Two Derivative Spectrophotometric Methods for the Simultaneous Determination of 4-AminoAntipyrine in Presence of Its Acidic Products

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Abstract

Simple, economic and sensitive mathematical spectrophotometric methods were developed for the estimation 4-aminoantipyrine in presence of its acidic product. The estimation of binary mixture 4-aminoantipyrine and its acidic product was achieved by first derivative and second derivative spectrophotometric methods by applying zero-crossing at (valley 255.9nm and 234.5nm) for 4-aminoantipyrine and (peak 243.3 nm and 227.3nm) for acidic product. The value of coefficient of determination for the liner graphs were not less than 0.996 and the recovery percentage were found to be in the range from 96.555 to 102.160. Normal ratio spectrophotometric method 0DD was used 50 mg/l acidic product as a divisor and then measured at 299.9 nm with correlation coefficient 0.998 and limit of detection 0.04098. ratio derivative methods 1DD and 2DD; are based on measuring the first derivative and second derivative for normal ratio spectrum at (peak 290.7 nm and valley 310 nm) for 1DD and (peak 286, valley 301 and peak 316nm) for 2DD the correlation coefficient for linearity graph not less than 0.997 and the recovery percentage were found to be in the range from 99.64 to 100.11.

Keyword: 4-Aminoantipyrine; zero-crossing; spectrophotometric; ratio derivative; 1DD and 2DD.

Introduction

4-Aminoantipyrine(4AAP) is an antipyretic, analgesic and anti-inflammatory properties [1]. It is used as a reagent for biochemical reactions producing phenol or peroxides [2], and used for the estimation of drugs via oxidative coupling reaction forming coloured products [3-5].

There are many methods for the determination of 4-Aminoantipyrine including electrochemical method based on fabrication of multi walled carbon nanotube electrodes for the estimation toxic drugs 4-Aminoantipyrine [6], solid-phase spectrophotometry [7], electrochemical method by using graphite pencil electrode [8], capillary electrophoresis [9] and LC/Mass spectrometry [10].

On the other hand, spectrophotometric methods such as zero-crossing [11-12] and ratio derivative [13-14] methods are still favorite studies because of the simplicity, accuracy and availability of the instrumentation [15-16]. Therefore, the aim of this study is to develop rapid, simple and inexpensive spectrophotometric methods for the analysis of 4-Aminoantipyrine in the presence of its acidic product without chemical process separation. Furthermore, the zero-crossing and ratio derivative spectrophotometric methods could be used for the estimation of 4-Aminoantipyrine without any interference from its acidic product.

Experimental

Instruments

1. Uv-Visble spectrophotometer (model 1650 PC, SHEMADZU, Japan) with software program.
2. FTIR spectrophotometer (SHEMADZU, Japan)

Materials

Standard pure powder of 4-Aminoantipyrine (Sigma-Aldrich) ($C_{11}H_{13}N_3O$) (M.wt= 203.24 gm/mol) and hydrochloric acid(BHD) prepared by 2N aqueous solution.

a. Preparation of acidic product for IR- spectral

0.01 gm of pure 4-Aminoantipyrine was refluxed with 100 ml 2N HCl for 60 min. after cooling, the solution was evaporated to dryness by using oven at 70^0C, the residue was extracted with ethanol, filtered and then dried in air. The separated acidic product was subjected to IR spectral analysis [17-18].

b. Preparation of standard solutions

1. 4-Aminoantipyrine stock standard solution 100mg/l was prepared by dissolving 0.01 gm of pure 4-Aminoantipyrine with distilled water and then complete to the 100ml with the same solvent. After then different volumes of 4-Aminoantipyrine stock standard solution (100mg/l) ranging from (2.5 ml to 17.5 ml) were transferred into a series of 25 ml volumetric flasks and completed to the mark with distilled water to obtain a range of concentrations from (10 to 70 mg/l).
2. 4-Aminoantipyrine acidic product stock standard solution was prepared by refluxing 0.01 gm of pure 4-Aminoantipyrine with 100ml 2N HCl for 60 min. after cooling, were transferred into a series of (2.5, 5, 7.5, 10, 12.5, 15, 17.5 ml) of this solution to 25 ml volumetric flasks and complete to the mark with distilled water to obtain the acidic product solutions in the concentration range of (10 to 70 mg/l).

Procedure

a. Zero-crossing method

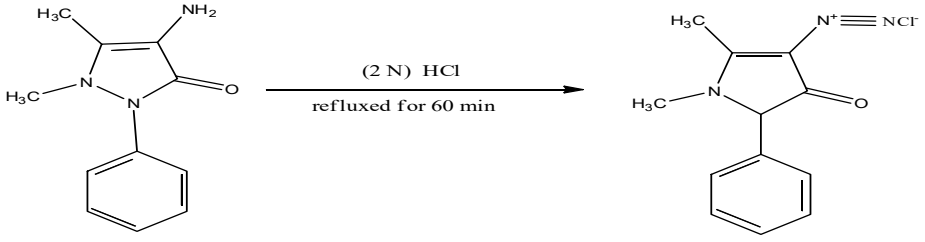
1. The first derivative 1D and second derivative 2D of the uv spectrum of pure 4-Aminoantipyrine standard solutions were measured. Two calibration graphs were obtained by plotting the valley of 1D spectra at 255.9nm and the valley of 2D spectra at 234.5nm (corresponding to zero-crossing of its acidic product) of 1D and 2D spectra against the corresponding concentrations. In the same way, the 1Dand 2D of 4-Aminoantipyrine acidic product standard solution were recorded. Two calibration graphs were obtained by plotting the values of 1D spectra at 243.3 nm and peak of 2D spectra at 227.3nm (corresponding to zero-crossing of pure 4-Aminoantipyrine) of 1D and 2D spectra against the corresponding concentrations.
2. To series of binary mixtures solutions of pure 4-Aminantipyrine standard and its acidic product were prepared; the first series was prepared by using a concentration of 20 mg/l of acidic product with different concentrations of pure 4-aminoantipyrine, while the second series of mixture was prepared by using a concentration 20 mg/l of pure 4-aminoantipyrine with difference concentrations of the acidic product.

b. Ratio spectra method

Standard solutions of 4-Aminoantipyrine ranging from 10 to 70 mg/l were scanned in the range (from 200 to 400nm), and then divided by a spectrum of standard solution (50 mg/l) of its acidic product (as a divisor). The value of peak 299.9nm of the resultant spectra were plotted against the corresponding concentrations to obtain a calibration graph.
The first derivative of ratio spectra(1DD) at peak 291 nm and valley 310 nm was selected, the value of the resultant at these pair of wavelength was measured and plotted against the concentrations to obtain two calibration graphs for 1DD method.
The second derivative of ratio spectra (2DD) at peak 286nm, valley 299.9 nm and peak 316nm were selected, three calibration graphs were constructed for 2DD method to the corresponding 4-Aminoantipyrine concentration and the regression validation parameters were calculated.

Results and discussion

The derivative spectrophotometric methods for the estimation of organic and pharmaceuticals compounds in presence of its acidic degradation products without chemical separation are always of interest. In this study, the acidic product of 4-Aminoantipyrine was carried out by dissolving the pure organic compound 4-Aminoantipyrine in 2M HCl and reflux at 100^0C for 60 min. the suggested scheme of acidic product might be written as follows:



4-Aminoantipyrine Acidic product

The acidic product was subjected to IR spectrophotometry analysis, the comparison of IR-spectra of 4-Aminoantipyrine with that the acidic product, the characteristic band at 3433.41-3331.18 corresponding to the NH_2 of the amine groups shown in figure(1a), has been disappeared in the IR- spectra of the acidic products figure (1b) [19].

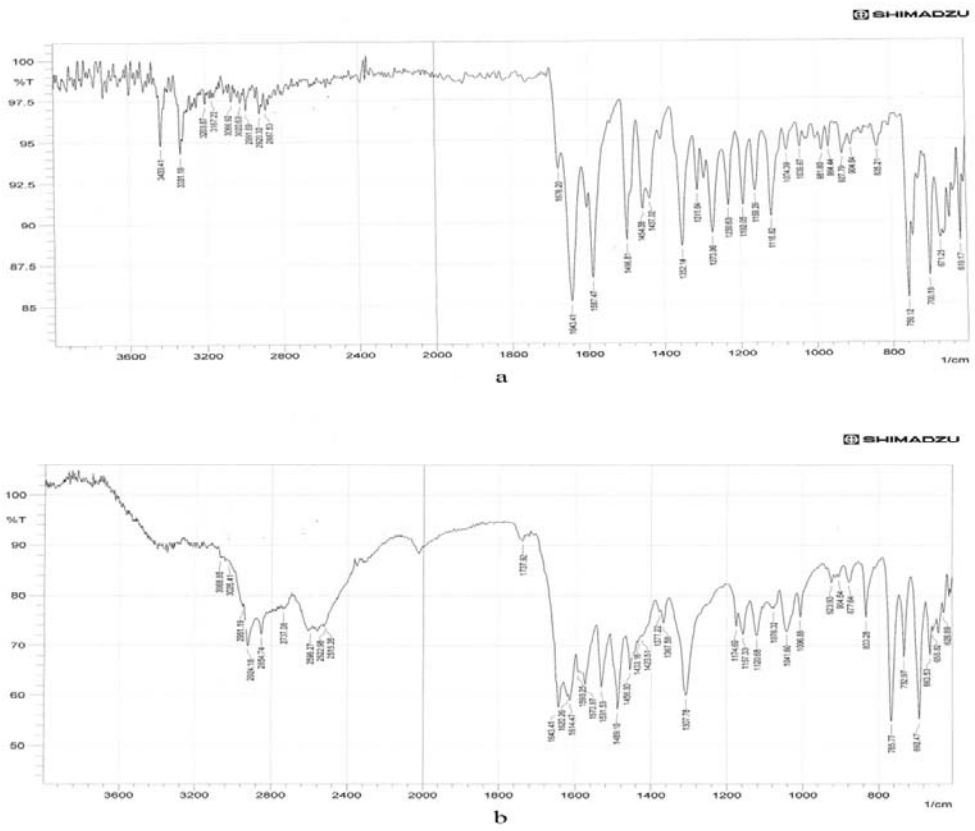


Figure (1): IR- spectra of (a) pure 4-Aminoantipyrine and (b) its acidic product

4-Aminoantipyrine and its acidic product UV-spectra are shown in figure (2); direct estimation of 4-Aminoantipyrine in presence of its acidic products is impossible, zero-crossing and ratio spectrophotometric methods can be resolved and estimation of 4-Aminoantipyrine in presence of its acidic products.

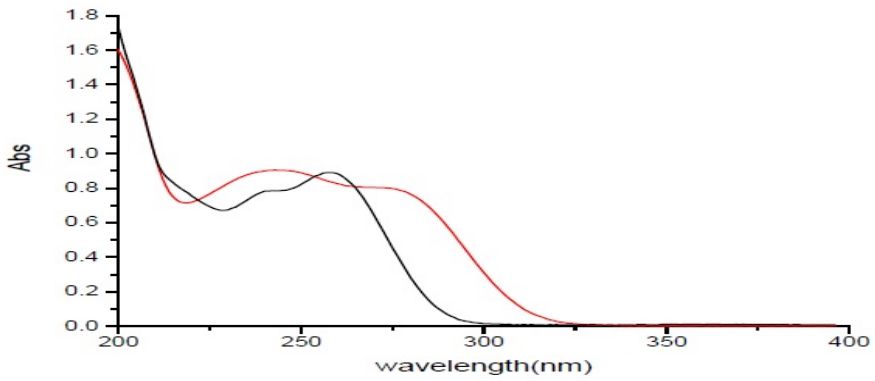


Figure (2): Zero order spectra of 4-Aminoantipyrine 30 mg/l(red) and acidic product 30 mg/l (black).

Zero-crossing method

Zero-crossing method used individual determination of 4-Aminoantipyrine and its acidic product in binary mixture at the selected wavelengths as shown in figure (3) and figure (4) respectively.

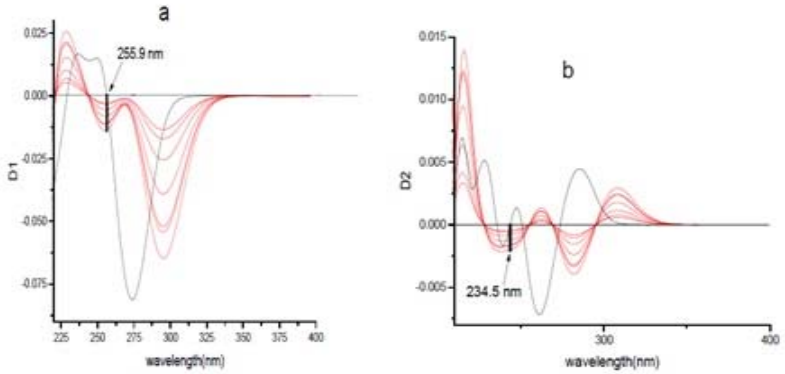


Figure (3): Zero-crossing measurements for (10-70 mg/l) 4-Aminoantipyrine (red) and 40 mg/l acidic product(black) a- 1D at valley 255.9nm, b- 2D at valley 234.5nm for determination of 4-Aminoantipyrine

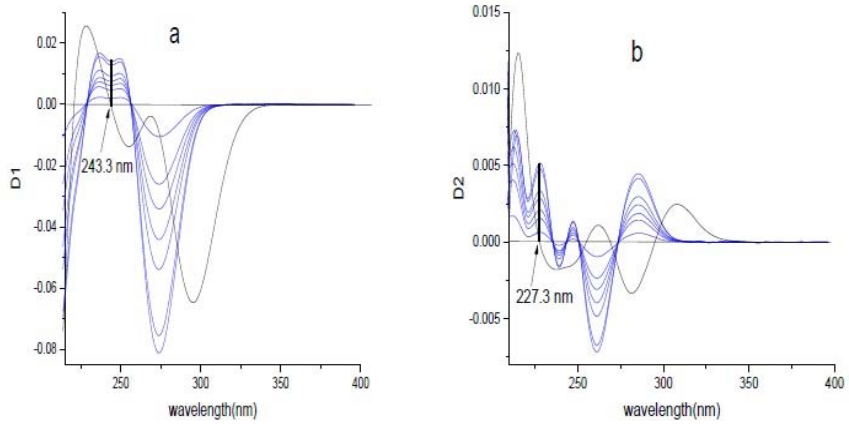


Figure (4): Zero-crossing measurements for (10-70 mg/l) acidic product(blue) and 40 mg/l 4- Aminoantipyrine(black) a- 1D at peak 243.3nm, b- 2D at peak 227.3nmfor determination of acidic product.

Linearity graphs for 1D and 2D at zero-crossing measurements of standard solutions of (10-70mg/l) for each of 4-Aminoantipyrine and its acidic product were obtained. linear equation, limit of detections and other validation parameters are listed in table (1).

Table (1): Validation parameters for the obtained calibration graphs for the determination of 4AAP and its acidic product using zero-crossing measurements.

Validation parameters	1D		2D	
	4AAP at valley 255.9nm	Acidic product at peak 243.3 nm	4AAP at valley 234.5nm	Acidic product at peak 227.3 nm
Linearity range (mg/L)	10-70	10-70	10-70	10-70
equation	Y= -0.026x -0.0041	Y=0.0095x +0.0012	Y=-0.0037x -0.018	Y=0.0093x +0.0135
R^2	0.9960	0.9980	0.9970	0.9970
Slope	-0. 026	0. 0095	-0.0037	0.0093
Intercept	-0.0041	0.0012	-0.018	0.0135
LOD	0.495	1.354	3.478	1.383
LQD	1.5	4.105	1.054	4.193

R^2= Coefficient of determination, 4AAP=4-Aminoantipyrine and LOD= limit of detection = $3.3\times SD_b/S$, LQD=$10\times SD_b/S$. where, SDb= is the standard deviation of the solvent (n=3) and S= is the slop of the corresponding linearity graph.

1D and 2D methods used for the estimation 4-Aminoantipyrine in presence of its acidic product by using zero-order measurements at valley 255.9nm and 234.5nm respectively. In the same way, 1D and 2D methods were used for estimation of the acidic product of 4-Aminoantipyrine in presence of 4-Aminoantipyrine by using zero-crossing measurements at peak values at 243.3 nm and 227.3 nm respectively. The relative error and recovery percents for the estimation of 4AAP and in presence of its acidic product in synthetic mixtures were calculated for triplicate measurements for the suggested zero-crossing spectrophotometric method, the values of recovery percentage were found in the range between 96.555 and 102.160 indicating that the recommended zero-crossing method is accurate as shown in table (2).

Table (2): The relative error and recovery percentage for estimation of 4AAP and its acidic product using zero-crossing method

Taken Mixture of 4AAP +acidic product	Found mg/l 4AAP 1D at valley 255.9nm	E%	Rec%	Found mg/l 4AAP 2D at valley 234.5nm	E%	Rec%
20 mg/l+0 mg/l	19.397	-3.015	96.985	19.781	-1.095	98.905
20 mg/l+20 mg/l	19.718	-1.41	98.590	19.920	-0.400	99.600
40 mg/l+20 mg/l	39.511	-1.222	98.777	39.130	-2.175	97.825
30 mg/l+5 mg/l	30.219	0.730	100.730	30.424	1.413	101.413
30 mg/l+10 mg/l	29.624	-1.253	98.746	29.110	-2.966	97.033
Taken Mixture of 4AAP +acidic product	Found mg/l Acidic product 1D at	E%	Rec%	Found mg/l Acidic product 2D at	E%	Rec%

	peak 243.3nm			peak 227.3nm		
0mg/l+30mg/l	29.676	-1.08	98.920	29.522	-1.593	98.406
20mg/l+10mg/l	9.732	-2.68	97.320	9.866	-1.340	98.660
20mg/l+20mg/l	19.995	-0.025	99.975	19.311	-3.445	96.555
10mg/l+10mg/l	10.054	0.54	100.540	10.216	2.160	102.160
30mg/l+10mg/l	10.124	1.24	101.240	10.098	0.980	100.980

4AAP=4-Aminoantipyrine, E% = relative error = $=\frac{found-taken}{taken}\times 100$ and Rec% =recovery= E%+100

Ratio spectrophotometric method

In the ratio spectrophotometric method the obtained absorption spectra of the mixtures of 4-Aminoantipyrine and its acidic product were divided then by the absorption spectrum of the acidic product standard solution (as divisor) as shown in figure (5). The first derivative 1DD and the second derivative 2DD spectra in each case was then obtained, as shown in figure (6).

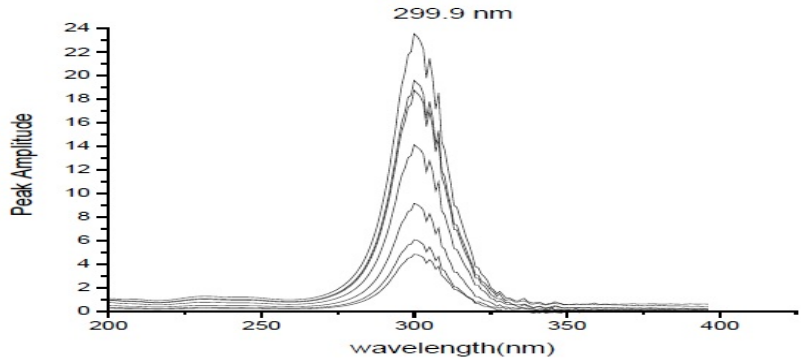


Figure (5): Normal ratio spectra (0DD) of 4-Aminoantipyrine (10-70 mg/l) using 50 mg/l of acidic product as a divisor

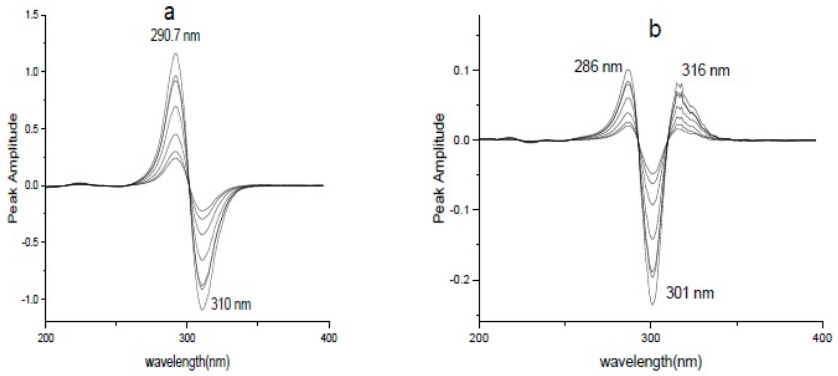


Figure (6): Derivative ratio spectra of 4-Aminoantipyrine (10-70 mg/l) using 50 mg/l of acidic product as a divisor: (a) first derivative ratio spectra (1DD) and (b) second derivative ratio spectra (2DD)

In order to optimize the Ratio spectrophotometric method, various concentrations divisor solution (10, 30, 50, 70 mg/l) were tried of acidic product; the best results were obtained when a 50 mg/l of acidic product was used as a divisor. Dividing the absorption spectrum of 4-Aminoantipyrine in the range(10-70mg/l) by absorption spectrum of 50 mg/l of acidic product (as a divisor). The validation parameters of the obtained linear graphs are summarized in table (3).

Table (3): Validation parameters for the linear graphs for the determination of 4AAP and its acidic product using 0DD, 1DD and 2DD methods.

Validation parameters	^{0}DD at peak 299.9nm	^{1}DD at peak 290.7 nm	^{1}DD at valley 310.nm	^{2}DD at peak 286 nm	^{2}DD at valley 301 nm	^{2}DD at peak 316 nm
Linearity range (mg/L)	10-70	10-70	10-70	10-70	10-70	10-70
Equation	Y=0.314x +1.338	Y=0.014x +0.093	Y=-0.014x -0.078	Y=0.01x +0.06	Y=-0.02x -0. 02	Y=0.01x +0.05
R^2	0.9980	0.9980	0.9970	0.9980	0.9970	0.9990
Slope	0.314	0.014	-0.014	0.01	-0.02	0.01
Intercept	1.338	0.093	-0.078	0.006	-0.02	0.05
LOD	0.040	0.919	0.919	1.287	0.643	1.287
LQD	0.124	2.785	2.785	3.9	1.950	3.9

R^2= coefficient of determination

The relative error and recovery percentage were calculated and presented in table (4). The obtained values correspond to triplicate analysis of 4-Amionantipyrine solution in the concentration range 25 -45 mg.l-1 using the ratio derivative method. The values of recovery percentage were found to be in the range between 99.64 and 100.11, indicating that the ratio derivative method is reliable and accurate.

Table (4): The relative error and recovery percentage for estimation of 4AAP and its acidic product using 0DD, 1DD and 2DD methods

parameters	^{0}DD at 299.9 nm	^{1}DD at 290.7 nm	^{1}DD at 310 nm	^{2}DD at 286 nm	^{2}DD at 301 nm	^{2}DD at 316 nm
Taken mg/l	25	25	25	25	25	25
Found mg/l	24.92	24.96	24.93	24.96	24.91	24.93
E%	-0.32	-0.16	-0.28	-0.16	-0.36	-0.28
Rec%	99.68	99.84	99.72	99.84	99.64	99.73
Taken mg/l	45	45	45	45	45	45
Found mg/l	44.95	44.98	45.08	44.93	44.96	45.02
E%	-0.11	-0.044	0.111	-0.155	-0.088	0.044
Rec%	99.88	99.95	100.11	99.84	99.91	100.04

Conclusion

The proposed methods are simple and accurate making them easily for estimation of 4-aminoantipyrine in presence its acidic product. The purposed methods require neither pH control nor temperature control and nor solvent extraction. So, the suggested spectrophotometric methods are appropriate for the estimation 4-aminoantipyrine and its acidic product in binary mixture.

References

[1] P. Deshmukh; P. K.Soni; A.Kankoriya; A. K. Halve and R. Dixit, 4-Aminoantipyrine: A Significant Tool for the Synthesis of Biologically Active Schiff Bases and Metal Complexes, Int. J. Pharm. Sci. Rev. Res., 34, 162-170. 2015

[2] J.Swaminathana; M.Ramalingamb; V.Sethuramana; N.Sundaraganesanc and S.Sebastianc, Vibrational spectroscopic studies and DFT calculations of 4-aminoantipyrine, Spectrochimica Acta Part A, 73, 593–600. 2009

[3]M. Jasim; W. S. Khayoon, and S. A. Hasssan, Batch and flow injection spectrophotometric methods for the determination of barbituric acid in aqueous samples via oxidative coupling with 4-aminoantipyrine, Karbala International Journal of Modern Science, 1,135-141. 2015

[4] J. M.Hong; J. K. Jun; H. Y. Kim; S. Ahn and S.Chang, Colorimetric signaling of Cu(II) ions by oxidative coupling of anilines with 4-aminoantipyrine, Tetrahedron Letters, 56, 5393–5396. 2015

[5] H. Y. Kim; H. J. Lee, Reaction-based colorimetric signaling of Cu^{2+} ions by oxidative coupling of phenols with 4-aminoantipyrine, Talanta, 132, 625-629. 2015

[6] J. I. Gowda; A. T. Buddanavar and S. T. Nandibewoor, Fabrication of multiwalled carbon nanotube-surfactant modified sensor for the direct determination of toxic drug 4-aminoantipyrine,Journal of Pharmaceutical Analysis, 5, 231-238. 2015

[7] I. Nukatsuka; S. Nakamura; K. Watanabe and K. Ohzeki, determination of phenol in tap water and river water samples by solid-phase spectrophotometry, Analytical Sciences, 16, 269-273. 2000

[8] J. I. Gowda and S. T. Nandibewoor, Electrochemical Behavior of 4-Aminophenazone Drug at a Graphite Pencil Electrode and Its Application in Real Samples Ind. Eng. Chem. Res, 51, 15936−15941. 2012

[9] E. Zlotorzynska, Capillary electrophoresis in the determination of pollutants, Electrophoresis, 18(1997), 2453-2464.

[10] D.Puig ; I.Silgoner ; M.Grasserbauer and D. Barcelo, Part-per-Trillion Level Determination of Priority Methyl-, Nitro-, and Chlorophenols in River Water Samples by Automated On-Line Liquid/Solid Extraction Followed by Liquid Chromatography/ Mass Spectrometry Using Atmospheric Pressure Chemical Ionization and Ion Spray Interfaces, Anal. Chem., 69(1997), 2756-2761.

[11] K.H.Al-Saidi and R.A.Hammza, Spectrophotometric Determination of Promethazine Hydrochloride and Paracetamol in Pharmaceutical Tablets Journal of Al-Nahrain University- Science, 17, 14-23. 2014

[12] A. R. Rote and P. D. Bari, Ratio Spectra Derivative and Zero-Crossing Difference Spectrophotometric Determination of Olmesartan Medoxomil and hydrochlorothiazide in Combined Pharmaceutical Dosage Form, AAPS Pharm. Sci. Tech., 10, 1200-1205. 2009

[13] K. A.M. Attia, M. W.I.Nassar; M. B. El-Zeiny and A. Serag, Different approaches in manipulating ratio spectra applied for the analysis of Cefprozil in presence of its

alkaline-induced degradation product: A Comparative study, SpectrochimicaActa Part A., 145, 289-294. 2015

[14] M. A. Hegazy; A.M. Yehia and A. A. Mostafa, Stability-indicating methods for the determination of mosapride citrate in the presence of its degradation products according to ICH guidelines, Drug Test. Analysis, 4, 104–15. 2012

[15] H. M. Lotfy;S.S. Saleh; N.Y. Hassan and S. M. Elgizawy, A Comparative Study of the Novel Ratio Difference Method versus Conventional Spectrophotometric Techniques for the Analysis of Binary Mixture with Overlapped Spectra, American Journal of Analytical Chemistry,3, 761-769**.** 2012

[16] H.M. Lotfy; S.M. Amer; H.E. Zaazaa and N.S. Mostafa, Spectrophotometric Methods for Quantitative Determination of Binary Mixture of Naproxen Sodium and Domperidone Maleate, Austin J Anal Pharm Chem., 2(2015), 1-8.

[17] M.A. Hegazy; A. M. Yehia and A.A. Mostafa, Stability-indicating methods f or the determination of mosapride citrate in the presence of its degradation products according to ICH guidelines, Drug Testing and Analysis, 4, 104-115. 2012

[18] S. Z. El Khateeb ; S.A. Abdel Razek and M.M. Amer, Stability-indicating methods for the spectrophotometric determination of norfloxacin, Journal of Pharmaceutical and Biomedical Analysis, 17 ,829–840**.** 1998

[19] M. A. Tantawya; N.A. El-Ragehya;N.Y. Hassana and M. Abdelkawy, Stability-indicating spectrophotometric methods for determination of the anticoagulant drug apixaban in the presence of its hydrolytic degradation product, spectrochemicaActa Part A, 159, 13-20. 2016