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Analytical Utility of Potassium Permanganate for the Assay of Albendazole in Bulk Drug and Pharmaceuticals

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Two rapid, simple, sensitive and cost-effective titrimetric and spectrophotometric methods are described for the determination of albendazole (ALB) in bulk drug and in pharmaceuticals. In titrimetry (method A), ALB is oxidized by a known excess of potassium permanganate ($KMnO_4$) in H_2SO_4 medium followed by the determination of unreacted permanganate by titration with ferrous ammonium sulphate (FAS). In spectrophotometry (method B), ALB is treated with a measured excess of permanganate in acid medium and the unreacted oxidant is measured at 545 nm. The molar ratio (stoichiometry) in titrimetry and the optimum assay conditions are studied. Titrimetry is applicable over 2-9 mg range and the calculations are based on a 1:1 (ALB: $KMnO_4$) molar-ratio. In spectrophotometry, Beers law is obeyed over 8.0-64.0 µg mL^{-1} concentration range of ALB. The molar absorptivity and Sandell sensitivity values are calculated to be 3.348×10^3 L mol^{-1} cm^{-1} and 0.08 µg cm^{-2}, respectively. The limits of detection (*LOD*) and quantification (*LOQ*) are also reported for the spectrophotometric method. The applicability of the developed methods is demonstrated by the assay of ALB in pure drug as well as in commercial formulations.

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Introduction

Albendazole (ALB), chemically known as methyl-5-(propyl thio)-2–benzimidazole carbamate [1], is widely used as an anthelmintic having a broad spectrum of activity [2]. The drug is official in British Pharmacopoeia [BP] and United States Pharmacopeias [USP]. BP [3] describes a potentiometric titration with perchloric acid in formic acid-acetic acid medium. Non-aqueous titrimetric method for the assay of ALB, where the end point being located visually using crystal violet indicator in USP method [4]. Quantitative assay of ALB in dosage forms has received wide attention and several methods have been reported, that include titrimetry in non-aqueous medium [5,6], redox titrimetry [7-13], UV-spectrophotometry [14-18], spectrofluorimetry [19,20], voltammetry [21-23], high performance liquid chromatography [24–28] and high performance thin layer chromatography [29,30]. (Figure 1)

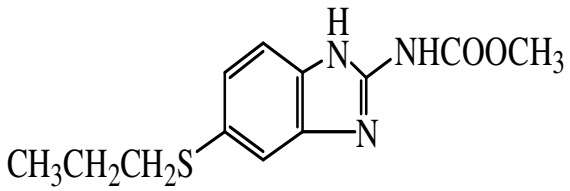

Fig. 1. Chemical structure of Albendazole

Various visible spectrophotometric methods, both direct and indirect, are found in the literature for the determination of ALB in pharmaceuticals. Basavaiah et al [31], in their methods treated ALB with a known excess of NBS in HCl medium, and the unreacted oxidant was reduced by iron(II) and the resulting iron(III) was complexed with thiocyanate or tiron offering two sensitive methods. Two more indirect methods [32] involving NBS-metol–sulphanilamide and NBS–celestein blue as chromogenic systems have been proposed by Sastry*et al.* Several other reaction schemes involving chloramine-T-methyl orange or indigo carmine [7], chloramine-T-metol-sulphanilicacid [8], NBS-methyl orange or indigo carmine [11], N-chlorosuccinimide- iron (II)-thiocyanate [12], $NaIO_4$-KBr-methyl orange or indigo carmine [13] and perchloric acid–crystal violet [4] are also found in the literature for the indirect spectrophotometric assay of ALB in its dosage forms.

Only a few direct spectrophotometric methods are reported for ALB. Zarapkar and Deshpande [33] have determined the drug in tablets and syrups based on the reduction of Folin- Ciocalteu reagent to a blue colored chromogen which was measured at 700 nm. The charge–transfer reaction of ALB with π–acceptor chloranilic acid in alcoholic acetone medium was used by Zhao *et al* [34] for the determination of the drug in tablets. Based on similar reaction and employing chloranilic acid and 2,3-dichloro-5,6-dicyano- p-benzoquinone (DDQ) as π–acceptors determination of ALB in tablets has been reported by Refat *et al* [35]. *Sane et al* [36] have described four procedures based on this reaction using bromocresol green, bromophenol blue, bromothymol blue and bromo phenol red as ion- pair reagents in acidic buffer medium. The ion- pair complexes formed were extracted into chloroform and measured at 420 nm. The methods were applied to tablets and syrup. Thymol blue and six alizarin derivatives [37] are the other ion-pair reagents used for the assay of ALB. Sastry *et al* [38] has devised extractive spectrophotometric methods for the estimation of some benzimidazole anthelmintics including ALB in pharmaceuticals based on ion-pair reaction and employing some acidic dyes.

All the indirect spectrophotometric methods cited above are cumbersome, involving multi reagents and multi-step reactions, and are hence prone to inaccuracy and imprecision. On the other hand, the reported direct spectrophotometric methods [34,35] are less sensitive.

The methods based on ion-pair reaction [36-38], though sensitive, involve tedious and time consuming extraction steps besides being critically dependent on the pH of the aqueous phase and the aqueous-organic phases ratio. Additionally, incomplete extraction of the analyte may lead to erratic results. The purpose of this study leads to minimize the above mentionedcritical conditions.

The present work proposes one titrimetric and one visible spectrophotometric method based on

the oxidizing property of $KMnO_4$ in acid medium. Simplicity, rapidity, sensitivity, wide linear ranges, mild experimental conditions and above all cost-effectiveness characterize the developed methods. Optimum conditions were established and both methods were validated according to International Conference on Harmonisation (*ICH)* guidelines. The validated methods when applied to the determination of ALB in tablets yielded results which were in good correlation with the label claim.

Materials and Methods

Apparatus

All absorbance measurements were made with a Systronics model 166 digital spectrophotometer equipped with 1 cm matched quartz cells.

Reagents and standards

All chemicals used were of analytical reagent grade and solutions were made in double distilled water. Pharmaceutical grade ALB (99.7 per cent pure) was received as a gift from Cipla India, Ltd., Mumbai, and used as received without further purification.

Potassium permanganate (0.01 M and 600 µg mL^{-1}) and ferrous ammonium sulphate [FAS] (0.05 M) were prepared and used [39].

Standard ALB solution

A stock standard solution equivalent to 1.0 mg mL^{-1} ALB was prepared by dissolving 100 mg of pure drug with 6:4 acetic acid in a 100 mL calibrated flask and used in method A. This 1000 µg mL^{-1} ALB was further diluted to 100 µg mL^{-1} with same acid for method B.

Tablets and suspension

Alworm-400 (Medopharm Ltd., Malur, India), ABD-400 (Intas Pharma. Ltd. Ahmedabad, India) and Bandy-400 (Mankind Pharma. Ltd., New Delhi, India) tablets and zentel suspension (GSK Pharma. Ltd., Bangalore, India) were purchased from local commercial stores.

General procedures

Titrimetry (Method A)

A 10.0 mL aliquot of pure drug solution containing 2.0-9.0 mg of ALB was measured accurately and transferred into a 100 mL titration flask. The solution was acidified by adding 5 mL of 5 M H_2SO_4. Then, 10 mL of 0.01 M $KMnO_4$ was added by means of a pipette and the flask was kept aside for standing time of 5 min at room temperature and unreacted $KMnO_4$ was titrated with 0.05 M ferrous ammonium sulphate to a colorless end point. A blank experiment was simultaneously performed.

The amount of ALB was calculated from the following equation:

$$Amount\ (mg) = \frac{V_r \times M_r \times S}{n}$$

Where, V_r = mL ferrous ammonium sulphate consumed

M_r = relative molecular mass of ALB

S = strength of $KMnO_4$, M.

n = number of moles of $KMnO_4$ for each mole of ALB = 1.

Spectrophotometry (Method B)

Different aliquots of standard ALB solution (100 µg mL^{-1}) in the range 0.8-6.4 mL equivalent to 8.0-64.0 µg mL^{-1} were accurately measured and transferred to a series of 10 mL volumetric flasks and the volume was adjusted to 6.4 mL with adequate quantity of acetic acid:water mixture (6:4 v/v). One mL of 5 M H_2SO_4 was added to each flask followed by 1 mL of 600 µg mL^{-1} $KMnO_4$ solution. The content was mixed and the flasks were let stand for 15 min before diluting to the mark with water. The absorbance of each solution was measured at 545 nm against water.

Calibration graph was prepared by plotting the decreasing absorbance values versus concentrations of ALB in method B. The unknown concentration was read from the respective calibration graph or deduced from the regression equation desired using the Beer's law data.

Procedure for tablets

Twenty tablets were weighed accurately and pulverized. A quantity of the powder containing 100 mg of ALB was accurately weighed into a 100 mL calibrated flask, added 60 mL of acetic acid:water mixture (6:4 v/v), and shaken for 20 min. Then, the volume was diluted to the mark with same acid, mixed and filtered using a Whatman No. 42 filter paper. First 10 mL of the filtrate was discarded and a suitable aliquot was used in the assay of ALB by method A. The filtrate (1000 µg mL^{-1}ALB) was diluted again with waterto obtain 100 µg mL^{-1} solutions for the use in method B and the analysis was completed using the procedure described above.

Procedure for suspension

The content of a full bottle of zentel suspension (10 mL) containing 400 mg ALB was quantitatively transferred to a 250 mL separating funnel, the bottle was rinsed with 4 × 10 mL of chloroform and the washings were transferred to the separating funnel followed by the addition of another 50 mL each of chloroform and water. The funnel was shaken for 5 min. and the organic layer was transferred to a 400 mL beaker after drying over anhydrous Na_2SO_4. The content was again extracted with 4 × 10 mL portions of chloroform, dried and combined with the chloroform layer in the beaker. The solvent was evaporated to dryness on a water bath, and the residue dissolved in 6: 4 acetic acid and the solution was transferred quantitatively to a 100 mL volumetric flask, diluted to the mark with the same acetic acid and mixed well. The resulting solution (4 mg mL^{-1} ALB) was diluted to 1 mg mL^{-1} solution using 6: 4 acetic acid and used for titrimetric assay. The above 1 mg mL^{-1} solution was diluted stepwise to working concentration of 100 µg mL^{-1} for spectrophotometric assay of ALB, using water in method B.

Procedure for placebo blank and synthetic mixture analyses

A placebo blank containing talc (25 mg), starch (30 mg), lactose (20 mg), calcium carbonate (20 mg), calcium dihydrogen orthophosphate (30 mg), methyl cellulose (30 mg), sodium alginate (60 mg) and magnesium stearate (20 mg) was prepared by mixing and 50 mg extracted with water and solution made as described under "procedure for tablets". A suitable aliquot of solution was subjected to analysis by titrimetry (method A) and spectrophotometry (method B) according to the general procedures.

A synthetic mixture was prepared by adding 100 mg of ALB to 100 mg of the placebo blank prepared above, homogenized and the solution was prepared as done under "procedure for tablets". The filtrate was collected in a 100 mL flask and a 5 mL aliquot was assayed by method A. The synthetic mixture solution (1000 µg mL^{-1} in ALB) was appropriately diluted to get 100 µg mL^{-1} solutions, and appropriate aliquot was subjected to analysis by method B.

Results and Discussion

The higher oxidation state of manganese in potassium permanganate (+7) leads to the strong oxidizing property and this property not yet applied for albendazole, authors attempted to do this work. The innate intense purple color solution of permanganate absorbs in the vicinity of 545 nm. As a strong oxidant it does not generate toxic byproducts.

The Mn-containing products from redox reactions depend on the pH. In acid solutions, permanganate is reduced to the faintly pink Mn^{2+} as represented by the following equation:

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

The standard potential in acid solution, E, has been calculated to be 1.51 volts, hence the permanganate ion in acid solution is a strong oxidizing agent. Sulphuric acid is the most suitable acid, as it has no action upon permanganate in dilute solution. With hydrochloric acid, there is the likelihood of the

reaction: taking place and some permanganate may be consumed in the formation of chlorine [40]. The proposed methods are based on the oxidation of ALB with known excess of $KMnO_4$ in acidic medium formed the albendazole sulphone and the unreacted $KMnO_4$ was determined by titrating it with 0.05 M FAS, the reaction stoichiometry was found to be 1:1 (ALB: $KMnO_4$) in titrimetry. Spectrophotometric method involves the measurement of unreacted $KMnO_4$ absorbance at 545 nm in acid medium. The proposed probable scheme is given in Figure 2.

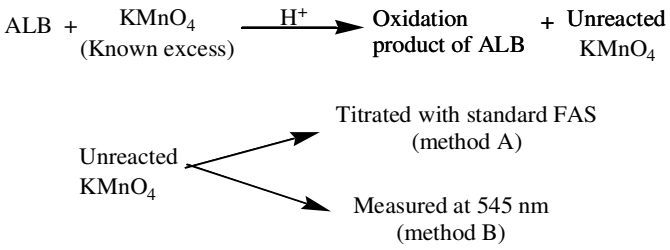

Fig. 2. Probable reaction scheme

Optimization of variables

The experimental variables which provided accurate and precise results were optimized by keeping other variable constant and varying one parameter at a time. The influence of each variable involved in the methods was determined.

Titrimetry (method A)

In titrimetry, the reaction was found to be stoichiometric in H_2SO_4 medium. The effect of acid concentration on the reaction between ALB and $KMnO_4$ was studied by varying the concentration of H_2SO_4 by keeping the fixed concentrations of $KMnO_4$ and drug. The reaction stoichiometry was found to be unaffected when 3-7 mL of 5 M H_2SO_4 was maintained. Hence, 5 mL of 5 M H_2SO_4 in a total volume of 25 mL was used. The reaction stoichiometry was calculated to be 1: 1 (ALB: $KMnO_4$) in the 2.0-9.0 mg range. Below and above these limimits non-stoichiometric results were obtained. The reaction between ALB and $KMnO_4$ was found to be complete and quantitative in 5 min. Hence 5 min was fixed throughout the titrimetric method.

Spectrophotometry (method B)

Absorption Spectra

When a fixed concentration of $KMnO_4$ (60 µg mL^{-1}) was reacted with varying concentrations of ALB, the $KMnO_4$ was consumed in proportion to ALB concentration and there occurred a concomitant decrease in the concentration of $KMnO_4$ as shown by the decreasing absorbance values at 545 nm with increase in ALB concentration. This is shown in Figure 3. This facilitated the evaluation of the linear range over which the method is applicable to the assay of ALB.

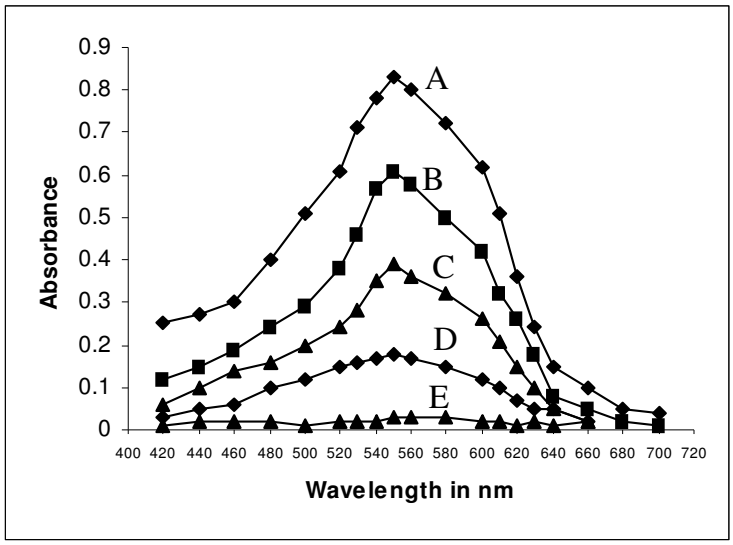

Fig. 3. Effect of ALB concentration on the absorbance of 600 µg mL^{-1} $KMnO_4$ (A.0.0; B.8.0; C.16.0; D.32.0 and E.64.0 µg mL^{-1} ALB) for method B

Concentration of $KMnO_4$

A preliminary experiment showed that permanganate can be determined up to 60 µg mL^{-1} at 545 nm in acid medium employed. Hence, different concentrations of ALB were reacted with 1 mL of 600 µg mL^{-1} $KMnO_4$ to determine the concentration range over which ALB could be determined. One mL of 600 µg mL^{-1} $KMnO_4$ must be accurately added in all the reaction flasks since

$KMnO_4$ absorbs maximally at this wavelength, the small changes in the volume of $KMnO_4$ have some affects on the absorbance reading.

Effect of H_2SO_4

To detect the effect of acidic condition, H_2SO_4 is used in this reaction. The reaction of the oxidant with the drug was carried out in H_2SO_4 medium. To know the effect of H_2SO_4 concentrationon the reaction,0.5-2.5 mL of 5 M H_2SO_4 was added to a fixed concentration of ALB (16 µg mL^{-1}) and $KMnO_4$ (60 µg mL^{-1}), and it was observed that maximum absorbance readings were obtained with 1.0 mL of acid beyond which absorbance slightly decreases. Hence 1.0 mL of 5 M H_2SO_4 in a total volume of 10 mL was used. (Figure 4)

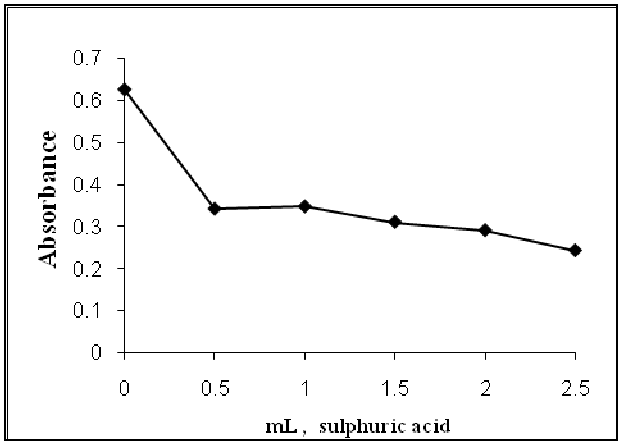

Fig. 4. Effect of study of sulphuricacid (16 µg mL^{-1}ALB at 545 nm) for method B

Reaction time

The reaction was found to be complete and quantitative when the reaction mixture was allowed to stand for 15 min, and beyond this standing time up to 30 minutes the absorbance remained constant (Figure 5). Hence, 15 min of reaction time was used in the assay.

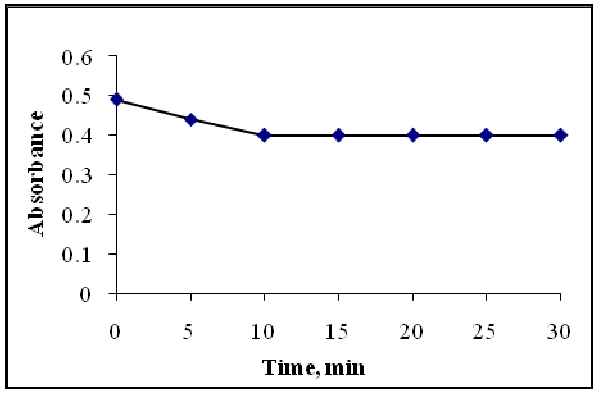

Fig. 5. Effect of reaction time and stability of the species (16 µg mL^{-1}ALB at 545 nm) for method B

Method validation

The proposed methods have been validated for linearity, sensitivity, selectivity, precision, accuracy and recovery according to current *ICH* guidelines.

Linearity and sensitivity

Over the range investigated (2.0-9.0 mg), a fixed stoichiometry of 1: 1 (ALB: $KMnO_4$) was obtained in titrimetry (method A), which served as the basis for calculations. In spectrophotometry, under optimum conditions a linear relation was obtained between absorbance and concentration of ALB in the range of 8.0-64.0 µg mL^{-1} and the Beer's law is obeyed in the inverse manner (method B). The calibration graph is described by the equation:

$$Y = a + b X \qquad (1)$$

(Where Y = absorbance, a = intercept, b = slope and X = concentration in µg mL^{-1}) obtained by the method of least squares. Correlation coefficient, intercept and slope for the calibration plot are predicted in Table 1. Sensitivity parameters such as apparent molar absorptivity and Sandell's sensitivity values, as well as the limits of detection and quantification, were calculated as per the current *ICH* guidelines [41] and compiled in Table 1. The results lead to the sensitivity of the proposed method. The limits of detection (LOD) and quantification (LOQ) were calculated according to the same guidelines using the formulae:

LOD=3.3σ/s and LOQ=10σ/s (2)

Where σ is the standard deviation of five reagent blank determinations, and s is the slope of the calibration curve.

Table 1. Sensitivity and regression parameters

Parameter	Method B
λ_{max}, nm	545
Beer's law limits, μg mL^{-1}	8.0-64.0
Molar absorptivity, L mol^{-1} cm^{-1}	3.348×10^3
Sandell sensitivity*, μg cm^{-2}	0.0793
Limit of detection, μg mL^{-1}	0.35
Limit of quantification, μg mL^{-1}	1.06
Regression equation, Y**	
Intercept, (a)	0.935
Slope, (b)	-0.0141
Standard deviation of intercept (S_a)	9.98×10^{-2}
Standard deviation of slope (S_b)	1.97×10^{-3}
Regression coefficient (r)	0.9953

[a] Limit of determination as the weight in μg mL^{-1} of solution, which corresponds to an absorbance of $A = 0.001$ measured in a cuvette of cross-sectional area 1 cm^2 and l = 1 cm.[b] $Y=a+bX$, Where Y is the absorbance, X is concentration in μg mL^{-1}

Accuracy and precision

In order to evaluate the precision of the proposed methods, solutions containing three different concentrations of the ALB were prepared and assayed in five replicates. The results obtained from this investigation are given in Table 2. The low values of the relative standard deviation (% RSD) and percentage relative error (% RE) indicate the precision and accuracy of the proposed methods.

Table 2. Evaluation of intra-day and inter-day accuracyand precision

Method	ALB* taken	Intra-day (n = 5)			Inter-day (n = 5)		
		ALB found[a]	%RSD[b]	%RE[c]	ALB found[a]	%RSD[b]	%RE[c]
Method A	3.0	3.10	0.75	3.33	3.11	2.16	3.72
	5.0	4.89	0.93	2.20	5.08	1.52	1.60
	7.0	6.90	1.43	1.38	6.87	1.86	1.21
Method B	20.0	19.28	2.64	3.58	19.22	2.59	3.90
	40.0	40.87	1.82	2.27	39.11	3.82	2.23
	60.0	59.2	1.43	0.75	59.57	1.22	0.71

*In method A, ALB taken/found are in mg and are μg mL^{-1} in method B.
[a]Mean value of five determinations; [b.] Relative standard deviation (%); [c.] Relative error (%).

The assay procedure was repeated five times, and percentage relative standard deviation (% RSD) values were obtained within the same day to evaluate repeatability (intra-day precision), and over five different days to evaluate intermediate precision (inter-day precision).

Selectivity

The proposed methods were subjected for selectivity by placebo blank and synthetic mixture analyses. A convenient aliquot of the placebo blank solution, prepared as described earlier, was subjected to analysis by both methods according to the assay procedures. In both methods, the inactive ingredients present in the placebo mixture did not affect the results shows the non-interference of the methods.

A separate experiment was conducted with the synthetic mixture. The analysis of synthetic mixture solution prepared above yielded percent recoveries of 98.72±0.99, and 102.5±2.12 for titrimetry and spectrophotometry, respectively. The results of this study indicate that the inactive ingredients present in the synthetic mixture did not interfere in the assay. These results further conclude the accuracy, as well as precision, of the developed methods.

Robustness and ruggedness

To perform the robustness of the methods, volume of H_2SO_4 (5±0.5 mL) and contact time (5±1 min) were slightly altered with reference to optimum values in titrimetry. However, in spectrophotometry, the reaction time (after adding $KMnO_4$, time varied was 15±1 min) and volume of H_2SO_4 were slightly altered (1±0.1 mL). To test the ruggedness, analysis was performed by four different analysts in both methods. The robustness and the ruggedness were checked at three different ALB levels (3, 5, 7 mg in method A and 20, 40, 60 µg mL^{-1} in method B). The intermediate precision, expressed as percent RSD, which is a measure of robustness and ruggedness, was within the acceptable limits (0.92–2.36 %) as shown in Table 3.

Table 3. Robustness and ruggedness.

Method A				Method B			
ALB (mg)	Robustness (RSD, %) Parameters altered		Ruggedness (RSD, %) Inter-burettes (n=4)	ALB (µg mL^{-1})	Robustness (RSD, %) Parameters altered		Ruggedness (RSD, %)
	Volume of H_2SO_4[a] (n=3)	Reaction time[b] (n=3)			Volume of H_2SO_4[c] (n=3)	Reaction time[d] (n=3)	Inter-cuvettes (n=3)
3.0	1.85	1.05	1.27	20.0	1.92	1.32	0.98
5.0	2.16	1.27	0.92	40.0	2.20	0.95	1.56
7.0	2.08	1.97	1.78	60.0	2.36	1.69	2.13

[a]In method A, volumes of 5 M H_2SO_4 varied were 5±1 mL, [b]the reaction time employed was 5±1min.
[c]In method B, volumes of 5 M H_2SO_4 varied were 1±0.1 mL, [c]the reaction time employed was 15±1 min.

Application to tablets and suspension

In order to calculate the analytical applicability of the proposed methods to the quantification of ALB in commercial tablets and in suspension, the results obtained by the proposed methods were compared to those of the official BP method [3] by applying Student's *t*-test for accuracy and the *F*-test for precision. The official BP method describes a potentiometric titration with perchloric acid in formic acid-acetic acid medium. The results (Table 4) show that the Student's *t*- and *F*-values at a 95 % confidence level are lower than the tabulated values, thereby confirming good agreement between the results obtained by

the proposed methods and the reference method, with respect to accuracy and precision.

Table 4. Results of analysis of tablets by the proposed methods and statistical comparison of the results with the official method.

Tablet brand name	Label claim mg/tablet	Found (Percent of label claim ±SD)[a]		
		Official method	Proposed methods	
			Method A	Method B
Alworm-400	400	99.78 ± 0.89	101.4 ± 1.41 ***t*** **=** 2.17 ***F*****=** 2.51	98.96 ± 1.37 ***t*** **=** 1.12 ***F***= 2.37
ABD-400	400	102.7 ± 0.54	101.8 ± 0.95 ***t*** **=** 1.85 ***F*****=** 3.09	103.4 ± 1.11 ***t*** **=** 1.27 ***F*****=** 4.23
Bandy-400	400	98.54 ± 0.68	99.56 ± 0.75 ***t*** **=** 2.24 ***F*****=** 1.22	97.92 ± 1.15 ***t*** **=** 1.04 ***F*****=** 2.86
Zentel suspension	400	101.25 ± 1.36	102.9 ± 1.75 ***t*** **=** 1.73 ***F*****=** 1.45	103.5 ± 2.15 ***t*** **=** 1.98 ***F*****=** 2.5

Mean value of five determinations.
Tabulated *t*-value at the 95% confidence level is 2.78.
Tabulated *F*-value at the 95% confidence level is 6.39.

Recovery studies

The accuracy and validity of the proposed methods were further ascertained by performing recovery studies. Pre-analyzed tablet powder and suspension were spiked with pure ALB at three concentration levels (50, 100 and 150% of that in tablet powder) and the total was then determined by the proposed methods. In both the cases, the added ALB recovery percentage values ranged from 97.20-102.4% with a standard deviation of 0.59-1.92 (Table 5), indicating good recovery and absence of interference from the co-formulated substances in the assay.

Table 5. Results of recovery study *via* standard addition method.

Tablets/ Suspenion studied	Method A				Method B			
	ALB in tablets, mg mL^{-1}	Pure ALB added, mg mL^{-1}	Total found, mg mL^{-1}	Pure ALB recovered*, Percent±SD	ALB in tablets, µg mL^{-1}	Pure ALB added, µg mL^{-1}	Total found, µg mL^{-1}	Pure ALB recovered*, Percent±SD
Alworm-300	3.04	1.5	4.50	99.2 ± 0.73	19.79	10	29.64	99.5± 0.84
	3.04	3.0	6.06	100.4 ± 0.98	19.79	20	40.35	101.4 ± 0.91
	3.04	4.5	7.61	100.9 ± 0.59	19.79	30	50.24	100.9 ± 0.75
ABD-400	3.05	1.5	4.42	97.2 ± 0.92	20.68	10	30.55	99.6 ± 0.54
	3.05	3.0	6.09	100.7 ± 0.79	20.68	20	40.88	100.5 ± 0.97
	3.05	4.5	7.66	101.5 ± 0.63	20.68	30	50.22	99.1 ± 0.79
Bandy-400	2.99	1.5	4.41	98.2 ± 1.23	19.58	10	30.23	102.4 ± 1.92
	2.99	3.0	6.07	101.4 ± 0.95	19.58	20	40.09	101.3 ± 0.98
	2.99	4.5	7.65	102.1 ± 1.31	19.58	30	49.28	99.4 ± 0.89
Zentel suspension	3.09	1.5	4.57	99.5 ± 1.45	20.70	10	31.78	103.5 ± 2.10
	3.09	3.0	6.24	102.4 ± 1.91	20.70	20	41.64	102.3 ± 1.98
	3.09	4.5	7.83	103.2 ± 1.75	20.70	30	51.66	101.9 ± 1.72

*Mean value of three determinations.

Conclusion

Two rapid, selective, sensitive and cost-effective titrimetric and spectrophotomtric methods are proposed. These are free from rigid experimental conditions such as rigid pH control, liquid-liquid extraction, etc., and are characterized by simplicity and sensitivity. These methods employ inexpensive and easily available chemicals and hence cost-effective when compared to the existing spectrophotometric methods. In addition, the methods have a high tolerance limit for common excipients found in drug formulations. The proposed methods are accurate and precise as indicated by good recoveries of the drugs and low RSD values. The found percent recovery of suspension was slightly high compare to the tablets; this indicates that the excipients present in it affect the results this can be overcome by using extraction procedure. The proposed methods can be applied for routine analysis and in quality control laboratories for quantitative determination of the drug both in the pure and formulations.

Conflict of interest

Authors certify that no actual or potential conflict of interest in relation to this article exists.

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