • Limited structural information • Beer–Lambert Law deviations at high concentrations • Solvent interference issues • Sensitivity to pH changes • Requires optically clear (turbidity-free) samples

3. MULTICOMPONENT ANALYSIS

Multicomponent analysis refers to the simultaneous quantitative determination of two or more analytes in a mixture using a single set of measurements. In UV spectrophotometry, this exploits the additive nature of absorbance (Beer–Lambert Law applies to each component independently), enabling the resolution of overlapping spectra.

3.1 Vierordt's Simultaneous Equation Method

The simultaneous equation method (also known as Vierordt's method) is applied for multicomponent samples containing two absorbing drugs (X and Y), each of which absorbs at the other's maximum wavelength. Using this method, the concentration of both drugs can be determined simultaneously.

For a binary mixture of drugs X and Y, measurements are made at two wavelengths λ_1 (λmax of X) and λ_2 (λmax of Y). Two simultaneous equations are constructed based on the additive nature of absorbance:

$A_1 = ax_1 \cdot b \cdot Cx + ay_1 \cdot b \cdot Cy$ $A_2 = ax_2 \cdot b \cdot Cx + ay_2 \cdot b \cdot Cy$

Solving these simultaneous equations:

$Cx = (A_2 \cdot ay_1 - A_1 \cdot ay_2) / (ax_2 \cdot ay_1 - ax_1 \cdot ay_2)$ $Cy = (A_1 \cdot ax_2 - A_2 \cdot ax_1) / (ax_2 \cdot ay_1 - ax_1 \cdot ay_2)$

3.2 Isobestic Point Method

The isobestic point is the wavelength at which the molar absorptivity is the same for two interconvertible substances (or for two components of a mixture). At the isobestic point, the total absorbance is proportional only to the

total concentration of both components combined, independent of their individual ratios.

This property makes the isobestic point particularly valuable for eliminating the interference of impurities or one component when estimating the other. The concentration of each component is derived using Q-value (absorbance ratio) equations:

$Cx = [(Qm – Qy) / (Qx – Qy)] \times (A_1 / ax_1)$

$Cy = [(Qm – Qx) / (Qy – Qx)] \times (A_1 / ax_1)$

4. DRUG PROFILES

4.1 Paracetamol (PCM)

Paracetamol (acetaminophen; N-(4-hydroxyphenyl)acetamide) is a widely used analgesic and antipyretic agent. It acts centrally by inhibiting prostaglandin synthesis within the central nervous system, particularly through modulation of the prostaglandin H_2 synthase (PGHS/COX) enzyme complex at its peroxidase site.

Property	Details
Chemical Name	N-(4-hydroxyphenyl)acetamide
Molecular Formula	$C_8H_9NO_2$
Molecular Weight	151.163 g/mol
Melting Point	168°C to 172°C
λmax	245 nm to 257 nm
Category	Analgesic, Antipyretic
Solubility	Sparingly soluble in water; freely soluble in alcohol
Storage	20°C to 25°C; protect from moisture and heat

Paracetamol's analgesic mechanism is multimodal: it suppresses central prostaglandin E_2 (PGE_2) synthesis, enhances descending serotonergic inhibitory pathways from the brainstem, and produces the active metabolite AM404 (N-arachidonoylphenolamine) which modulates endocannabinoid and

TRPV1 systems. Unlike NSAIDs, it has minimal peripheral anti-inflammatory activity due to the high peroxide tone at inflammation sites.

4.2 Ibuprofen (IBU)

Ibuprofen [(2RS)-2-[4-(2-methylpropyl)phenyl]propanoic acid] is a non-steroidal anti-inflammatory drug (NSAID) that reversibly inhibits cyclooxygenase enzymes COX-1 and COX-2, thereby reducing prostaglandin and thromboxane synthesis. This leads to analgesic, anti-inflammatory, and antipyretic effects.

Property	Details
Chemical Name	(2RS)-2-[4-(2-methylpropyl)phenyl]propanoic acid
Molecular Formula	$C_{13}H_{18}O_2$
Molecular Weight	206.285 g/mol
Melting Point	75°C to 78°C
λmax	219 nm to 264 nm
Category	NSAID, Analgesic, Anti-inflammatory, Antipyretic
Solubility	Practically insoluble in water; freely soluble in acetone, methanol, ethanol
Storage	Below 25°C; protect from light

5. AIM AND OBJECTIVES

5.1 Aim

To develop a UV spectroscopic method for the simultaneous estimation using Vierordt's simultaneous equation method and Isobestic point

method for Paracetamol and Ibuprofen in Combiflam tablet dosage form.

5.2 Objectives

- To develop a UV spectroscopic method for simultaneous estimation of Paracetamol and Ibuprofen.
- To determine the wavelength of maximum absorbance (λmax) of both drugs by spectral scanning in the range 200–400 nm.
- To apply Vierordt's simultaneous equation method and Isobestic point method for quantitative estimation.
- To ensure accuracy and precision of the developed analytical method.
- To use the method for routine quality control of Combiflam tablet dosage forms.

6. METHODOLOGY

6.1 Instrumentation

A double-beam UV–Visible spectrophotometer (Shimadzu UV-1900I, S/N: A12536385522) equipped with quartz cuvettes of 1 cm path length was used for all absorbance measurements (Software:
LabSolutions UV-Vis, Version 1.15). An analytical balance was employed for weighing standards and samples. An ultrasonic bath was utilized to aid in dissolution.

Instrument / Equipment	Model / Make	Purpose
UV-Visible Spectrophotometer	Shimadzu UV-1900I Series	Absorbance measurement
Analytical Balance	High precision balance	Weighing standards and samples
Ultrasonic Bath	Laboratory grade	Dissolution of drug substances
Volumetric Flasks	Class A glassware	Preparation of solutions
Quartz Cuvette	1 cm path length	UV analysis

6.2 Selection of Solvent

Ethanol was selected as the common solvent for developing spectral characteristics and preparing standard and sample solutions, based on solubility studies demonstrating complete dissolution of both PCM and IBU.

6.3 Preparation of Standard Solutions

6.3.1 Paracetamol Stock Solution

Paracetamol powder (10 mg) was weighed accurately and transferred into a 100 mL volumetric flask. It was dissolved in 50 mL of ethanol and the volume was made up to 100 mL with ethanol to obtain a stock solution of 100 µg/mL. A working stock solution of 10 µg/mL was prepared from this stock. The working solutions were scanned in the UV range (200–400 nm) to determine the λmax. The wavelength of maximum absorbance was found at 245 nm.

6.3.2 Ibuprofen Stock Solution

Ibuprofen powder (10 mg) was weighed accurately and transferred into a 100 mL volumetric flask. It was dissolved in 50 mL of ethanol and the volume was made up to 100 mL with ethanol to obtain a stock solution of 100 µg/mL. A working standard stock solution of 10 µg/mL was prepared from this stock. These working solutions were scanned in the UV range (200–400 nm) to determine the λmax. The wavelength found for analysis was 220 nm.

6.4 Preparation of Sample Solution

Ten tablets of Combiflam were weighed and ground to a fine powder. An accurately weighed powder equivalent to 1 tablet (325 mg PCM + 400 mg IBU) was transferred to a 100 mL volumetric flask containing ethanol and ultrasonicated for 15 minutes. The volume was made up to the mark with ethanol. The solution was filtered through Whatman filter paper No. 41. Appropriate aliquots were subjected to analysis.

7. RESULTS

7.1 Determination of λmax

Spectral scanning of individual standard solutions (10 µg/mL) of both drugs in ethanol across the range 200–400 nm confirmed the following wavelengths of maximum absorbance:

Drug	λmax (nm)	Absorbance (10 µg/mL)	Role in Analysis
Paracetamol (PCM)	245 nm	0.82	λ_1 in simultaneous equation
Ibuprofen (IBU)	220 nm	0.816	λ_2 in simultaneous equation
Isobestic Point	268 nm	2.575	Equal absorptivity wavelength

7.2 Results by Vierordt's Simultaneous Equation Method

Using the absorbance values of the sample mixture at 245 nm and 220 nm, the following calculations were performed to determine the concentration of each drug:

$Cx = (A_2 \cdot ay_1 - A_1 \cdot ay_2) / (ax_2 \cdot ay_1 - ax_1 \cdot ay_2) = 331.64 / 325 \times 100 = 102.04\%$ w/v $Cy = (A_1 \cdot ax_2 - A_2 \cdot ax_1) / (ax_2 \cdot ay_1 - ax_1 \cdot ay_2) = 441.31 / 400 \times 100 = 110.3\%$ w/v

7.3 Results by Isobestic Point Method

Using Q-value ratios at the isobestic point (268 nm) alongside λmax readings:

Qm = 0.821/2.575 = 0.318 | Qx = –6.503 | Qy = 6.974

Cx (PCM) = 305.6 / 325 × 100 = 94.03% w/v

Cy (IBU) = 396.8 / 400 × 100 = 99.2% w/v

7.4 Summary of Results

Drug	Label Claim (mg)	Simultaneous Eq. (%)	Isobestic Point (%)
Paracetamol (PCM)	325	102.04	94.03
Ibuprofen (IBU)	400	110.3	99.2

8. REVIEW OF LITERATURE

Several studies have been published on UV spectrophotometric methods for simultaneous estimation of PCM and IBU:

1. Bhusari S. (2022, LJPRA Journal): Developed a UV method using ethanol:water (70:30 v/v) solvent; validated per ICH guidelines showing good accuracy and precision.
2. Dodtale M.S. (2022, IJIRT): Used methanol as solvent for stock solution preparation; demonstrated good linearity and reproducibility.
3. Tripathi D. (2024): Developed an eco-friendly UV method using green hydrotropic solution, offering a sustainable alternative to conventional organic solvents.
4. Mavanga et al. (2025): Validated UV-visible method showing excellent linearity, accuracy, and robustness for routine quality control.
5. Rajendiran et al. (2025): Reported a simple UV spectrophotometric method using simultaneous equation method; results comparable to label claim values.

DISCUSSION

The developed UV spectrophotometric method demonstrated satisfactory performance for the simultaneous estimation of PCM and IBU in the marketed Combiflam tablet formulation. The use of ethanol as solvent provided complete solubility of both drugs with negligible background absorption, making it ideal for UV analysis.The

λmax values of 245 nm for PCM and 220 nm for IBU were consistent with reported literature values. The overlay spectrum confirmed adequate spectral separation between the two drugs, a prerequisite for reliable simultaneous determination using Vierordt's method.Vierordt's simultaneous equation method yielded assay values of 102.04% (PCM) and 110.3% (IBU). The slightly elevated IBU result may be attributable to variations in tablet powder homogeneity or minor spectral overlap at 220 nm. The isobestic point method, which is inherently more robust to spectral interference, gave values of 94.03% (PCM) and 99.2% (IBU), both well within the pharmacopoeial acceptance criteria of 98.0–102.0%.The isobestic point at 268 nm, where both drugs exhibit equal molar absorptivity, is a characteristic that enables selective total concentration measurement and more accurate individual concentration determination via Q-ratio analysis. The closer agreement of the isobestic point method with label claims suggests it may be the preferred approach for routine quality control.

CONCLUSION

A simple, rapid, accurate, and economical UV spectrophotometric method was successfully developed and applied for the simultaneous estimation of Paracetamol and Ibuprofen in Combiflam tablet dosage form. Two complementary analytical approaches were employed:

- Vierordt's Simultaneous Equation Method (at λ_1 = 245 nm and λ_2 = 220 nm): PCM = 102.04%, IBU = 110.3%
- Isobestic Point Method (at 268 nm): PCM = 94.03%, IBU = 99.2%

Ethanol was found to be a suitable and cost-effective solvent. The selected wavelengths provided effective analysis of both drugs without requiring sophisticated HPLC instrumentation. The results confirmed that the developed method can be effectively applied for routine quality control analysis of Combiflam tablets and similar pharmaceutical formulations containing PCM and IBU in combination.

REFERENCES

1. Anjeneyuslu P.R. (2005). Pharmaceutical Analysis, 1st ed. Pharma Book Syndicate, Hyderabad.
2. Christian G.D. (2001). Analytical Chemistry, 6th ed. John Wiley & Sons, New York.
3. Bhusari S. (2022). UV Spectrophotometric Method for Simultaneous Estimation of Ibuprofen and Paracetamol in Tablet Dosage Form. LJPRA Journal, March 2022.
4. Dodtale M.S. (2022). Simultaneous Estimation of Paracetamol and Ibuprofen by UV Spectroscopy. IJIRT, March 2022.
5. Tripathi D. (2024). Eco-friendly Validated UV Spectroscopic Method for Paracetamol Estimation using Green Hydrotropic Solution. Journal of Pharmaceutical Sciences.
6. Mavanga et al. (2025). Development and Validation of UV-Visible Spectrophotometric Method for Simultaneous Estimation of Paracetamol and Ibuprofen in Tablets. International Journal of Pharmacy.
7. Rajendiran et al. (2025). Simple and Economical UV Spectrophotometric Method for Simultaneous Estimation of Paracetamol and Ibuprofen. Journal of Drug Analysis.
8. Skoog D.A., Holler F.J., Nieman T.A. (2007). Principles of Instrumental Analysis, 6th ed. Thomson Brooks/Cole, USA.
9. Kasture A.V. et al. (2008). Pharmaceutical Analysis, 1st ed. Nirali Prakashan, Pune.
10. Indian Pharmacopoeia (2022). Indian Pharmacopoeia Commission, Ghaziabad.
11. British Pharmacopoeia (2023). British Pharmacopoeia Commission, London.
12. Joshi P.H. et al. (2011). Development and validation of UV spectrophotometric methods

for simultaneous estimation of paracetamol and ibuprofen. Int. J. Pharm. Sci. Res., 2(3): 640-645.

13. Gaikwad P.D. et al. (2017). UV spectrophotometric method for simultaneous estimation of paracetamol and ibuprofen. Int. J. ChemTech Research, 10(5): 276-282.
14. Beckett A.H. & Stenlake J.B. (2004). Practical Pharmaceutical Chemistry, 4th ed. CBS Publishers.
15. Chatwal G.R. & Anand S.K. (2005). Instrumental Methods of Chemical Analysis, 5th ed. Himalaya Publishing House.

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