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Kinetic and Thermodynamic Spectrophotometric Technique to Estimate Gabapentin in Pharmaceutical Formulations using Ninhydrin

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Abstract

Background: Simple and sensitive spectrophotometric method is described based on the reaction of drug (gabapentin) with ninhydrin in pure form and in pharmaceutical preparations.

Methods: Complex formed during this reaction is measured at 575 nm as a function of time. Kinetic study involve initial-rate, rate-constant and fixed-time (80 minutes) procedures to determine the concentration of the drug.

Results: Drug was studied in the concentration range of 10-30 μgmL^{-1} showing correlation coefficient 0.9997, 0.9970 and 0.9990 for initial rate, rate constant and fixed time respectively. Limit of detection (LOD) and limit of quantification (LOQ) was found to be 0.13 and 0.04 nana grams respectively. The variables affecting the reactions were optimized and the developed method was validated according to ICH guidelines.

Conclusion: The proposed method has been efficiently applied to the estimation of gabapentin in pharmaceutical formulation with first-class recovery (98.3-101.4%). Thermodynamic parameters were studied i.e., association constants and standard free energy changes were determined by Benesi–Hildebrand equation while, Gibbs free energy change for the complex was also estimated.

Keywords: Spectrophotometric determination; gabapentin; ninhydrin and charge transfer complex

Background

The new anti-convulsant drug gabapentin (1-(aminomethyl)cyclo-hexaneacetic acid) is a GABA analogue. It was originally developed for the treatment of epilepsy, and currently, gabapentin is widely used to relieve pain, especially neuropathic pain, it is indicated in the treatment of epilepsy and neuropathic pain, also in the treatment of bipolar disorder and may be effective in reducing pain and spasticity in multiple sclerosis. Gabapentin is a γ-aminobutyric acid (GABA) analogue that does not bind to GABA receptors or alter GABA metabolism in the brain (Goldlust et al. 1995). Its action is attributed to the irreversible inhibition of the enzyme GABA-transaminase, thus preventing the physiological degradation of GABA in the brain (Ouellet et al. 2001). Analytical methods reported for its determination consist of high-performance liquid chromatography (HPLC) (Jiang & Li 1999; Tang et al. 1999; Chollet et al. 2000; Ifa et al. 2001; Ratnaraj & Patsalos 1998; Wad & Kramer 1998), spectrofluorimetry (Belal et al. 2002; Hassan et al. 2001), gas chromatography–mass spectrometry (GC–MS) (Kushnir et al. 1999; Van Lentea & Gatautis 1998), capillary electrophoresis (Rada et al. 1998) and spectrophotometry applying Hantzsch reaction (al-Zehouri et al. 2001). So far, no traces of any attempts have been found for determination of gabapentin by colorimetric method and the literature is still starving for such analytical procedures. There are number of methods for determination of gabapentin in literature (Manera et al. 2009; Lin et al. 2004; Jia et al. 2012; Ribeiro et al. 2007; Abdulrahman & Basavaiah 2011; Abdulrahman & Basavaiah 2012; Jalali et al. 2007; Hegde et al. 2009; Patel et al. 2011; Siddiqui et al. 2010).

Reactions with ninhydrin (NIN) has been widely used to analyze and characterize amino acids, thiophen and proteins as well as numerous other NIN positive

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compounds in biomedical, clinical, food, forensic, histochemical, microbiological, nutritional and plant studies (Friedman 2004). It has been extensively used in the determination of the compounds of pharmaceutical importance applied to their kinetic studies (Rahman & Azmi 2001a; Campins-Falco et al. 1996; Arayne et al. 2008). Present study describes a direct, sensitive and precise spectrophotometric method simpler than the existing UV and HPLC methods that is free from such experimental variables as extraction step for the determination of gabapentin in reference material and pharmaceutical formulations by means of developing charge transfer complex with NIN.

No interference was observed in the assay of gabapentin from common excipients in levels found in pharmaceutical formulations. The method rely on the use of simple and inexpensive technique but give out sensitivity analogous to that procured by sophisticated and expensive techniques such as HPLC, and are validated as per ICH recommendations (ICH Topic Q2(R1) 2005). The kinetic approach for determining gabapentin in commercial dosage form, using NIN as a reagent, confer simplicity and rapidity as the procedure simply require heating and cooling of the reaction mixture. During this study the reaction conditions and application of the methods for determination of gabapentin in pharmaceutical formulations have been established, in addition, the association constant, stoichiometric ratio of reactants and the standard free energy changes (ΔG°) were determined.

Our present study suggests kinetic and thermodynamic spectrophotometric procedure for the determination of gabapentin in pharmaceutical formulations. The methods are based on the reaction of primary amino group of gabapentin with NIN.

Experimental

Apparatus

Shimadzu 1601 double beam UV–visible spectrophotometer possessing a fixed slit width (2 nm) with quartz cells of 10 mm path length connected to a PIV computer loaded with Shimadzu UVPC version 3.9 software were used to record the absorption spectra.

Materials and reagents

All reagents were of analytical grade. Gabapentin pure drug was obtained from Godecke AG, Darmstadt, Germany under license of Park-Davis (Pvt.) Ltd. Karachi, Pakistan. Gabin® capsules 200 mg (PharmEvo Pharmaceutical Company (Pvt.) Ltd., Karachi, Pakistan), Gaba® capsules 100 mg (Nabi Qasim Pharmaceuticals (Pvt) Ltd., Karachi, Pakistan), Gabaplus® capsules 100 mg (Platinum Pharma (Pvt.) Ltd., Karachi, Pakistan) and Neupentin® capsules 400 mg (Highnoon Pharma (Pvt.) Ltd., Karachi, Pakistan) were purchased from the market. Ninhydrin was purchased from Merck Schuchardt OHG, Darmstadt, Germany. HPLC grade methanol was from fisher scientific UK.

General procedure

Preparation of standard stock solutions

Solution of 0.1 $mgmL^{-1}$ gabapentin was prepared in water by dissolving 10 mg of gabapentin in 100 mL of purified water and stored in a cool (<25°C) and dark place. Ninhydrin reagent was 2 $mgmL^{-1}$ in methanol and was prepared fresh daily.

Method

Aliquots of 1 mL of stock solution corresponding to 100 μgmL^{-1} of gabapentin were transferred into heating tubes. 2 mL of 1% NIN solution was added and heated on boiling water bath for 2 hours, after cooling the mixture was transferred into 25 mL volumetric flask and diluted to volume with distilled water. Increase in absorbance at 575 nm was recorded as a function of time against the reagent blank at room temperature (spectra 1). The initial rate of reaction at different concentrations was calculated from the initial slope of absorbance time curve. The calibration curves were constructed by plotting logarithm of initial-rate of reaction versus logarithm of molar concentration, rate-constant versus final concentration and absorbance measured at a fixed-time versus final concentration of gabapentin.

Procedures for pharmaceuticals formulation

Twenty capsules of each formulation were weighed and powdered. The powder equivalent to 10 mg of gabapentin was dissolved in 100 mL of water to give 0.1 mg mL^{-1} of gabapentin. The procedure was continued as described under general procedures.

Stoichiometric study

Job's method of continuous variation (Rose 1964) was employed. Master equimolar solution of gabapentin was prepared in water whereas NIN was prepared in methanol and made up to volume with the same solvent. A series of 10 mL portions of master solution of gabapentin with NIN was made up comprising different complementary proportions (0:10, 1:9, 2:8……9:1) in 10-mL calibrated flasks. The absorbance of the resulting solutions were measured at the wavelength of maximum absorption after the appropriate time against reagent blanks treated similarly.

Interference from excipients

Samples were prepared by mixing 50 mg of gabapentin with various amounts of common excipients such as

glucose, lactose, talc powder, magnesium stearate, pyrrolidone, HPMC (hydroxypropylmethylcellulose) and starch. The procedure was continued as described under general procedures.

Results and discussion

Gabapentin exhibits a very low UV absorption, with $A_{1cm}^{1\%}$ at 276 nm = 6.5 (Abdellatef & Khalil 2003) and as a result poor sensitivity will be achieved by conventional UV spectrophotometric methods. There was a critical need to develop a spectrophotometric method that could quantitate gabapentin in pharmaceutical formulations.

Reaction with Ninhydrin (NIN)

Ninhydrin reagent is used for the determination of an aliphatic primary amine or an amino acid group (Friedman 2004; Rahman & Azmi 2001a; Campins-Falco et al. 1996; Arayne et al. 2008; Rahman & Azmi 2001b; Nobrega Jde et al. 1994; Molnar-Perl & Pinter-Szakacs 1989). The presence of an aromatic ring exhibits the response; the exhibition increases if the amino group is nearer to the ring. The end product of NIN reaction with amino acid (Ruhemanns purple) give best color in methanol, however water can be used as good option in case when extraction of the active molecule is compromised. The reaction mixture is heated for a short while and is measured at maximum wavelength 568 nm which is dependent on solvent system and reaction condition (Görög 1995).

Gabapentin interacts with NIN in pure methanol via oxidative deamination of the primary amino group followed by the condensation of the reduced NIN to form the purple colored reaction complex with λ_{max} at 575 nm (Figures 1 and 2).

Gabapentin was found to be competent of reacting with NIN only at higher temperatures. Maximum color was obtained by heating on a water bath at 70 ± 5°C for 80 minutes. Prolonged heating decreased the chromogenic intensity, so the reaction time should be controlled. Different solvents such as water, ethanol, methanol, isopropanol, and acetonitrile have been tried, but the best results were obtained with methanol.

Optimization of reaction

The reaction between gabapentin and ninhydrin in methanol resulted in the formation of blue colored complex. At 70°C, the intensity of color increased with time and became stable after 80 minutes.

Kinetic studies

Initial rate method In order to study the kinetic parameters of the proposed reactions, the initial rate of the reaction was determined by using time curve (from the measurement of the slope of the initial tangent to the absorbance). Concentration of NIN was kept constant and the reaction was studied at different concentrations of gabapentin to establish the order of reaction with respect to gabapentin. For each run, a plot of log $A_{¥}/A_{¥}-A_t$ versus time was a straight line indicating a first order reaction. The first order rate constant was also estimated from the slopes of the above plot.

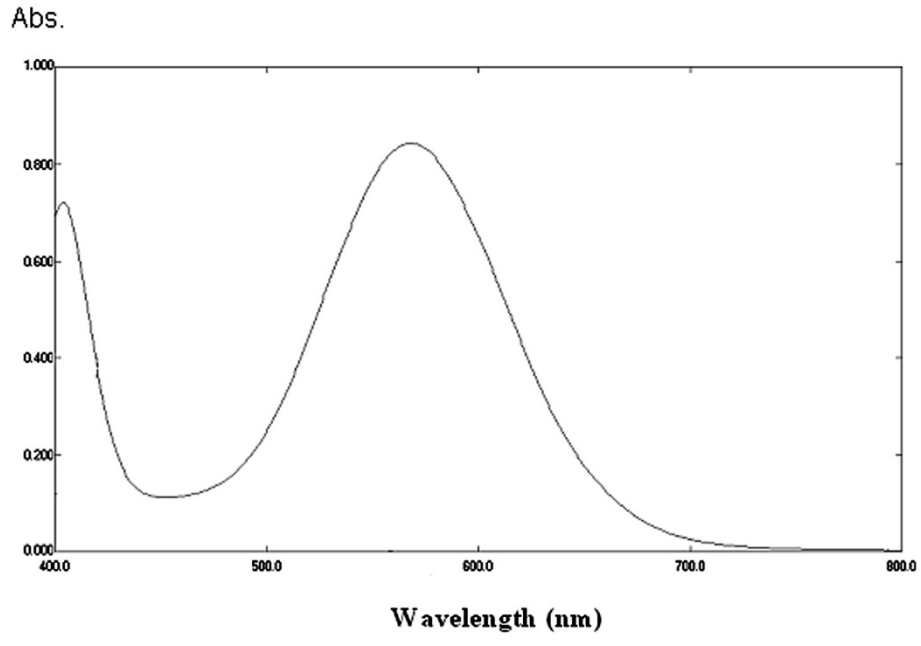

Figure 1 Absorption spectra of the reaction products of gabapentin with NIN.

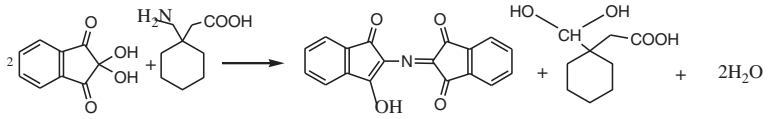

Figure 2 Suggested reaction pathway between gabapentin and NIN.

Similarly to establish order of reaction with respect to NIN, all subsequent investigations were conducted with fixed concentration of gabapentin and varied concentrations of NIN. The first order kinetics was also confirmed by plot of log $A_¥/A_¥–A_t$ versus time. The initial rate of reaction under pseudo-first order conditions would obey the following equation:

$$\text{Rate} = dA/dt = k'C^n$$

Where, "k'" is the pseudo-first order rate constant, "C" is the concentration of gabapentin, "n" is the order of reaction. The above equation may be written in the logarithmic form as,

$$\text{Log rate} = \log k' + n \log C$$

Linear regression analysis was used to calculate slope, intercept and correlation coefficient (Table 1). The regression of log rate versus log C gave a linear regression equation,

$$\text{Log rate} = \log k' + 0.01018 \log C$$

The value of "n" in the regression equation also indicated the first order reaction with respect to gabapentin concentration. The calibration curve constructed in the range of 10-30 μgmL^{-1} (absorbance of different concentrations of gabapentin versus time) showed a linear relationship.

Rate-constant method The rate constant values analogous to different concentrations of gabapentin were calculated by plotting the slopes of log $A_¥/A_¥–A_t$ versus time under pseudo-first order conditions (Table 2). The calibration graph was constructed by plotting rate constant against the concentration of gabapentin, and a linear response in the concentration range of 10-30 μgmL^{-1} were observed. Consequent data is presented in Table 2.

Table 1 Statistical and regression data of proposed method

	Initial Rate	Rate Constant	Fixed Time
Intercept	0.0021	−0.22284	−0.0028
Slop	0.01018	0.014626	0.0129
r^2	0.9994	0.9990	0.9999
Correlation coefficient (**r**)	0.9997	0.9970	0.9990

Fixed time method A single concentration of gabapentin was monitored at 575 nm against reagent blank at a pre selected fixed time. A plot of absorbance versus initial concentration of gabapentin was calibrated at fixed time (20, 40, 60 and 80 minutes). Regression equations were developed keeping working standards in view and important analytical parameters have been calculated (Table 3) which were found to be in acceptable limits for correlation coefficient, intercept and slope at all fixed time. It is hence suggested that any fixed time can be used for assay of gabapentin.

The high values of correlation coefficients resulting from regression equations demonstrate reliable linearity of the methods. The values of slopes of the regression equations of the proposed methods indicate good sensitivity. The small values of the standard deviation address the precision of the calibration data points around the line of regressions for all the proposed procedures. Independent repeatability studies were performed of the proposed methods with five replicates for each method (Table 4). The obtained data shows that the methods can be applied to dosage formulations with accuracy and precision (Table 5).

Stoichiometry of the reaction

On observing the molar ratio of the gabapentin with NIN using Job's method of continuous variation (Rose 1964), it was found to be 1:2 for NIN.

Thermodynamic studies

Association constants and standard free energy changes

The association constants were determined for the interaction of gabapentin with NIN using Benesi–Hildebrand equation (Benesi & Hidelbrand 1949) was 1.418×10^3.

$$\frac{Ca}{A} = \frac{1}{\varepsilon} + \frac{1}{Kc \cdot \varepsilon} \cdot \frac{1}{Cb}.$$

Table 2 Method of rate constant

Concentration μgmL^{-1}	Calculated Value of Rate Const (slope) Min^{-1}
10	0.0147
14	0.0146
18	0.0146
20	0.0146
30	0.01463

Table 3 Regression characteristics of gabapentin concentration at different time interval

(Fixed Time)	20	40	60	80
Intercept	−0.002	−0.0022	−0.0034	−0.0036
Slope	0.0112	0.0124	.0114	0.0115
Correlation coefficient (**r**)	0.9990	0.9992	0.9998	0.9999

where *Ca* and *Cb* are the concentrations of the acceptor and donor respectively, *A* is the absorbance of the complex, ε is the molar absorptivity of the complex and K_c is the association constant of the complex.

Straight line was obtained by plotting *Ca* versus *A* and Gibbs Free energy change for the complex was calculated to be (-4.947) by using equation as given below (Martin et al. 1969).

$$\Delta G^{\circ} = -2.303\, R\, T\, log\, K_C$$

Where ΔG° is the free energy change of the complex (kJ mol^{-1}), *R* the gas constant (1.987 cal mol^{-1} deg^{-1}), *T* the temperature in Kelvin (273 +°C) and K_c is the association constant of drug-acceptor complexes (1 mol^{-1}).

Linearity, accuracy and precision

Linearity, accuracy and precision were assessed for the method in the range of 10 to 30 μgmL^{-1}. Regression statistics were calculated for the colorimetric procedures and linear regression plots showed the directly proportional relationship of absorbance over Beer's law range given in Tables 1 and 4. The table also shows the results of the statistical analysis of the experimental data, such as the slopes, the intercepts, the Square of correlation coefficients obtained by the linear least-squares treatment of the results.

Five different concentrations of gabapentin were prepared, each solution was analyzed in five replicate to evaluate the accuracy and precision of the methods.. The mean Standard Deviation and% relative standard deviation (%RSD) as depicted in Table 4 were found to be in the acceptable range of (0.0793 – 0.8376) and (0.494 – 0.8317) respectively.

It was observed that at specific wavelength the absorption intensity was dependent upon the concentration of gabapentin. It was observed that Beer's law was followed in all cases with very small range of intercept values (-0.0028 to 0.0021) and slopes ranged from (0.01018 to 0.0146) for the concentration ranges as described in Table 1. The correlation coefficient values were found to be in the range of 0.9970 – 0.9997 using the least-square method.

Specificity

The interference of excipients, additives and other substances present in formulation and the affect of degradation products of gabapentane on the proposed method were experimentally observed. Ionization potential of the donor and the electron affinity of the acceptor are the two main parameters which influenced the energy of complex. The basic nature of gabapentin due to charge transfer is responsible for its specificity to the reaction. Hence a degradation product of gabapentin does not have specificity for the reaction as they lack the basicity. The percentage recoveries as shown in Table 6 confirmed that there was no interference from any excipient present in the formulation for the proposed method.

Limit of detection (LOD) and limit of quantification (LOQ)

The theoretically determined values of LOD and LOQ for gabapentin with NIN were cross checked by actual analysis of these concentrations using proposed methods. LOD of gabapentin with NIN 0.04 μg mL^{-1} while LOQ were 0.13 μg mL^{-1}.

Analysis of pharmaceutical dosage forms

The determination of gabapentin in formulation was carried out using the proposed charge transfer spectrophometric method along with the reference

Table 4 Accuracy and precision of proposed method

	Initial Rate		Rate Constant		Fix Time	
Amount	Found	% Recover	Found	% Recover	Found	% Recover
10	10.05	100.5	9.96	9.96	10.1	101
14	14.14	101	13.95	9.96	14.15	101
18	18.22	101.22	18.17	10.09	17.98	99.8
20	19.86	99.3	20.22	10.11	20.2	101
30	30.41	101.36	29.85	9.98	30.17	100
Mean		100.6778		10.01575		100.70
STD		0.837361		0.079303		0.4987
RSD		0.831723		0.791779		0.494

STD = Standard deviation, RSD = Relative standard deviation

Table 5 Determination of gabapentin in pharmaceuticals formulations by proposed

	Ini. Rate		Rate Constant		Fix Time		Reference method	
	Gabaplus 100 mg cap (Platanium)							
Taken	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**
100	100.78	100.78	99.38	99.38	101.30	101.3	99.2	99.2
100	99.540	99.54	100.84	100.84	98.88	98.88	101.4	101.4
100	101.230	101.23	98.41	98.41	99.40	99.4	100.66	100.66
100	98.670	98.67	101.28	101.28	100.66	100.66	98.3	98.3
100	100.230	100.23	99.63	99.63	99.30	99.3	100.7	100.7
Mean	100.090	100.09	99.91	99.908	99.91	99.908	100.05	100.052
STD	1.014	1.01417	1.16	1.15662	1.02	1.023191	1.27	1.26512
RSD	1.013	1.013263	1.16	1.157685	1.024133	1.024133	1.264459	1.26446
T-Test	0.72		0.83		0.94			
F-Test	1.26		1.39		1.05			
	Gabin 200 mg cap (PharmEvo)							
Taken	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**
200	201.300	100.65	202.20	101.1	199.30	99.65	202.2	101.1
200	200.680	100.34	199.30	99.65	201.50	100.75	197.9	98.95
200	198.950	99.475	198.80	99.4	200.80	100.4	198.6	99.3
200	199.200	99.6	201.30	100.65	201.40	100.7	200.6	100.3
200	198.300	99.15	200.80	100.4	199.40	99.7	200.6	100.3
Mean	199.686	99.843	200.48	100.24	200.48	100.24	199.98	99.99
STD	1.254	0.627092	1.41	0.704805	1.07	0.533151	1.73	0.86342
RSD	0.628	0.628079	0.70	0.703117	0.531875	0.531875	0.86351	0.86351
T-Test	0.68		0.94		0.73			
F-Test	1.25		1.48		1.17			
	Neupentin 400 mg cap (Highnoon)							
Taken	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**
400	400.800	100.2	398.40	99.6	398.50	99.625	402.87	100.718
400	402.100	100.525	397.50	99.375	401.20	100.3	400.96	100.24
400	398.600	99.65	401.50	100.375	400.90	100.225	397.5	99.375
400	399.400	99.85	402.80	100.7	401.20	100.3	398.2	99.55
400	398.200	99.55	398.80	99.7	400.90	100.225	404.3	101.075
Mean	399.820	99.955	399.80	99.95	400.54	100.135	400.77	100.192
STD	1.616	0.404042	2.24	0.56097	1.15	0.287554	2.92	0.73106
RSD	0.404	0.404224	0.56	0.561251	0.287167	0.287167	0.729663	0.72967
T-Test	0.74		0.68		0.84			
F-Test	1.39		1.47		1.14			
	Gaba 100 mg cap (NabiQasim)							
Taken	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**	**Found**	**%Rec**
100	101.200	101.2	98.58	101.2	101.33	101.33	101.2	101.2
100	99.800	99.8	99.64	99.8	99.66	99.66	98.96	98.96
100	100.600	100.6	110.80	100.6	98.44	98.44	99.47	99.47
100	100.700	100.7	100.33	100.7	101.30	101.3	100.22	100.22
100	99.500	99.5	101.20	99.5	100.66	100.33	99.32	99.32

Table 5 Determination of gabapentin in pharmaceuticals formulations by proposed *(Continued)*

Mean	100.360	100.36	100.11	100.36	100.28	100.278	99.83	99.834
STD	0.695	0.694982	1.03	0.694982	1.23	1.230577	0.89	0.8919
RSD	0.692	0.692489	1.03	0.692489	1.227166	1.227166	0.892481	0.89248
T-Test	0.65		0.88		0.94			
F-Test	1.37		1.62		1.08			

method (Abdellatef & Khalil 2003) using the same samples. Similar accuracy and precision were observed for the calculated and theoretical values (95% confidence) of the proposed and official methods as no remarkable difference was observed for the t and F tests. From Table 5 it is apparent that the present method can be followed for the analysis of these drugs in their single dosage forms. The recoveries in the range from 98.3 to 101.4% clearly showed no interference of any excipients of formulation.

Spectroscopic studies

Infrared spectra

The IR spectra of gabapentin+Nin Complex showed neither the expected doublet of primary NH_2 in the region 3200 – 3400 cm^{-1} nor the usual carbonyl stretch of COOH near 1710 cm^{-1}. Instead multiple peaks were observed in the region 2500 – 3000 cm^{-1} that can be attributed to ammonium ion (NH_3^+), the asymmetric and symmetric peaks of carboxylate ion were observed at 1600 and 1400 cm^{-1} coincide with the one observed in amino acids (Wright & Vanderkooi 1997) and NH_3^+ bending at 1550 cm^{-1} conclude that the gabapentin exists in zwitterionic form. Our studies match up to the already reported infrared absorptions of gabapentin (Chimatadar et al. 2007).

NIN produced two broad bands at 3300 and 3250 cm^{-1} and a C-O stretching at 1061 cm^{-1} signify the presence of two OH groups. The carbonyl gave two peaks in the region 1660 to 1760 cm^{-1}. Aromatic resonance appeared at 750 cm^{-1} (Arayne et al. 2008; Charles & Pouchert 1989; Charles & Pouchert 1981).

Primary amines to give Ruhemann's Purple complex with NIN (Arayne et al. 2008). The formation of the complex was evidenced by comparing the spectra of complex with parent reactant. Many of the functionalities of NIN and gabapentin were found absent which confirms the formation of complex. The doublet of carbonyl in NIN changed significantly into one single sharp peak at 1680 cm^{-1} and the broad band of O-H shifted to 3400 cm^{-1}.

Table 6 Recovery of Gabapentin in presence of different excipient

	Pyrro	Lactose	Talc	Mag Stea	Starch	HPMC
Initial Rate	99.46	99.39	100.26	99.87	101.2	98.96
Rate Constant	98.92	100.66	100.33	99.55	101.47	99.1
Fixed Time	100.43	99.24	101.27	98.92	99.37	100.84

Nuclear magnetic resonance spectra

The ^1H NMR spectra of gabapentin showed two $-CH_2$ peaks at Δ 2.443 and Δ 2.873 ppm and the cyclohexyl protons appeared in the region of Δ 1.365–1.585 ppm. The likely peak of NH_2 near Δ 2 ppm and that of carboxylic OH near Δ 11 ppm were not observed but one peak of NH3+ at 4.849 Δ ppm was observed, may be as suggested earlier, due to zwitterion formation. Same is also reported in literature (Chimatadar et al. 2007). NIN exhibited two singlets at Δ 7.240 and Δ 7.446 ppm for the four protons of the aromatic group and a singlet at Δ 1.52 ppm for two protons of the OH group. This coincides with the reported studies (Arayne et al. 2008; Charles & Pouchert 1981). By studying the ^1H-NMR spectrum of the gaba-NIN complex it was found that the NH_2 protons completely diminished and the broad multiplet appearing between Δ 7.42 and Δ 8.163 ppm showing eight aromatic CH protons. A singlet at Δ 4.803 ppm represents the enolic OH proton. The above results were found in accord with UV and IR spectra, confirming the proposed structure.

Conclusion

The data given above divulge that the proposed methods are easy, accurate and sensitive with good precision and accuracy. With these methods, one can do the analysis with pace at low cost without losing accuracy. The proposed methods can be used as alternative methods to the reported ones for the routine determination of gabapentin in pharmaceutical formulations. This encourages their successful use in routine analysis of these drugs in quality control laboratories.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

FAS designed, coordinated and carried out experiments the study. NS, NS and HS carried out experiments, FAS, NS, NS, HS and AZ drafted the manuscript. All authors read and approved the final manuscript.

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