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Research Article

A Stability Indicating Method was Developed and Validation for the Estimation of Carbamazepine in Bulk and Tablet Dosage form by UV-Spectroscopic Techniques

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Abstract

Carbamazepine is an anticonvulsant. It works by decreasing nerve impulses that cause seizures and nerve pain, such as trigeminal neuralgia and diabetic neuropathy. It is well known that contemporary pharmaceutical analysis establishes robust, sensitive, economic, stability-indicating analytical procedures. The current study aimed to develop and assess UV-spectrophotometric (zero order, first order, second order, area under the curve) methods for estimating carbamazepine in its pharmaceutical dosage form. Method A is a simple zero-order spectrophotometric method for determining carbamazepine at 285 nm, and the correlation coefficient in the linearity study was found to be 0.9976, LOD, and LOQ are 0.45 and 1.48 µg/ml. Method B is a first-order spectrophotometric method for determining carbamazepine at 269 nm, and the correlation coefficient in the linearity study was found to be 0.9944, LOD, and LOQ are 0.29 and 0.96 µg/ml. Method C is a second-order spectrophotometric method for determining carbamazepine at 254 nm, and the correlation coefficient in the linearity study was found to be 1.00, LOD, and LOQ are 0.62 and 2.04 µg/ml. Method D is an area under the curve spectrophotometric method for determining carbamazepine at 266 to 300 nm, and the correlation coefficient in the linearity study was found to be 0.9975, LOD, and LOQ are 0.14 and 0.46 µg/ml. All developed methods demonstrated good repeatability and recovery with %RSD <2. Studies on stress degradation show that oxidation and acid degradation mostly impact carbamazepine solutions.

Keywords: Carbamazepine, UV-spectrophotometric, Tegrital, Degradation study.

INTRODUCTION

Carbamazepine is a first-line drug in the treatment of most forms of epilepsy and also the drug of first choice in trigeminal neuralgia. Furthermore, it is now frequently used in bipolar depression. Most oral formulations of carbamazepine are well absorbed with high bioavailability [1]. Carbamazepine ($C_{15}H_{12}N_2O$) is a tricyclic compound that is most efficient against partial seizure with or without secondary generalization. Carbamazepine was first discovered and developed in Basel, Switzerland, at the labs of J.R. Geigy AG by Schindler and others around 1954. In the USA, carbamazepine won initial approval from the FDA for treating trigeminal neuralgia in 1968. Approval for use in epilepsy (Tegretol) did not occur until 1974 and was not extended to use in children until several decades later [2]. Currently, carbamazepine is FDA-indicated as a first-line treatment for trigeminal neuralgia or tic douloureux [3]. Carbamazepine (Figure 1) manages and treats epilepsy, trigeminal neuralgia, and acute manic and mixed episodes in bipolar I disorder. Indications for epilepsy are specifically for partial seizures with complex symptomatology (psychomotor, temporal lobe), generalized tonic seizures (grand mal), and mixed seizure patterns [4]. Carbamazepine shows mechanisms of action two basic: 1. enhancement of sodium channel inactivation by reducing high-frequency repetitive firing of action potentials, and 2. action on synaptic transmission [5]. Carbamazepine is metabolized in the liver to carbamazepine-10, 11-epoxide, which is the active metabolite that leads to pharmacological action. Carbamazepine is highly bound to plasma proteins [6]. In patients, the protein-bound fraction ranged from 75-80% of the total plasma concentration. Bioavailability ranges from 75-85%. The rate or extent of absorption was not affected by food. Carbamazepine induces its own metabolism, leading to increased clearance, shortened serum half-life, and progressive decrease in serum levels [7]. The most common side effects of carbamazepine include dizziness, drowsiness, ataxia, nausea, and vomiting [8].

Various analytical techniques have been reported for quantifying carbamazepine by UV-spectrophotometric methods. Surini et al., have developed a validated UV-Vis spectroscopic assay method for determining carbamazepine in microparticles [9], Zadbukeet al., proposed a newly develop validate UV-visible spectroscopic method for estimation of carbamazepine in bulk and tablet dosage form [10], estimation of carbamazepine by zero-order and area under the curve UV spectrophotometric methods [11], carbamazepine estimating and determining in bulk and tablet dosage form [12], quantification of carbamazepine by UV and HPLC methods and the bioanalytical study on rabbit plasma [13], stability-indicating analytical approaches to determine the carbamazepine by

HPLC method [14], determination of assay of carbamazepine CR tablets by HPLC method [15]. According to the previously reported analytical methods, our main aim is to develop robust, rapid, sensitive, selective, linear, and precise different types of UV-spectrophotometric methods to determine and validate the method as per the United States Pharmacopeia [16] and ICH guidelines [17]. As per ICH Q2(R1) guidelines [18], linearities, accuracy, precision, specificity, the limit of detection (LOD), and limit of quantification (LOQ) are performed and utilized in determining the drug content of the carbamazepine in various pharmaceutical products.

MATERIALS AND METHODS

Materials

Mylan Laboratories Ltd., Hyderabad, India, provided carbamazepine bulk powder as a kind gift. Carbamazepine commercial formulation Tegrital (200 mg) was purchased from the local pharmacy. The investigation used only chemical reagents of analytical quality. From GlaxoSmithKline Pharmaceuticals Limited in Mumbai, India, ethanol was procured. From Gujarat, India's Ideal Chemicals Pvt. Ltd., we received disodium hydrogen phosphate, bovine albumin, sodium hydroxide, hydrogen peroxide, and hydrochloric acid.

Instrumentation

Shimadzu 1800 UV spectrophotometer was used for this analysis, with 1 cm matched quartz cells for all measurements. Data were acquired and processed using UV probe software (series-4.2). The investigation employed a digital analytical balance (Mettler Toledo, India), an ultrasonic sonicator (Spectra Lab, India), and validated borosilicate glass pipettes, volumetric flasks, and beakers.

Selection of solvents based on the solubility and stability studies

The drug solubility and stability at 25°C were evaluated using a variety of solvents. 10 mL of volumetric flasks containing various solvents and buffers, including water, ethanol, methanol, acetonitrile, phosphate buffer saline pH 7.2, phosphate buffer pH 5.5, 5.6, 7.2, and 7.4 were each given 10 mg of the drug. Comparatively, the drug observed throughout the experiment was completely soluble in water, ethanol, methanol, and acetonitrile but not in buffers. To conduct additional studies on solution stability, prepare 10 µg/ml solutions with each of the above solvents and continuously examine the samples using UV-visible spectroscopy at 2, 4, 6, 8, and 12 hr. Most organic phase solutions showed stability over more than 24 hours at room temperature in the stability investigation.

Different Methods of Development

Establishing experimental conditions for examining chemical samples is done through the development of analytical procedures. The analytical method development aims to show the ident drug identity, purity, physical characteristics, and potency of the drug's bioavailability and stability. The advantage of the UV methods does not require elaborate treatment and procedures usually associated with specific characters. It is less time-consuming and economical. A statistical comparison of the quantitative determination of chemicals demonstrates that the UV approaches are simple, robust, and easy compared to other techniques. The results indicate that UV spectroscopic methods adequately quantify carbamazepine in pure and dosage forms.

Method A (Zero order spectrophotometric method)

The simplest way to run various analyses is using the principle of UV-spectroscopy. A blank solution for the diluent was maintained [19]. From 200 to 400 nm, samples were recorded. After the optimization study, the λ_{max} was confirmed to be 285 nm.

Method B (First-order spectrophotometric method)

The approach can recover unresolved band spectra with qualitative and quantitative data [20]. The diluent was kept as a blank solution. Spectra between 200 and 400 nm were measured. The zero-order spectra were transformed into first-order derivative spectra (delta lambda 8, scaling factor 1) using the inbuilt software of the instrument. After interpreting optimization study data, the λ_{max} was found to be 269 nm.

Method C (Second-order spectrophotometric method)

Developed primary data may be used by recovering unresolved band spectra [21]. A blank solution was preserved for the diluent. We measured the spectra between 200 and 400 nm. The instrument's built-in software converted zero-order to second-order derivative spectra (delta lambda 2, scaling factor 1). The standard drug was examined, and the lambda max was determined to be 254 nm.

Method D (Area under the curve spectrophotometric method)

Effectively solves the broad spectrum with the methodology is two effective points on the mixed spectrum are directly proportional to the concentration of the spectral component of interest [22]. A reference solution was preserved for the diluent. Samples were captured between 200 and 400 nm. Using UV probe software-2.42, the spectra between 266 and 300 nm were recorded. The area versus concentration data was used to conduct the linearity assessment.

Preparation of phosphate-albumin buffered saline (pH 7.2)

Dissolve 10.75 gm of disodium hydrogen phosphate, 7.6 gm of sodium chloride, and 10 gm of bovine albumin in distilled water and volume up to 1000.0 ml with the distilled water. Immediately before use adjust the pH to 7.2 using a dilute sodium hydroxide solution or dilute phosphoric acid.

Sample Preparations UV-spectroscopic methods

Preparation of solution for standard drug

Accurately weigh and transfer 10 mg of carbamazepine into a 10 ml clean, dry volumetric flask, add the ethanol, and sonicate to dissolve it completely and make volume up to the mark with the ethanol. Based on the requirement, samples are prepared for methods A, B, C, and D by dilution with the ethanol made from the working standard. The solutions with the requisite concentrations for procedures A, B, C, and D were diluted with the phosphate-albumin buffered saline (pH 7.2) made from the working standard and stored at 15°C for analysis.

Preparation of solution for commercial formulation

Ten commercial tablets of Tegrital (200 mg) were carefully weighed for the assay investigation, and the average weight was determined. The tablets were crushed uniformly to obtain a fine powder. The amount of powder equivalent to 25 mg of carbamazepine was transferred into the volumetric flask of 25 ml volume and sonicated for 15 minutes with sufficient ethanol to dissolve the drug; the volume was regulated up to the mark with the ethanol. The obtained solution was filtered using the Whatman filter paper. After the filtration solution was diluted with the phosphate-albumin buffered saline (pH 7.2) to produce the sample solutions for methods A, B, C, and D, the percentage estimation of the drug was calculated using the assay formula.

Method Validation

A crucial task in the pharmaceutical sector is method validation. Validation studies are necessary to confirm that the analytical approach suits its objectives. The data demonstrate the analytical approach's efficacy, dependability, and consistency. The analytical methodology was carried out following ICH Q2 (R1) recommendations for validating analytical methods for system suitability, linearity, detection limit, quantification, accuracy, precision, and robustness for all proposed methods [23].

Stress Degradation Studies by UV-Spectroscopic Methods

In the pharmaceutical industry, degradation studies offer a method for analysing the stability of drug samples. The chemical stability of the molecule has an impact on the safety and effectiveness of drug products. Information on molecule stability offers the information needed to choose the best formulation, container, storage environment, and shelf life. These data are crucial for regulatory documentation and play a significant part. Stability studies of novel drug compounds must be conducted before filling out the registration dossier. As per International Conference on Harmonization (ICH) guidelines (Q1A), stability studies must be performed to propose new drug substances and/or products' shelf life. To assess the suggested method's stability indicating characteristics and specificity, stress degradation studies by UV-spectroscopic methods of carbamazepine were also carried out, followed by ICH recommendations [24-25] and Mondal *et al*., (2016) [26]. All solutions used in stress studies were prepared at an initial concentration of 1mg/ml of carbamazepine and further diluted in the ethanol to give a final concentration of 10 µg/ml for methods A, B, D, and 6 µg/ml for method C and filtered the solutions before injection. Acid degradation was conducted in 0.5M hydrochloric acid, alkaline degradation was conducted using 0.5N sodium hydroxide, and solutions for oxidative stress studies were prepared using 10 % hydrogen peroxide refluxed for 90 min at 60°C. The drug solution was heated in a thermostat for thermal stress degradation testing, and the sample solution was cooled and used. Photostability was exposed to UV light for 6 hours under a UV chamber (365 nm) and analysed.

RESULTS

Method Validation

The developed spectroscopy methods for estimating carbamazepine are accurate, precise, robust, and specific. The results were based on the International Conference on Harmonization (ICH) guidelines. This guideline applies to new or revised analytical procedures used for the release and stability testing of commercial drug substances and products (chemical and biological/biotechnological).

Linearity

Linearity is an analytical method that produces test results directly proportional to the concentration of analyte present in the test sample. In Linearity studies, calibration curves were graphed in a concentration range of 4-12 µg/ml for Methods A, B, C, and D. The linear regression equation of method A is y = 0.0535x + 0.0198 with a correlation coefficient of 0.9976 (Figures 2 and 3), Method B is y = 0.0012x + 0.0002 with a correlation coefficient of 0.9944 (Figure 4 and 5), Method C is y = 0.0005x with a correlation coefficient of 1.00 (Figure 6 and 7), Method D is y = 0.3779x + 0.0206 with a correlation coefficient of 0.9975 (Figure 8 and 9).

Precision

When RSD in precision studies was less than 2%, the suggested procedure had acceptable reproducibility. The performance of intraday and interday precision and the percent RSD for the response of six replicate measurements in each developed method A, B, C, and D, were within the acceptable ranges. Results from the intraday and interday precision studies are summarized in Tables 1 and 2.

Accuracy

The percentage of recovery values in the accuracy studies demonstrates that the proposed method is accurate, and that interference response exists. By adding an adequate amount of carbamazepine standard stock solution to the sample solution, accuracy was evaluated at three different concentration levels (50%, 100%, and 150%). Three replicate measurements are performed for methods A, B, C, and D showing that the percent recovery was within the allowed ranges (Table 3).

Robustness

The robustness study was performed by altering the wavelength (±2 nm) in methods A, B, C, and D. All the parameters were passed with no notable changes. The percent RSD was within the acceptable range (Table 4).

Limits of Detection (LOD) & Limit of Quantification (LOQ)

The LOD and LOQ parameters were determined from the regression equation of carbamazepine; LOD = 3.3 σ/S, LOQ = 10 σ/S, where the standard deviation of the response (σ) and S is the slope of the corresponding calibration curve. In the LOD analysis, the detection limits for methods A, B, C, and D were 0.45, 0.29, 0.62, and 0.14 µg/ml, while the LOQ was 1.48, 0.96, 2.04, and 0.46 µg/ml, respectively. Table 5 displays the relevant LOD and LOQ values for carbamazepine.

Analysis of Marketed Formulations

The commercially available Tegrital -200 mg formulations of carbamazepine assay were carried out, and the purity percentage was assessed by methods A, B, C, and D. Neither substantial variation was found during the percentage purity analysis. The interpretation findings for the marketed tablets of carbamazepine are depicted in Table 6.

Stress Degradation Studies

Studies on stress degradation were carried out under various stressful conditions, but no significant degradation was observed. The highest degradation percentage was observed in oxidation stress tribunals, where methods A, B, C, and D observed 20.86%, 23.07%, 25%, and 26.12% of degradation, respectively (Figures 10, 11, 12, and 13).

Studies on acid stress degradation indicated that methods A, B, C, and D exhibited 16.90, 23.07, 25%, and 23.17% degradation, respectively (Figures 14, 15, 16, and 17).

In investigations on alkali stress degradation, it was revealed that methods A and D exhibited degradation rates of 7.77% and 3.83%, respectively (Figures 18, and 21). However, methods B and C showed no indications of deterioration (Figures 19, and 20).

Thermal stress degradation studies observed less degradation, with methods A, B, and D finding 14.20%, 23.07%, and 20.15% (Figures 22, 23, and 25). However, no degradation was seen in method C throughout the analysis period (Figure 24).

Regarding photolytic stress degradation, methods A and D showed degradation percentages of 1.79% and 7.03% (Figures 26 and 29); however, methods B and C showed no degradation at all (Figures 27 and 28).

The summary of the validation parameters is illustrated in Table 7, while Table 8 summarises the desired outcome of stress degradation studies.

Table 1: Intraday precision for method A, B, C, and D of carbamazepine.

Sl.No.	Conc. (µg/ml)	Method A	Method B	Method C	Method D	%RSD			
		Absorbance			Area	Method			
						A	B	C	D
1	10	0.544	0.013	0.005	3.748	0.51%	0%	0%	0.19%
2	10	0.551	0.013	0.005	3.752				
3	10	0.547	0.013	0.005	3.745				
4	10	0.547	0.013	0.005	3.745				
5	10	0.550	0.013	0.005	3.762				
6	10	0.551	0.013	0.005	3.750				

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method) Method D (Area under the curve spectrophotometric method).

Table 2: Interday precision for methods A, B, C, and D of carbamazepine.

Sl.No.	Conc. (µg/ml)	Method A	Method B	Method C	Method D	%RSD			
		Absorbance			Area	Method			
						A	B	C	D
1	10	0.534	0.013	0.005	3.724	1.57%	0%	0%	0.38%
2	10	0.557	0.013	0.005	3.752				
3	10	0.548	0.013	0.005	3.734				
4	10	0.552	0.013	0.005	3.762				
5	10	0.539	0.013	0.005	3.754				
6	10	0.542	0.013	0.005	3.753				

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method) Method D (Area under the curve spectrophotometric method).

Table 3: Carbamazepine accuracy observations for methods A, B, C, and D.

Level	Conc. (µg/ml)	Amount of drug added (µg/ml)		Amount recovered (µg/ml)				% Recovery			
		Pure	Formulation	Method				Method			
				A	B	C	D	A	B	C	D
50%	3	2	1	2.92	2.95	2.95	2.89	1.03%	0.70%	0.19%	1.02%
	3	2	1	2.96	2.98	2.96	2.92				
	3	2	1	2.98	2.99	2.96	2.95				
100%	6	2	4	5.98	5.97	5.99	5.96	0.79%	0.19%	0.84%	0.09%
	6	2	4	5.96	5.99	5.95	5.96				
	6	2	4	5.89	5.99	5.89	5.97				
150%	9	2	7	8.96	8.98	8.93	8.96	0.34%	0.17%	0.28%	0.06%
	9	2	7	8.98	8.97	8.98	8.97				
	9	2	7	8.92	8.95	8.95	8.97				

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method), and Method D (Area under the curve spectrophotometric method).

Table 4: The carbamazepine robustness data for several UV approach techniques.

Method	Condition	%RSD
A	Wavelength 283 nm	0.65
	Wavelength 287 nm	0.87
B	Wavelength 267 nm	0.54
	Wavelength 271 nm	0.95
C	Wavelength 252 nm	1.23
	Wavelength 256 nm	1.34
D	Wavelength 264nm to 298 nm	1.04
	Wavelength 268 nm to 302 nm	1.47

*Mean of six observations.

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method), Method D (Area under the curve spectrophotometric method).

Table 5: Employing UV techniques, the carbamazepine sensitivity assessments (LOD and LOQ).

Method	LOD (µg/ml)	LOQ (µg/ml)
Method A	0.45	1.48
Method B	0.29	0.96
Method C	0.62	2.04
Method D	0.14	0.46

*Mean of three observations.

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method), Method D (Area under the curve spectrophotometric method).

Table 6: Assay data for the commercially available carbamazepine formulations (Tegrital) using UV techniques.

Drug and label claim	Amount estimated (mg/tab)				Purity (% w/w) ± S.D, (%RSD)			
	Method				Method			
	A	B	C	D	A	B	C	D
Tegrital (200 mg)	199 ± 0.52	199 ± 0.87	199 ± 0.32	199 ± 0.63	99.85± 0.46 (0.58%)	99.78 ± 0.36 (0.69%)	99.65 ± 0.24 (0.39%)	99.67 ± 0.41 (0.35%)

*Mean of three observations.

Method A (Zero order spectrophotometric method), Method B (First-order spectrophotometric method), Method C (Second-order spectrophotometric method), and Method D (Area under the curve spectrophotometric method).

Table 7: Overview of carbamazepine UV-spectrophotometric validation parameters.

Parameters	Method A	Method B	Method C	Method D
λmax	285 nm	269 nm	254 nm	266-300 nm
Linearity (µg/ml)	4-12 µg/ml	4-12 µg/ml	4-12 µg/ml	4-12 µg/ml
Regression coefficient	R^2 = 0.9976	R^2 = 0.9944	R^2 = 1.00	R^2 = 0.9975
Regression equation (y=mx+c)	y = 0.0535x + 0.0198	y = 0.0012x + 0.0002	y = 0.0005x	y = 0.3779x + 0.0206
Intra-day precision (% RSD)	0.51%	0%	0%	0.19%
Inter-day precision (% RSD)	1.57%	0%	0%	0.38%
Robustness (% RSD)	0.65-0.87	0.54-0.95	1.23-1.34	1.04-1.47
LOD (µg/ml)	0.45	0.29	0.62	0.14
LOQ (µg/ml)	1.48	0.96	2.04	0.46

Table 8: The desired outcome of carbamazepine stress degradation studies employing UV-spectrophotometric approaches.

Degradation Condition	Method A	Method B	Method C	Method D	% Degradation			
	Absorbance			Area	Method			
					A	B	C	D
Oxidation	0.440	0.010	0.002	2.745	20.86%	23.07%	25%	26.62%
Acid	0.462	0.010	0.002	2.874	16.90%	23.07%	25%	23.17%
Alkali	0.477	0.010	0.003	2.987	14.20%	23.07%	0%	20.15%
Thermal	0.546	0.013	0.003	3.478	1.79%	0%	0%	7.03%
Photolytic	0.552	0.013	0.003	3.741	0.36%	0%	0%	0%

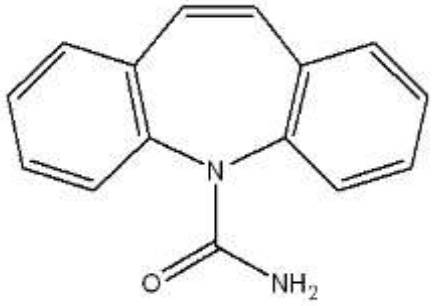

Figure 1: Chemical structure of carbamazepine.

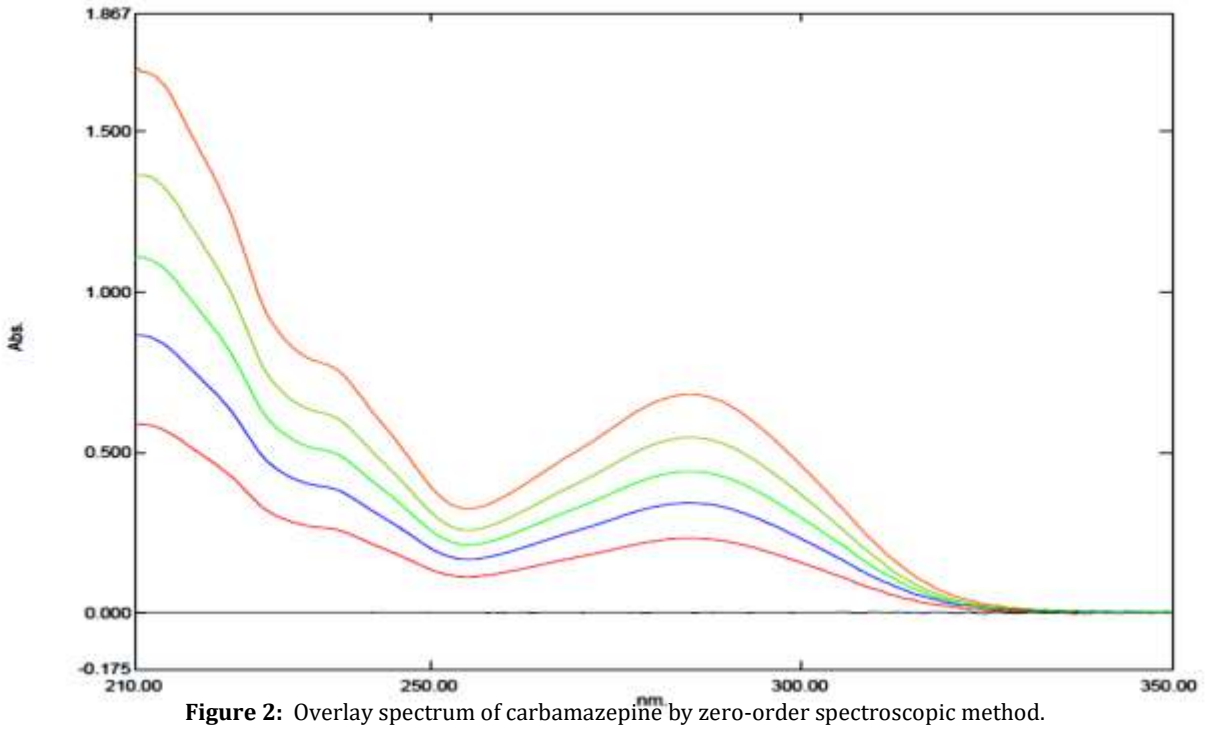

Figure 2: Overlay spectrum of carbamazepine by zero-order spectroscopic method.

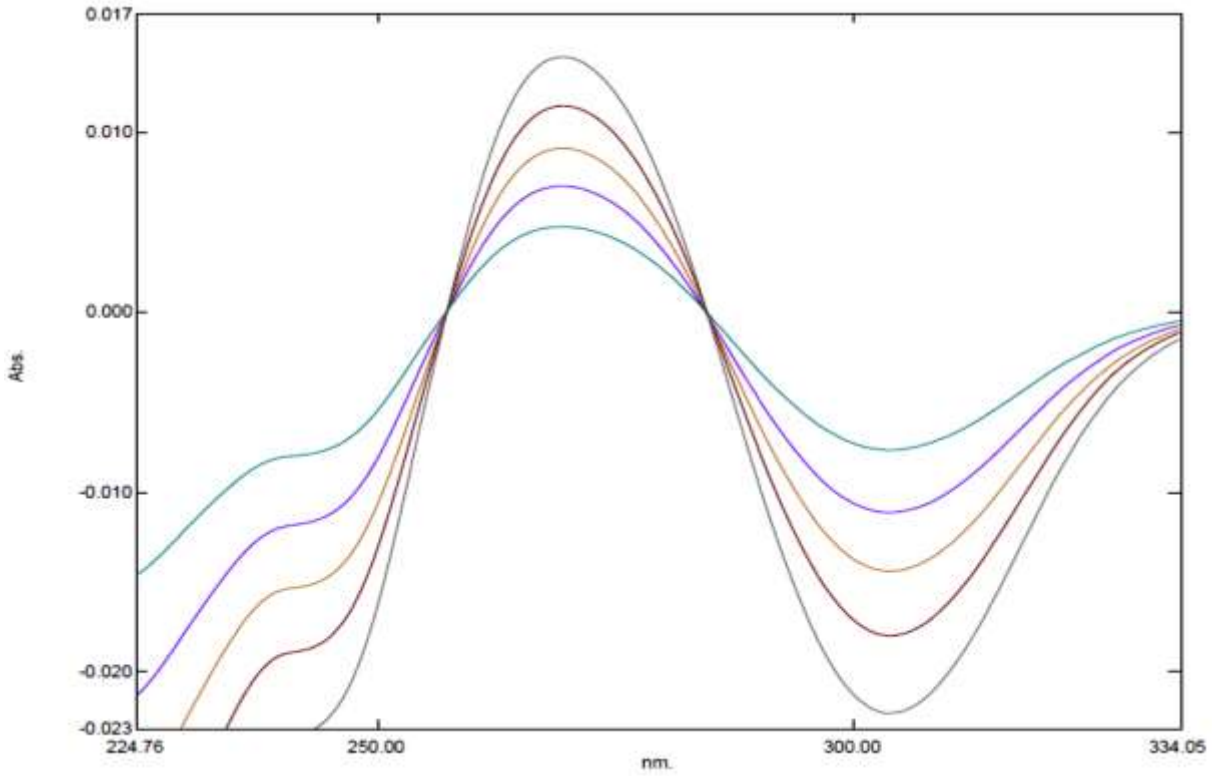

Figure 3: Overlay spectrum of carbamazepine by first-order spectroscopic method.

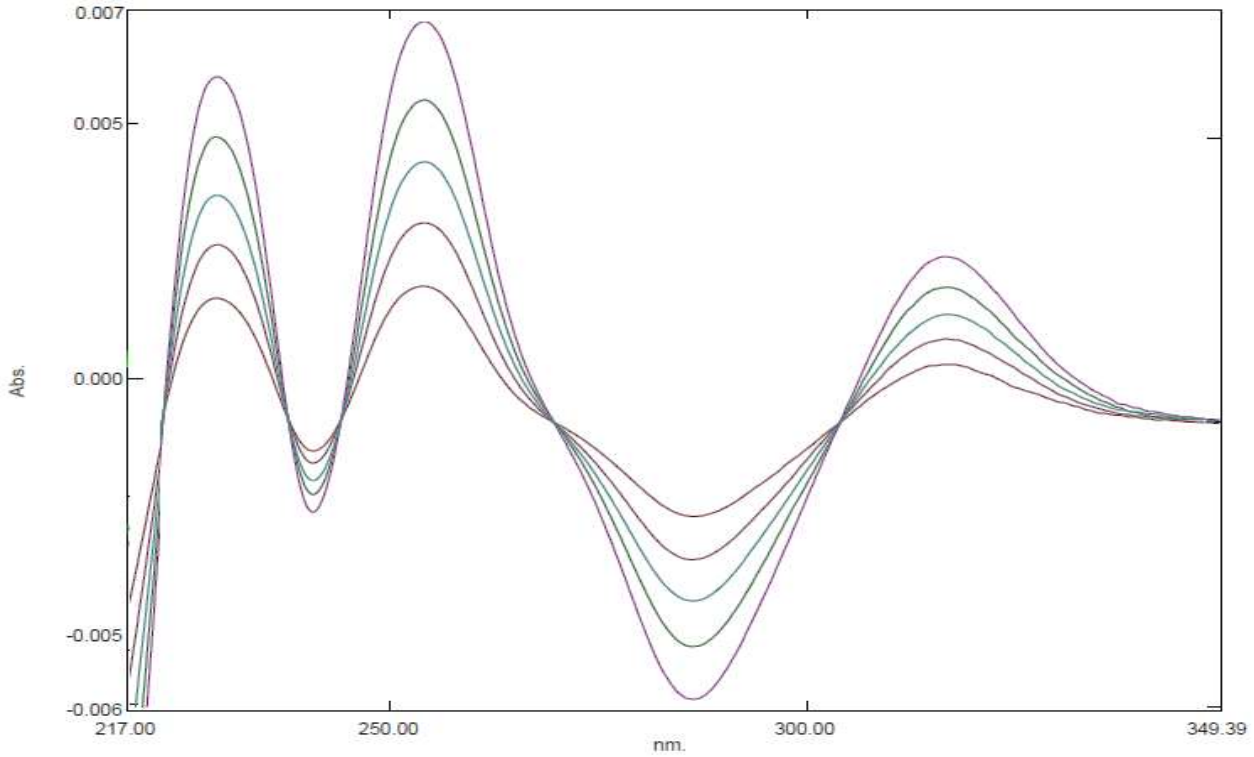

Figure 4: Overlay spectrum carbamazepine by second-order spectroscopic method.

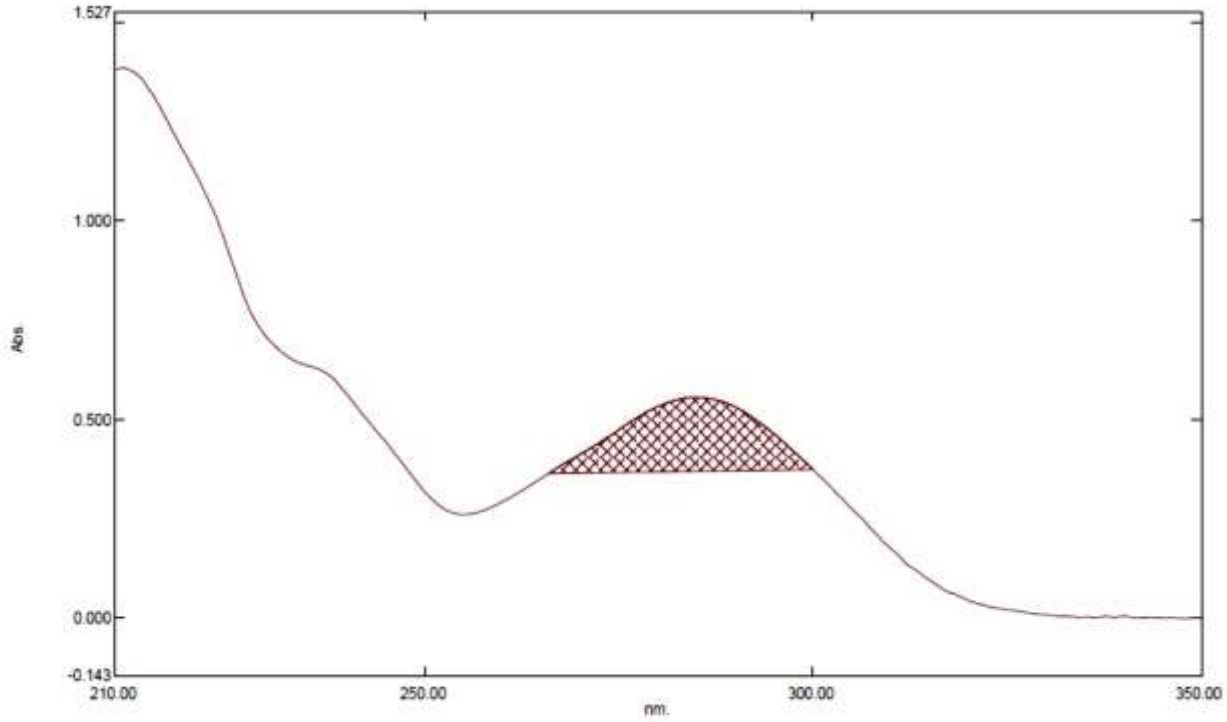

Figure 5: Optimised spectrum of carbamazepine at 10 µg/ml concentration by the area under the curve spectroscopic method.

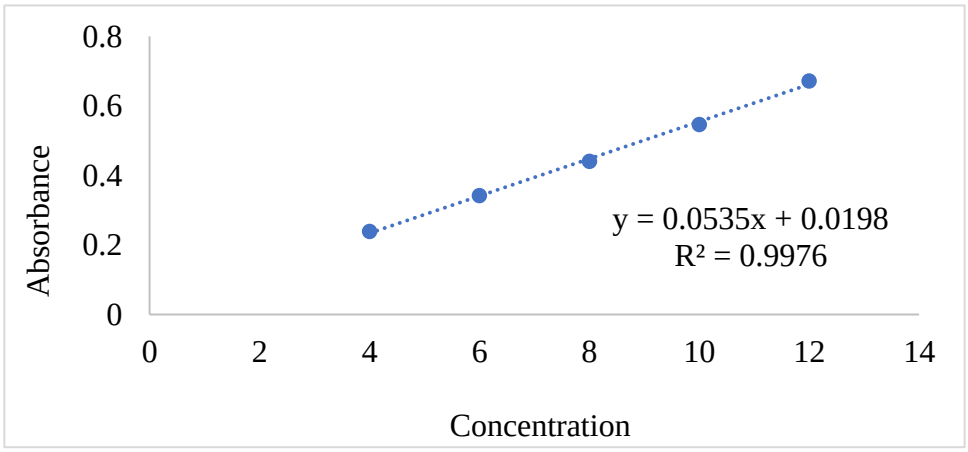

Figure 6: Calibration curve of carbamazepine for method A (Zero-order spectrophotometric method)

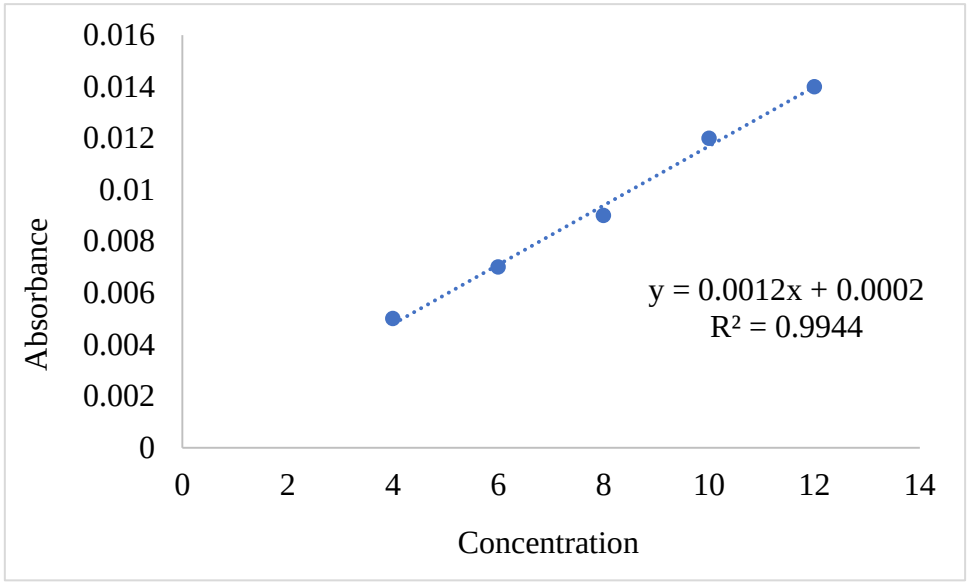

Figure 7: Calibration curve of carbamazepine for method B (First-order spectrophotometric method)

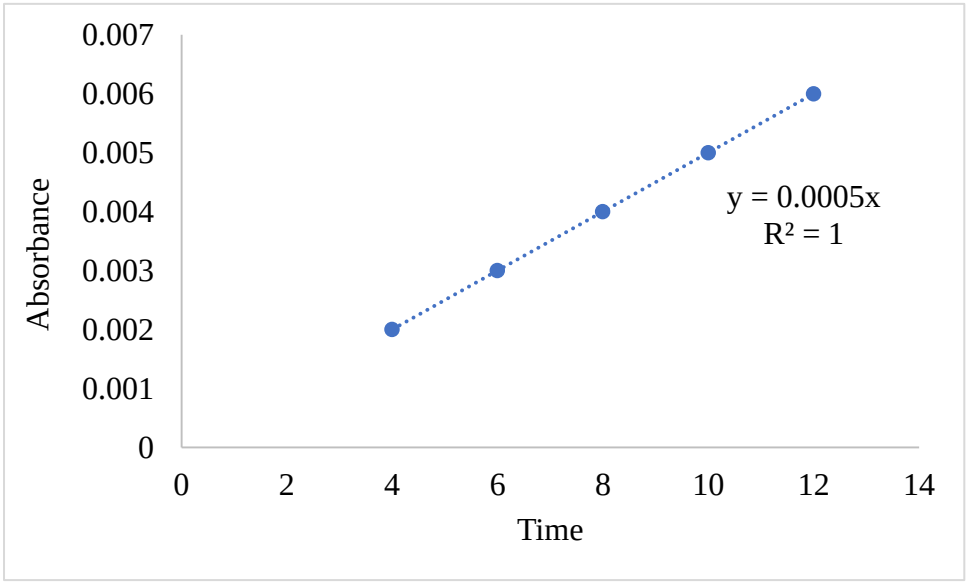

Figure 8: Calibration curve of carbamazepine for method C (Second-order spectrophotometric method)

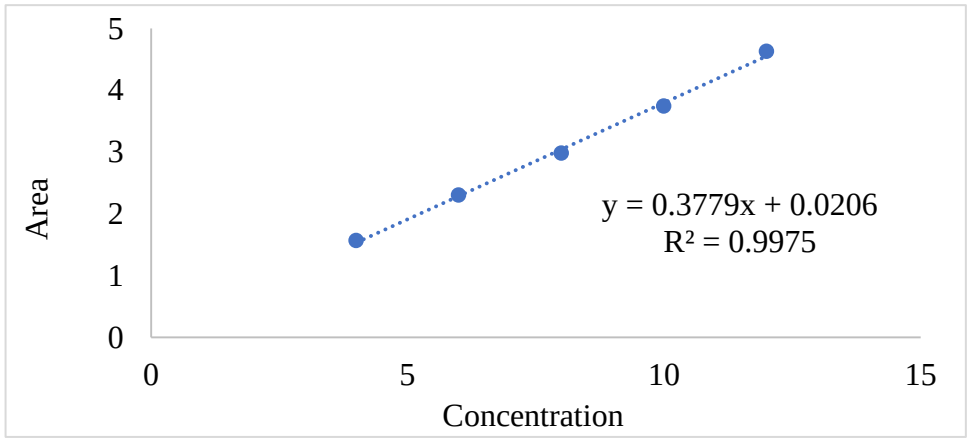

Figure 9: Calibration curve of carbamazepine for method D (Area under the curve spectrophotometric method)

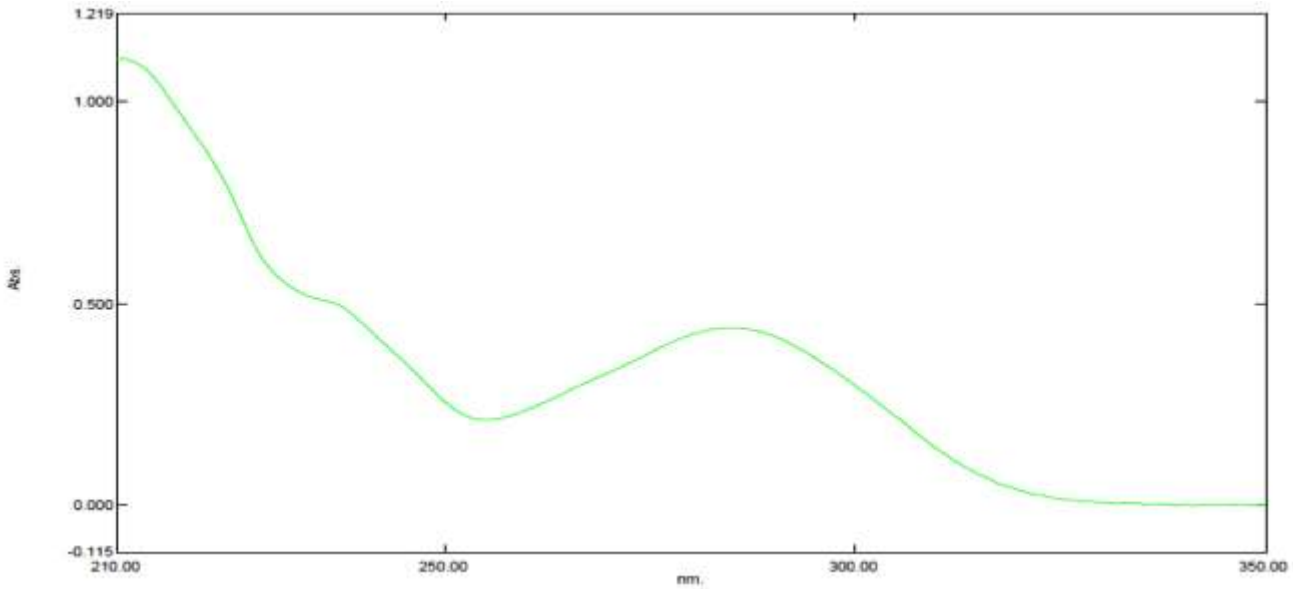

Figure 10: Spectrum of carbamazepine in oxidation degradation studies by zero-order spectroscopic method.

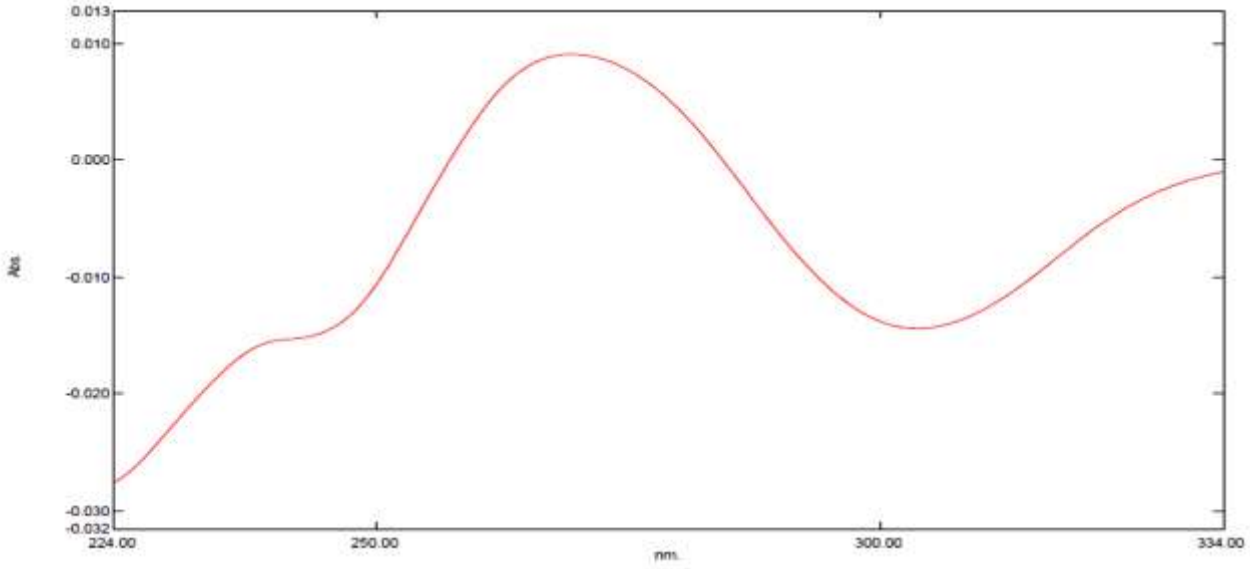

Figure 11: Spectrum of carbamazepine in oxidation degradation studies by first-order spectroscopic method.

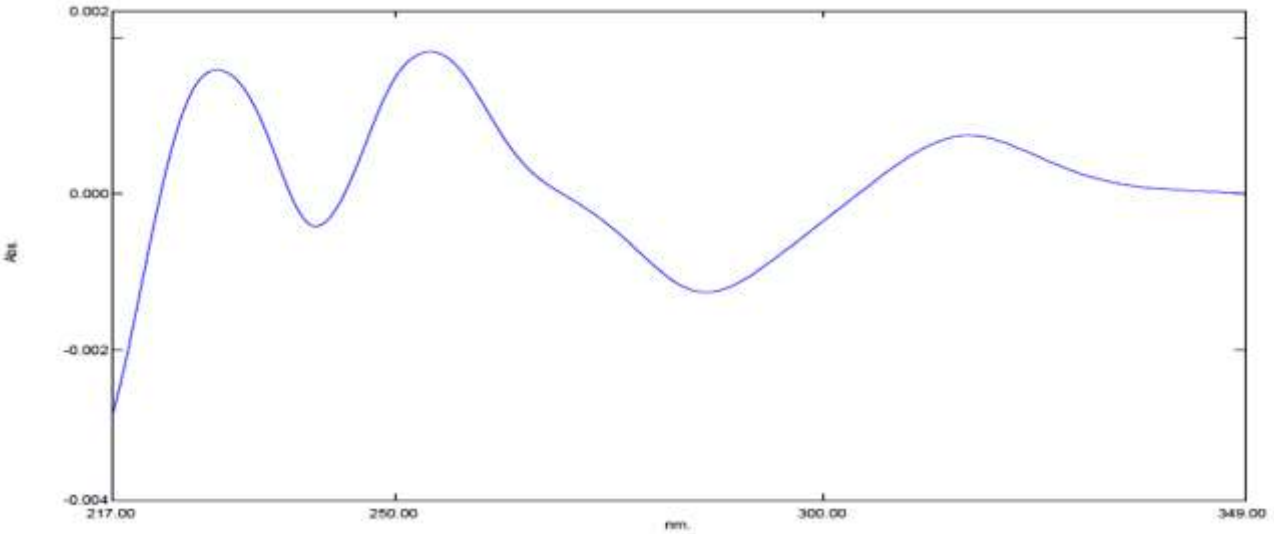

Figure 12: Spectrum of carbamazepine in oxidation degradation studies by second-order spectroscopic method.

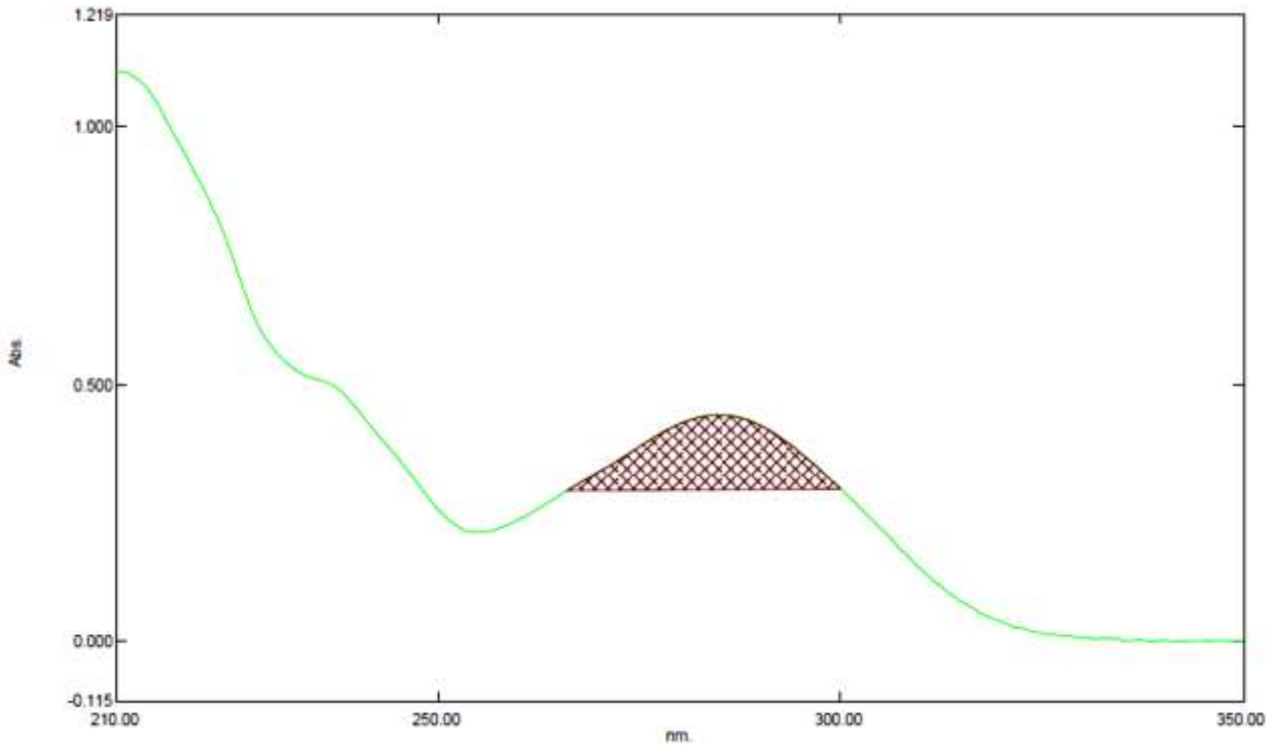

Figure 13: Spectrum of carbamazepine in oxidation degradation studies by the area under the curve spectroscopic method.

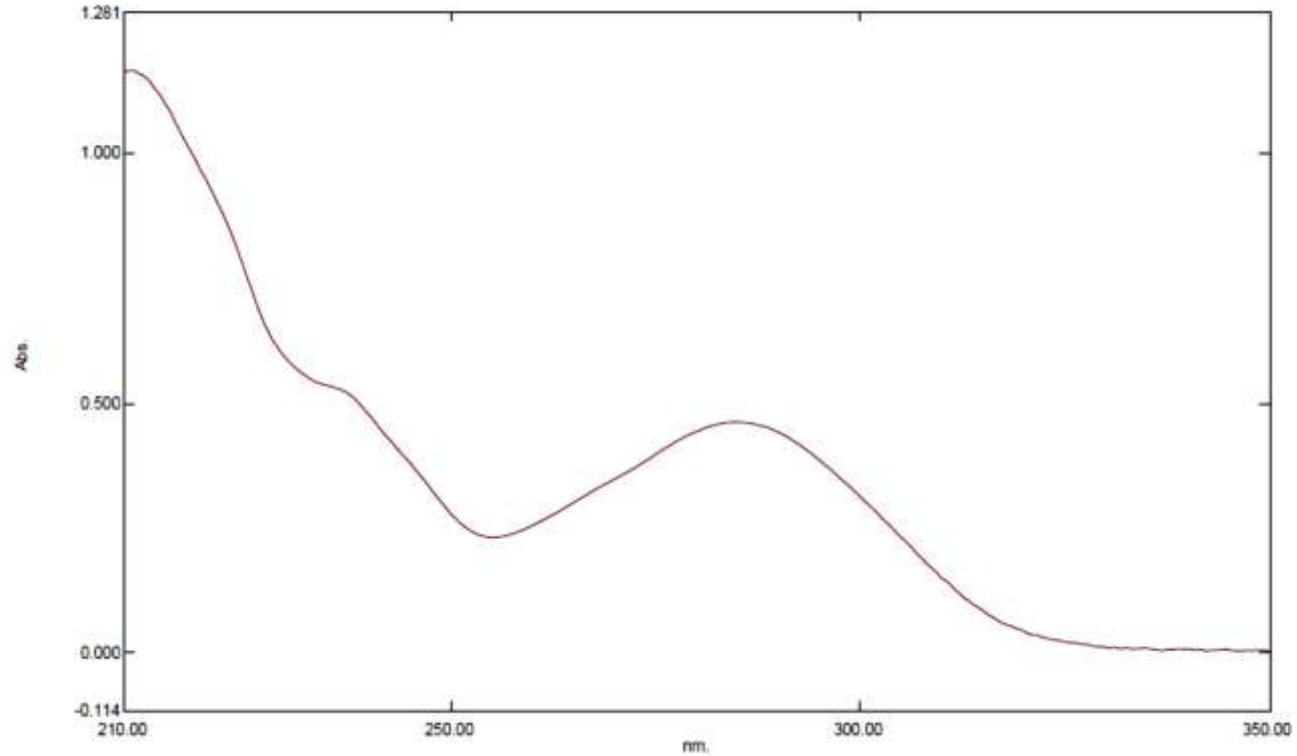

Figure 14: Spectrum of carbamazepine in acid degradation studies by zero-order spectroscopic method.

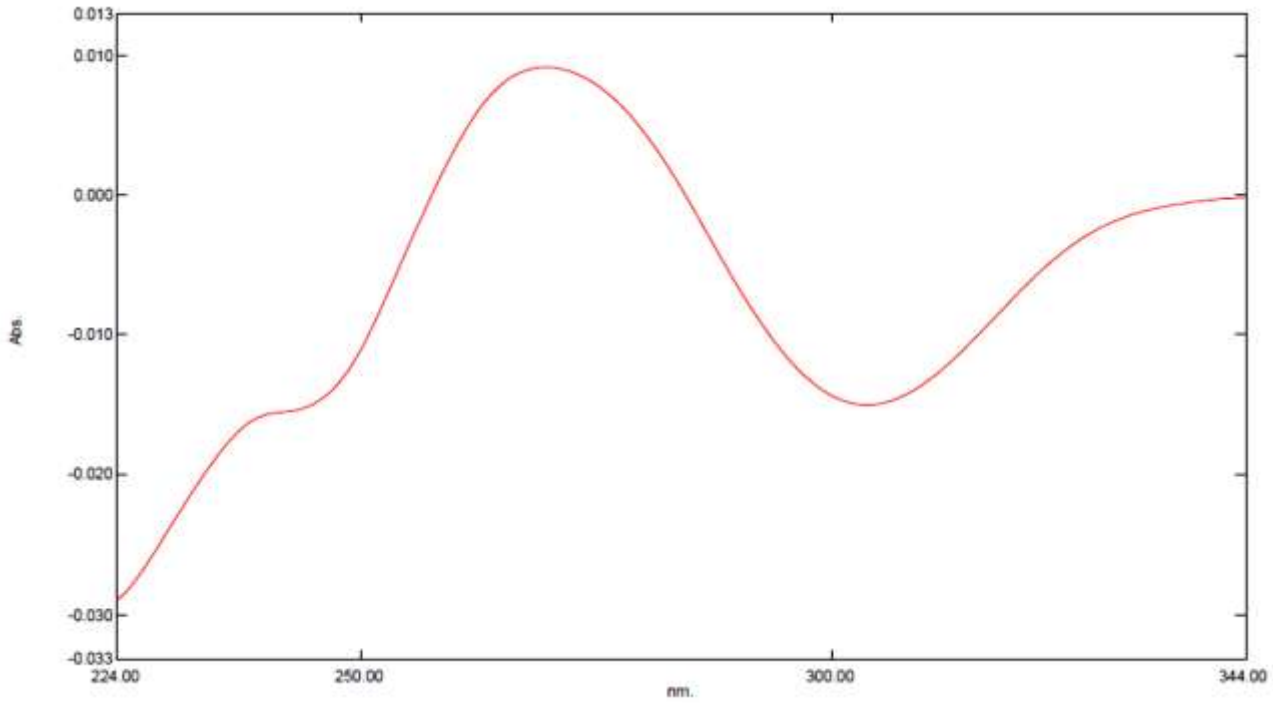

Figure 15: Spectrum of carbamazepine in acid degradation studies by first-order spectroscopic method.

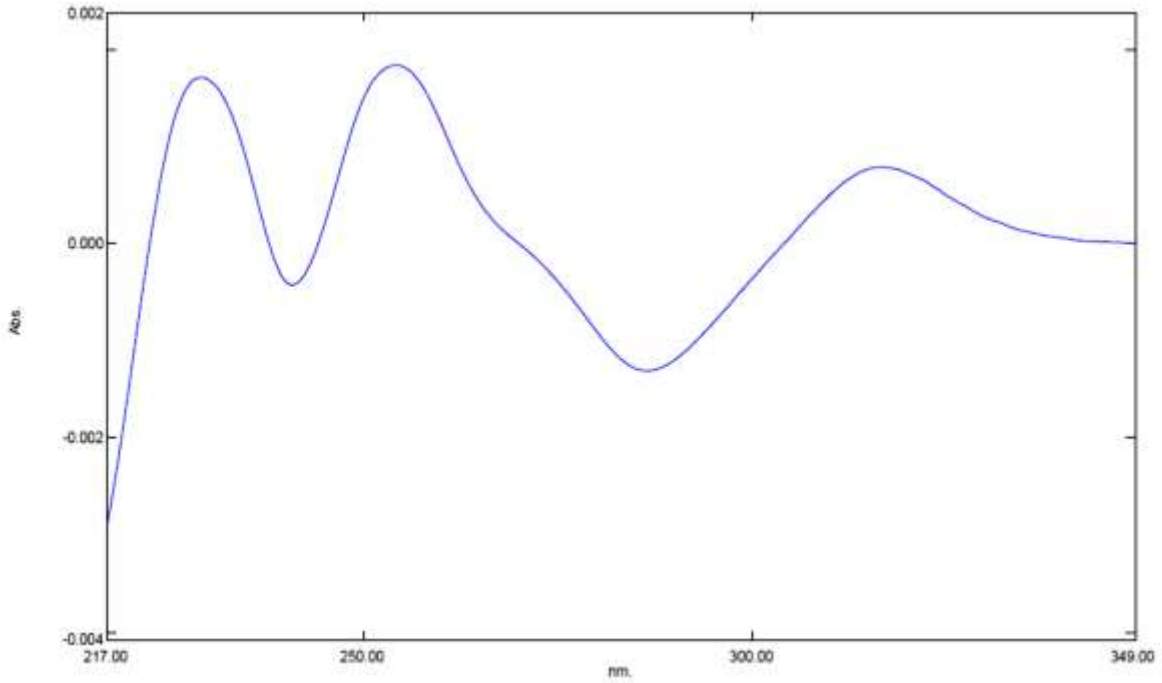

Figure 16: Spectrum of carbamazepine in acid degradation studies by second-order spectroscopic method.

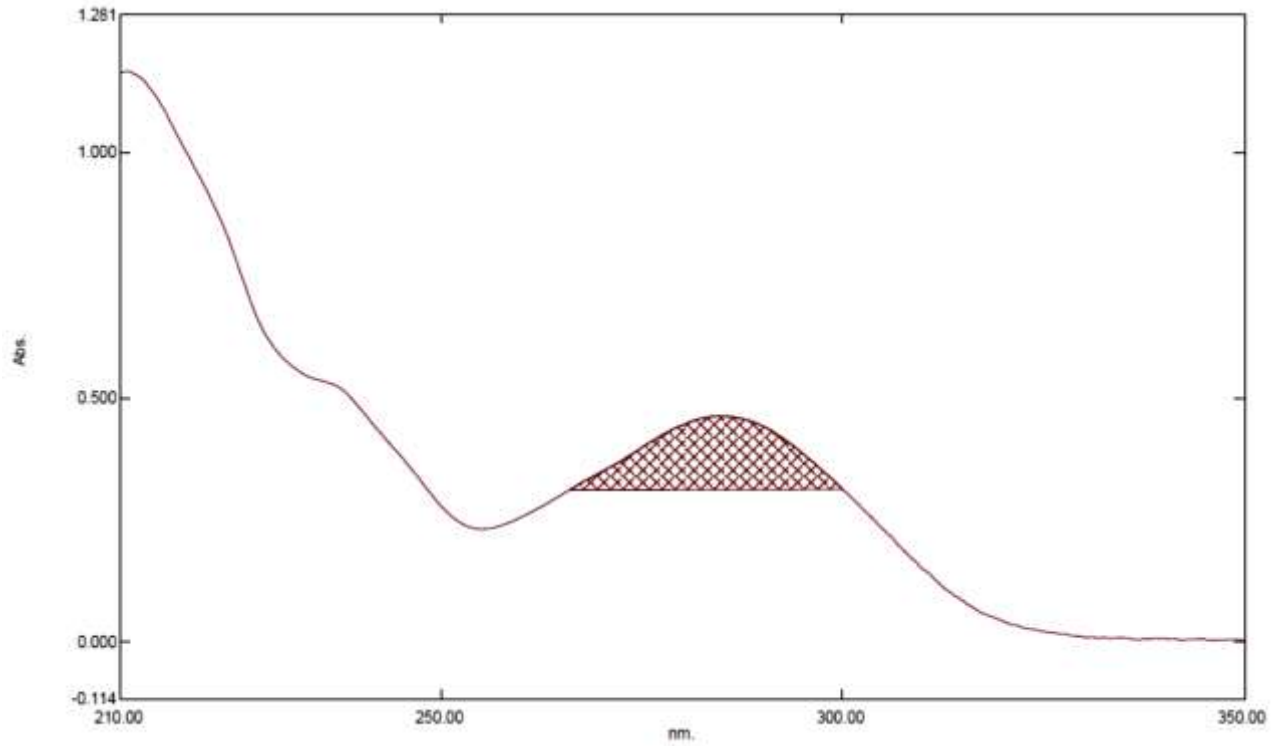

Figure 17: Spectrum of carbamazepine in acid degradation studies by the area under the curve spectroscopic method.

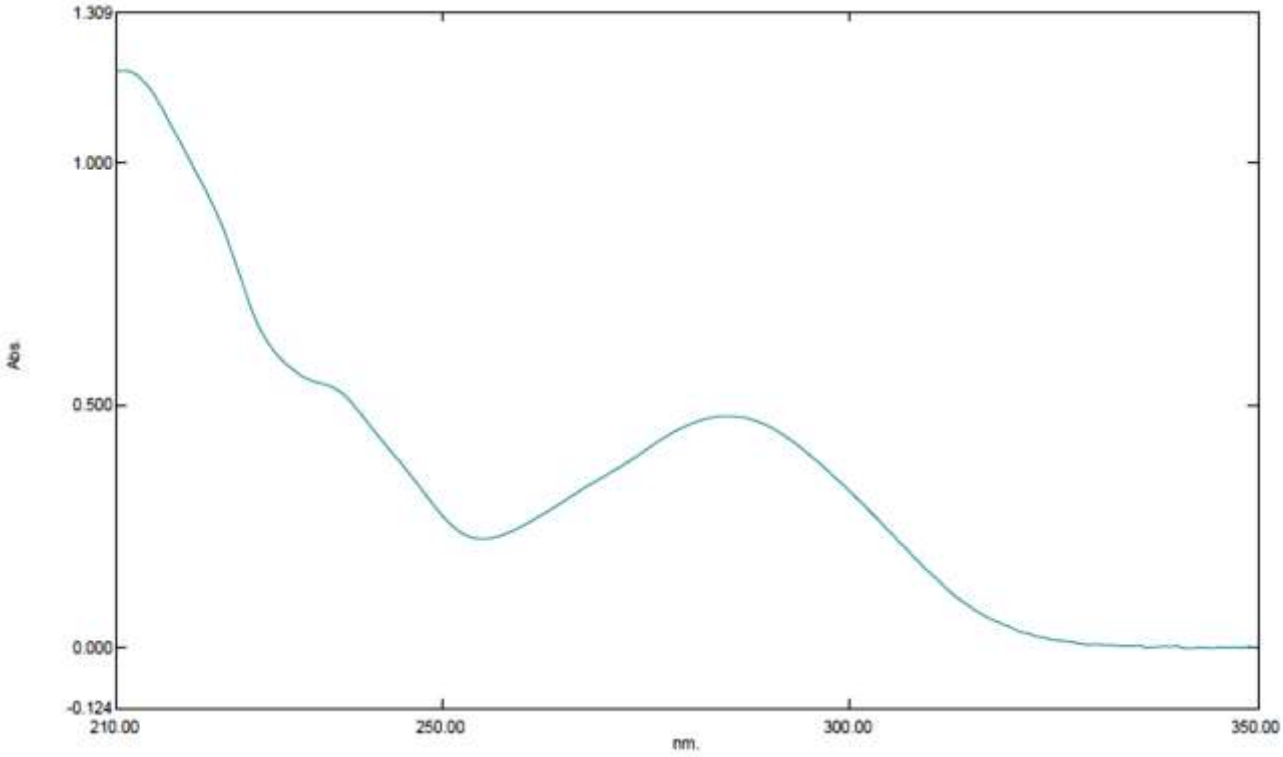

Figure 18: Spectrum of carbamazepine in alkali degradation studies by zero-order spectroscopic method.

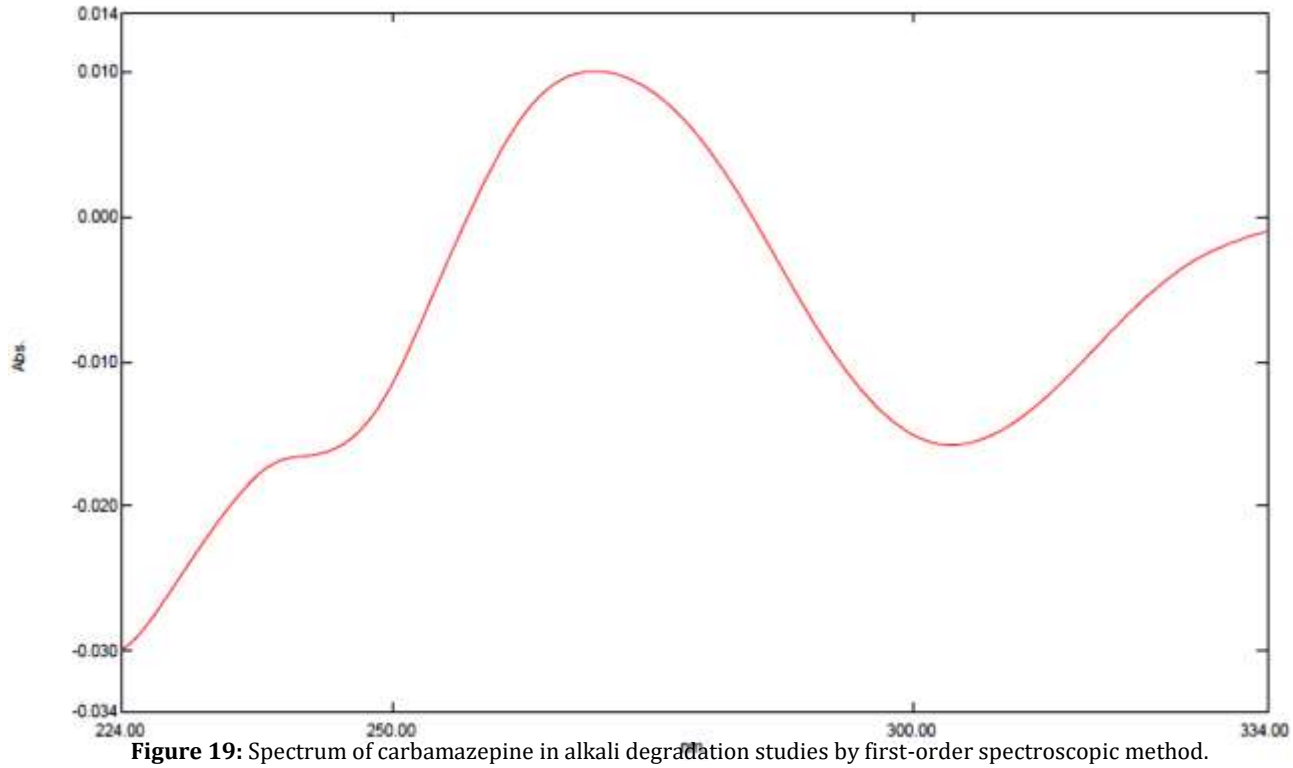

Figure 19: Spectrum of carbamazepine in alkali degradation studies by first-order spectroscopic method.

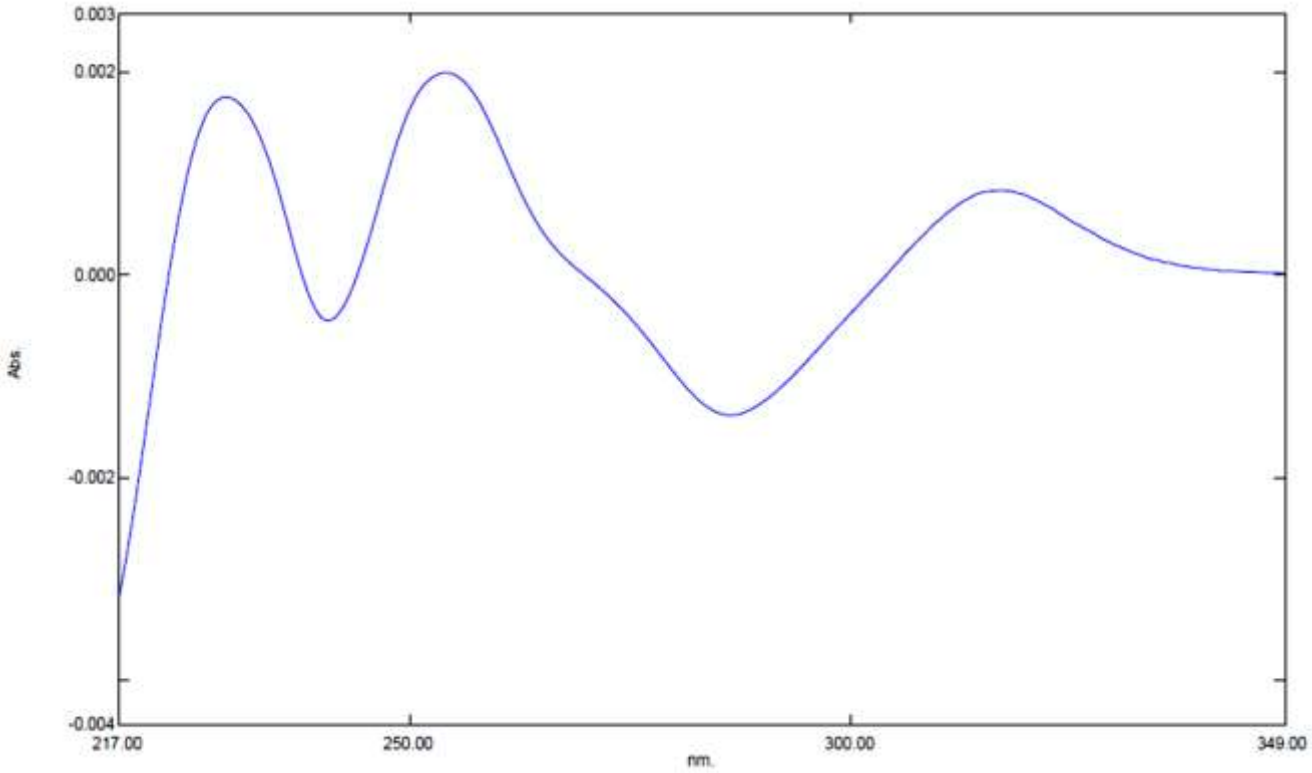

Figure 20: Spectrum of carbamazepine in alkali degradation studies by second-order spectroscopic method.

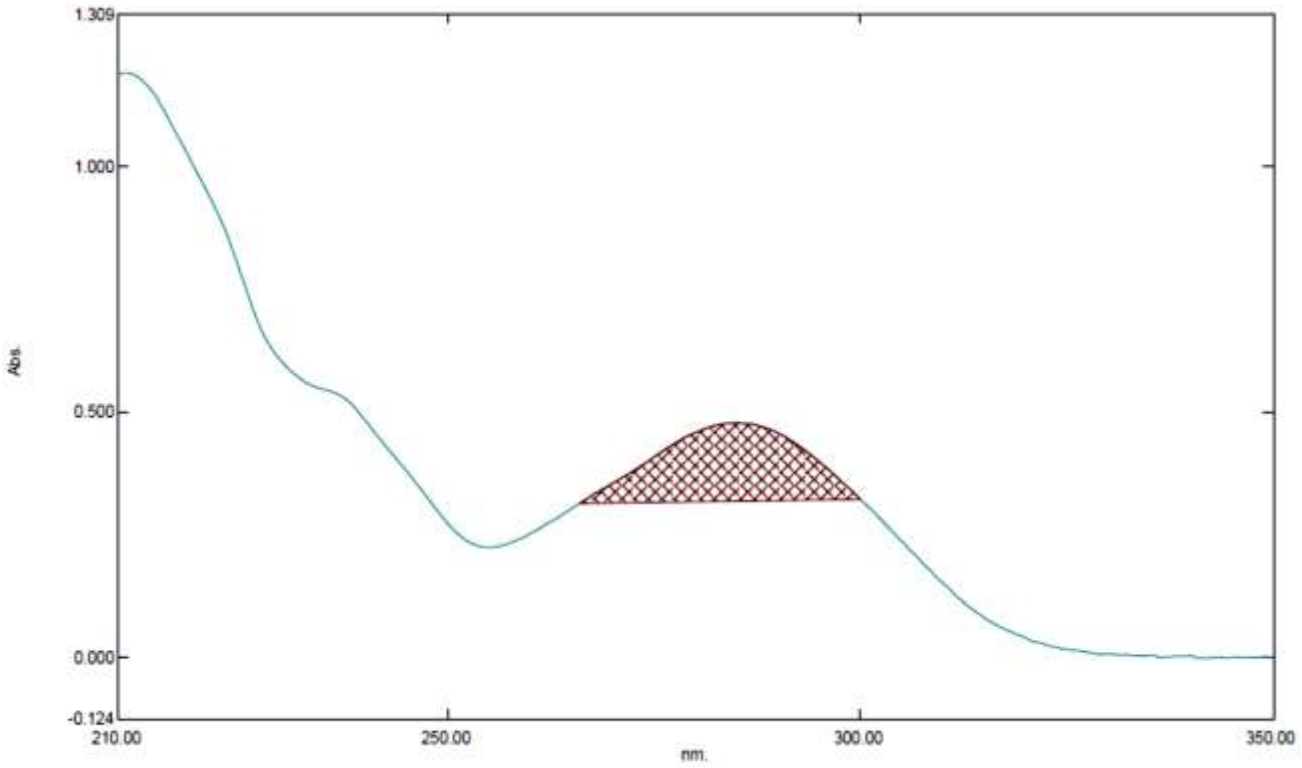

Figure 21: Spectrum of carbamazepine in alkali degradation studies by the area under the curve spectroscopic method.

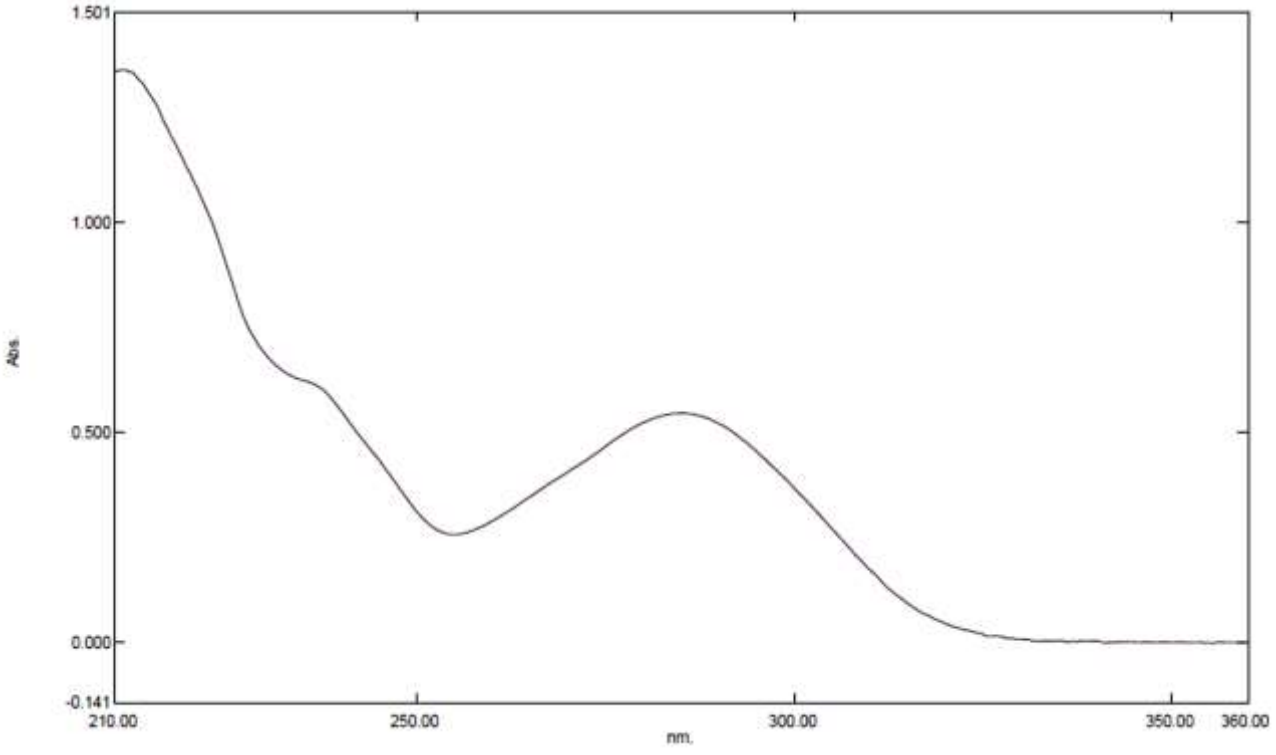

Figure 22: Spectrum of carbamazepine in thermal degradation studies by zero-order spectroscopic method.

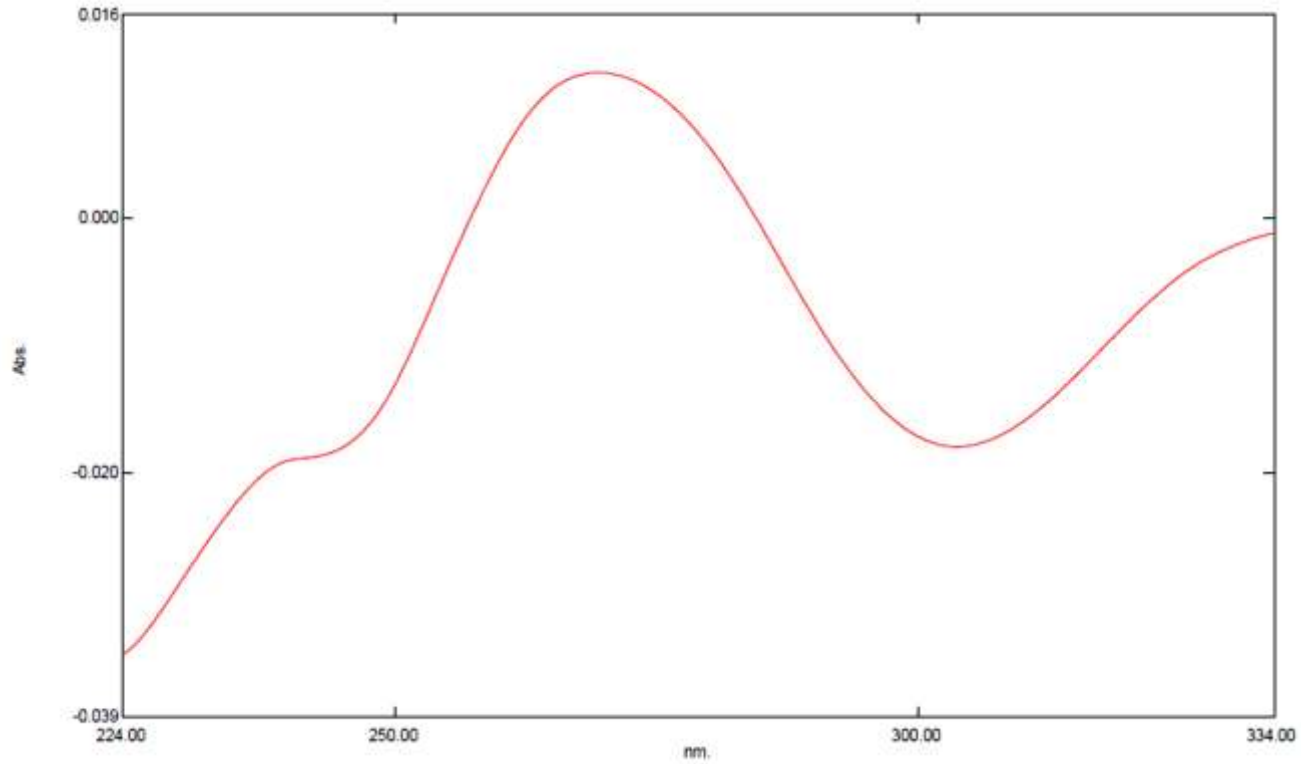

Figure 23: Spectrum of carbamazepine in thermal degradation studies by first-order spectroscopic method.

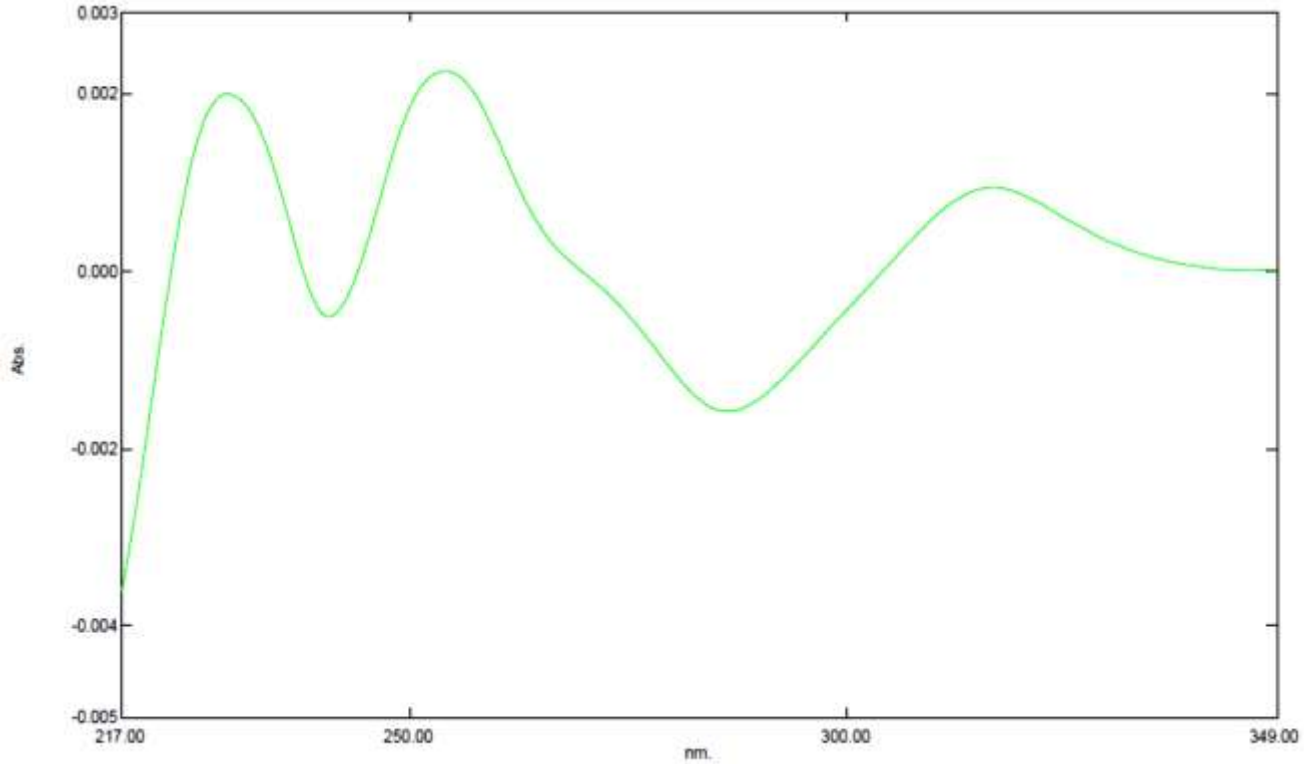

Figure 24: Spectrum of carbamazepine in thermal degradation studies by second-order spectroscopic method.

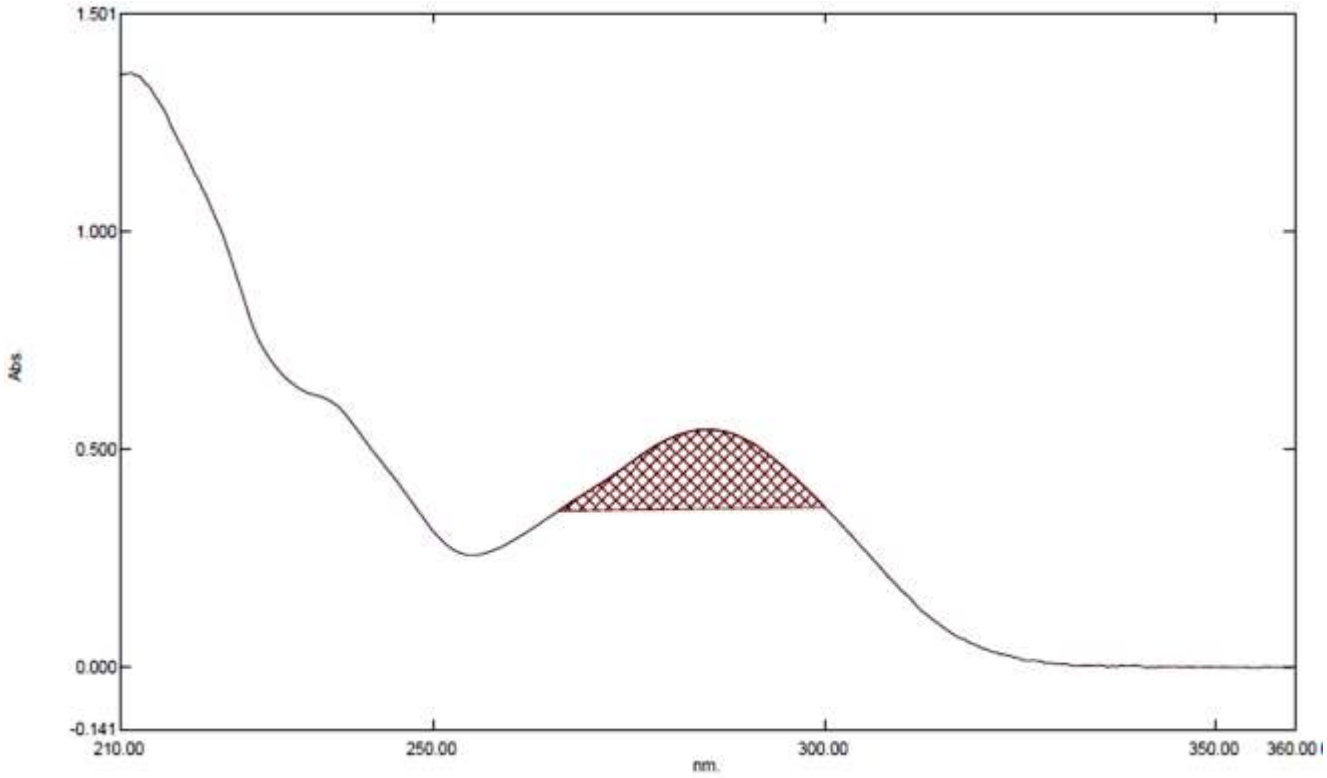

Figure 25: Spectrum of carbamazepine in thermal degradation studies by the area under the curve spectroscopic method.

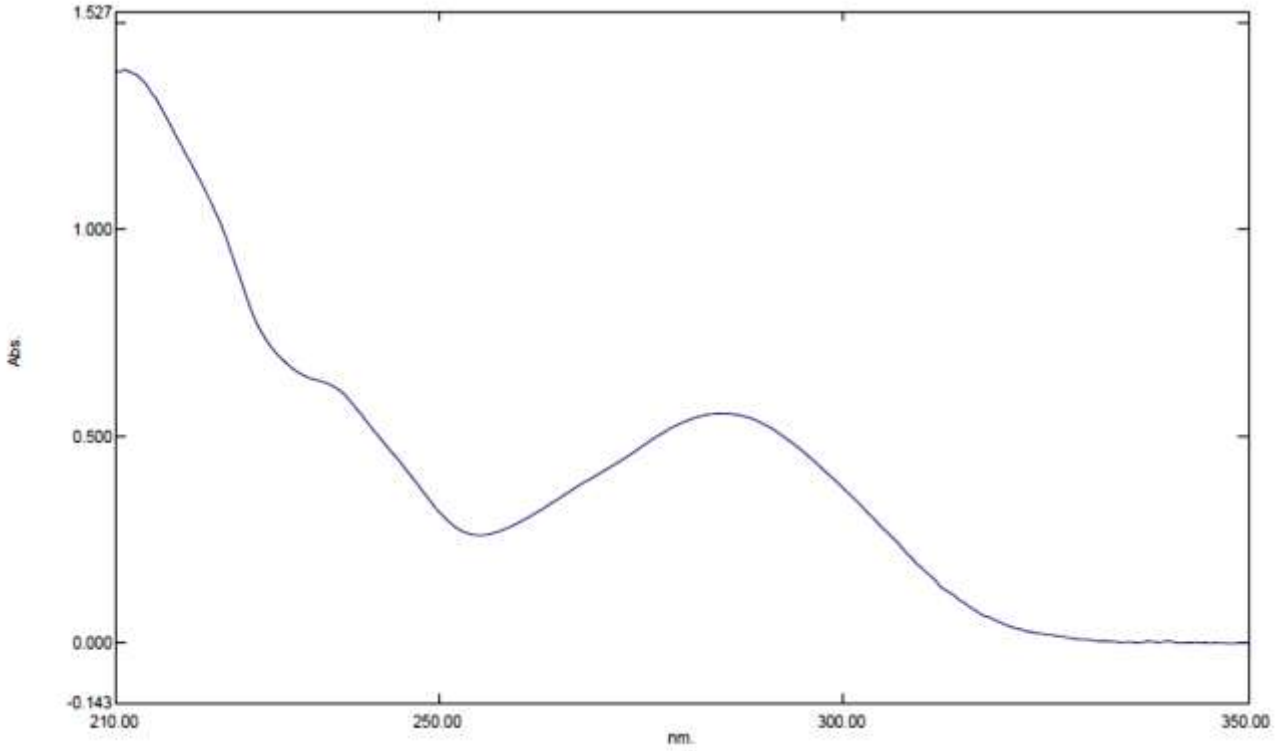

Figure 26: Spectrum of carbamazepine in photolytic degradation studies by zero-order spectroscopic method.

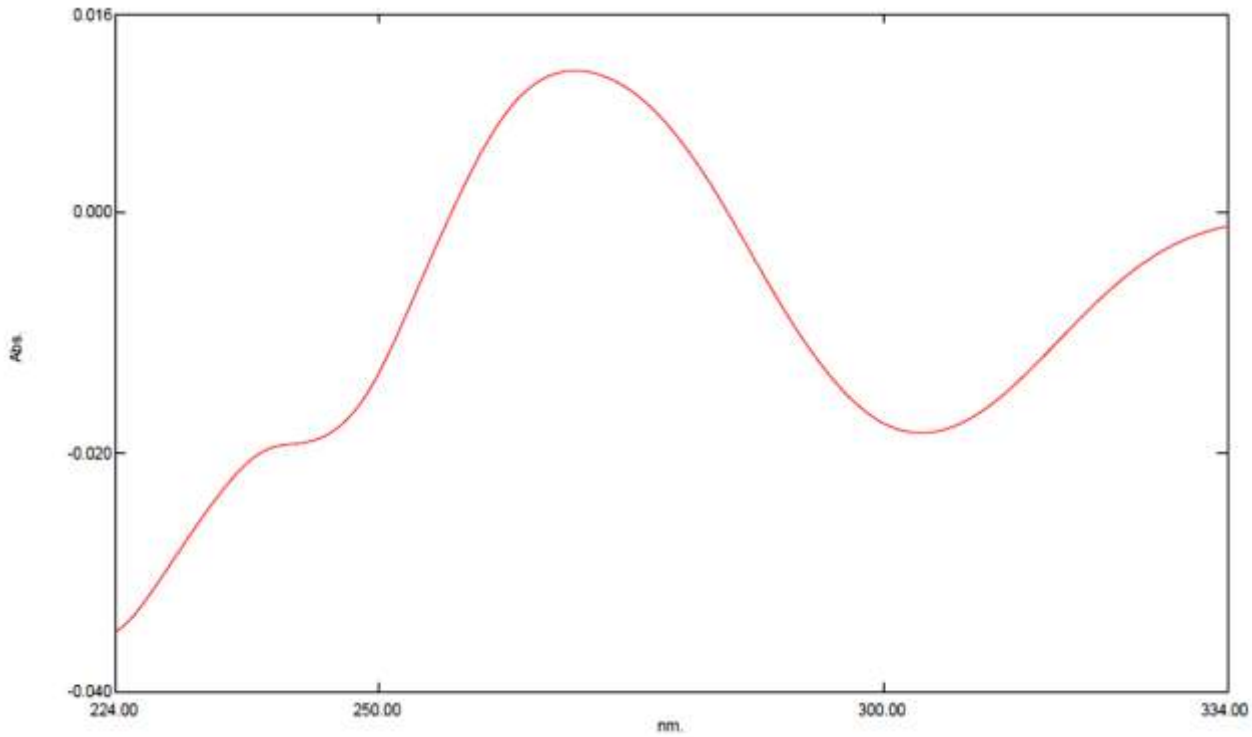

Figure 27: Spectrum of carbamazepine in photolytic degradation studies by first-order spectroscopic method.

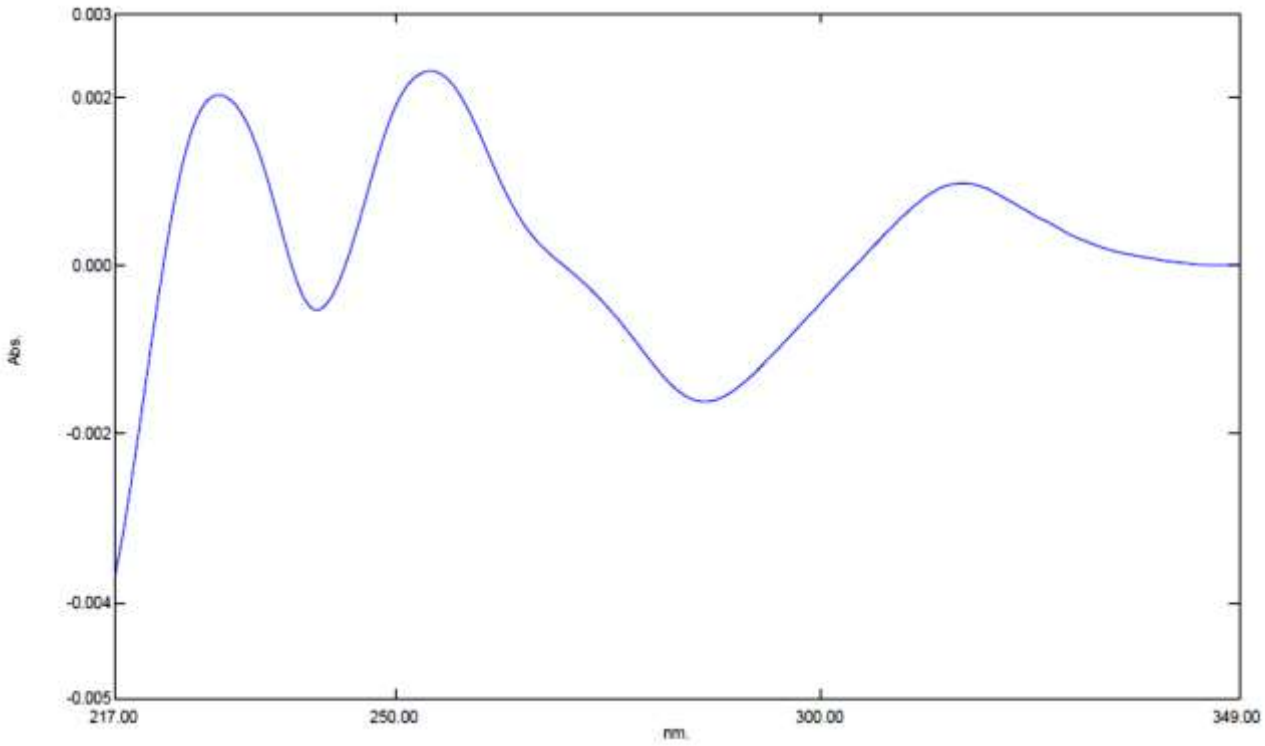

Figure 28: Spectrum of carbamazepine in photolytic degradation studies by second-order spectroscopic method.

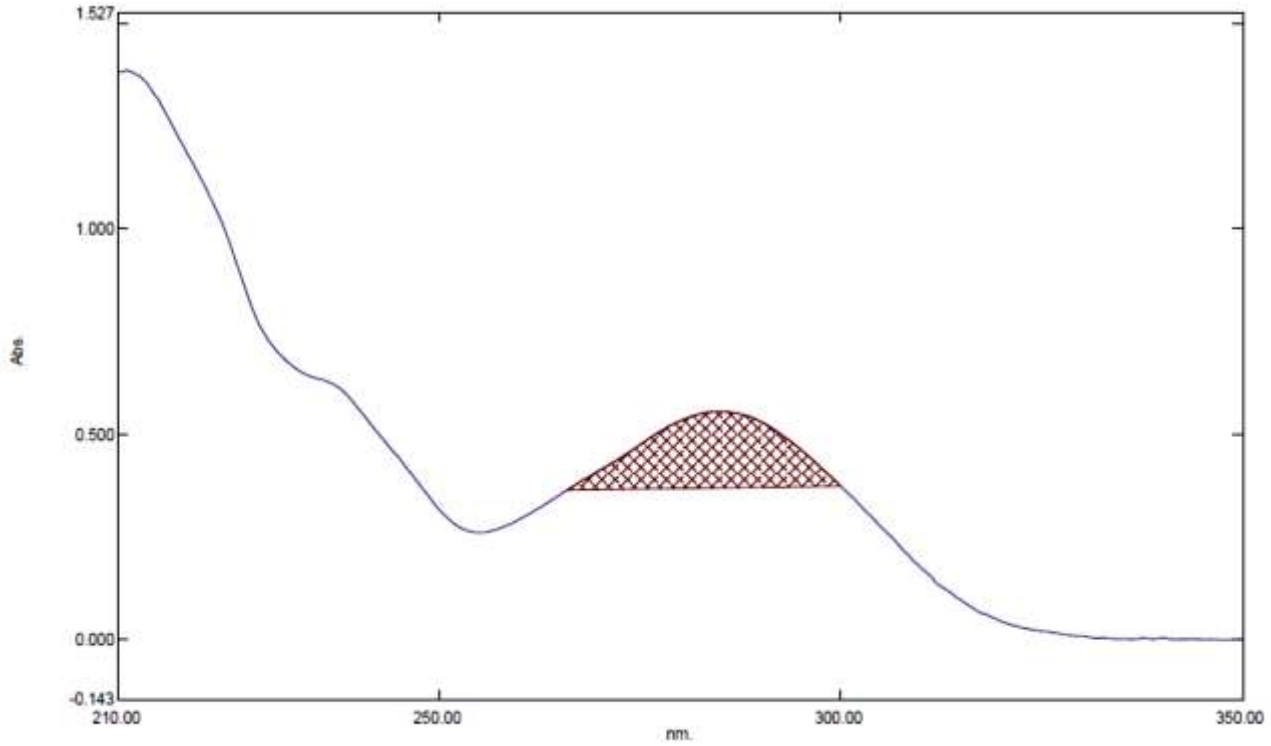

Figure 29: Spectrum of carbamazepine in photolytic degradation studies by the area under the curve spectroscopic method.

DISCUSSION

The findings of the current investigation indicate that efficient identification and selectivity were achieved in a shorter runtime using the developed and validated method. The spectrophotometric method linear response was obtained in the 4-12 µg/mL concentration range, with a correlation coefficient of 0.99. The developed and validated method was found to be linear, accurate, precise, and robust against the wide concentration of carbamazepine, which might help qualitative and quantitative validation. The significant objective of this study was to pinpoint the spectroscopic techniques that were reliable enough to appropriately identify the components with a good spectrum. The target analytical profile was created to identify critical method attributes influencing critical quality attributes, and a systematic risk analysis was conducted. The most important quality variables were specificity, resolution, spectrum, and appropriate solvents. International Council validated the proposed method for Harmonization (ICH) guidelines [17-18], Validation of Analytical Procedures: Text and Methodology Q2 (R1). According to studies on stress degradation, UV-spectroscopic analysis of carbamazepine solutions demonstrated no indications of insignificance degradation [14].

CONCLUSION

The current research UV-spectroscopic approaches are accurate, efficient, and specific for routine analysis of carbamazepine. We have explored the specific maximum wavelength regions in the zero, first, and second order derivative spectra and area under curve techniques for the estimation of carbamazepine, and this has not been reported in previous studies. It may be used to identify related substances or contaminants during storage conditions and estimate the analyte of interest without interferences. The reported development methods were validated as per ICH Q2 (R1) guidelines. UV-spectroscopic methods can analyse the carbamazepine analyte in bulk and dosage form.

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CONFLICT OF INTEREST

For this work, the authors report no conflicts of interest.

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