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Spectrophotometric determination of pipazethate HCl, dextromethorphan HBr and drotaverine HCl in their pharmaceutical preparations

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Abstract

A simple, accurate and highly sensitive spectrophotometric method is proposed for the rapid determination of pipazethate hydrochloride, dextromethorphan hydrobromide and drotaverine hydrochloride using chromotrope 2B (C2B) and chromotrope 2R (C2R). The method consists of extracting the formed ion-associates into chloroform in the case of pipazethate HCl and dextromethorphan HBr or into methylene chloride in the case of drotaverine HCl. The ion-associates exhibit absorption maxima at 528, 540 and 532 nm with C2B and at 526, 517 and 522 nm with C2R for pipazethate HCl, dextromethorphan HBr and drotaverine HCl, respectively. The calibration curves resulting from the measurements of absorbance–concentration relations (at the optimum reaction conditions) of the extracted ion-pairs are linear over the concentration range 4.36–52.32 $\mu g\,mL^{-1}$ for pipazethate, 3.7–48.15 $\mu g\,mL^{-1}$ for dextromethorphan and 4.34–60.76 $\mu g\,mL^{-1}$ for drotaverine, respectively. The effect of acidity, reagent concentration, time, solvent and stoichiometric ratio of the ion-associates were estimated. The molar absorptivity and Sandell sensitivity of the reaction products were calculated. Statistical treatment of the results reflects that the procedure is precise, accurate and easily applied for the determination of the drugs under investigation in pure form and in their pharmaceutical preparations.

Keywords: Spectrophotometry; Pipazethate HCl; Dextromethorphan HBr; Drotaverine HCl; Chromotrope 2B; Chromotrope 2R; Extraction; Pharmaceutical preparations

1. Introduction

Pipazethate hydrochloride (PiCl), 10*H*-pyrido[3,2-*b*][1,4] benzothiadiazine-10-carboxylic acid 2-(2-piperidinoethoxy) ethyl ester [1] is a bronchodilator that suppresses irritative and spasmodic cough by inhibiting the excitability of the cough center and the peripheral neural receptors in the respiratory passage. The response to the drug takes about 10–20 min and lasts for 4–6 h. Pipazethate has been determined using a limited number of techniques including spectrophotometry [2–4] TLC [5], HPLC [6], conductimetry [7] and ISE [8]. PiCl was used in determination of Mo (VI) in alloy steels and soil samples [9].

Dextromethorphan hydrobromide (DEX), [(+)-3-methoxy-17-methyl-9α, 13α, 14α-morphinan hydrobromide monohydrate] is a cough suppressant, used for the relief of non-productive cough [10]. Different methods reported for the determination of DEX in the bulk drug, in the dosage forms with other drugs in cough–cold products and in biological samples. HPLC have been reported [11–15], the first and second-derivative technique UV spectrophotometry [16–19], capillary electrophoresis [20–22], GC [23,24], LC [25–28] and TLC [29,30].

Drotaverine [1-(3,4-diethoxybenzylidene)-6,7-diethoxy-1,2,3,4-tetrahydroiso-quinoline] [985-12-6], a hydrated derivative of papaverine, is an effective spasmolytic agent [31]. They include HPLC [32–34] and TLC [35]. Other alternatives include spectrophotometry [4,36], differential spectrophotometry [37,38], computer-aided spectrophotometry [39] potentiometry [40,41] and square-wave polarography [42]. The spectrophotometric methods of drug analysis usually suffer from poor selectivity (Fig. 1).

Chromotropic acid (4,5-dihydroxynaphthalene-2,7-disulphonic acid), is used for the preparation of azo dyes which are very famous indicators for the spectrophotometric and chelatometric determination of metal ions [43,44]. Recently, some chromotropic acid azo dyes have been used for the extraction-spectrophotometric determination of cephalosporins [45], betamethazone [46], terfenadine [47], meclozine HCl and

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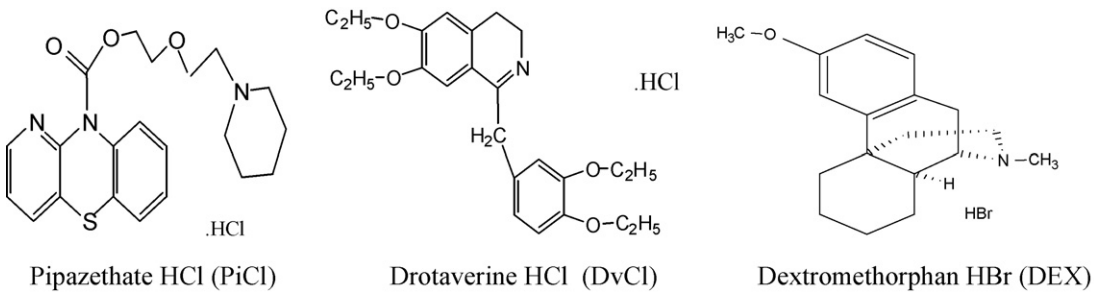

Fig. 1. The chemical structure of the studied drugs.

papavarine HCl [48], erythromycin [49] and dipyridamole and chlopheniramine maleate [50].

Chromotrope 2B (C2B), is 3-(*p*-nitrophenylazo)-chromotropic acid (acid red 176, CI 16575). Chromotrope 2R (C2R), is 3-(phenylazo) chromotropic acid, disodium salt (acid red 29, CI 16570).

The present work aims to present a simple, rapid and sensitive method for the determination of pipazethate hydrochloride, dextromethorphan hydrobromide and drotaverine hydrochloride in pure form and in their pharmaceutical preparations and can be used for the quality control and assurance of these drugs in industry. The method is based on the formation of ion-associate between the cited drugs and some chromotropic acid mono azo dyes. These methods are very simple in application and less expensive in comparison to the above mentioned techniques but at the same time offering a high degree of accuracy and precision when compared to the pharmacopoeial method and could be used simply to determine the shelve-stability time of the studied drugs.

2. Experimental

2.1. Apparatus

All absorption spectra were made using Kontron 930 (UV–vis) spectrophotometer (German) with a scanning speed of 200 nm/min and a bandwidth of 2.0 nm, equipped with 10 mm matched quartz cells.

2.2. Reagents and materials

Analytical grade reagents and double distilled water was used to prepare solutions.

- Pure grade pipazethate hydrochloride and its pharmaceutical preparations (Selgon, tablets 20 mg and drops 40 mg mL^{-1}) were provided by the Egyptian International Pharmaceutical Industries Company (EIPICO), Egypt.
- Dextromethorphan hydrobromide and its pharmaceutical preparations (Tussilar tablets 10 mg) supplied by Kahira Pharm. & Chem. Ind. Company, Egypt.
- Drotaverine hydrochloride and its pharmaceutical preparations (Do-Spa, tablets 40 mg) were obtained from Alexandria Co. for Pharmaceutical Chemical Industries (Alexandria, Egypt).
- Standard solution (1×10^{-3} M) of pipazethate HCl (PiCl) ($M_w = 435.968$), dextromethorphan HBr ($M_w = 370.4$) or drotaverine HCl (DvCl) ($M_w = 433.968$) were prepared by dissolving pure drug (pharmaceutical grade) in 100 mL bidistilled water and made up to 100 mL with bidistilled water. The solutions remained stable for 2 months when kept refrigerated.
- Chromotrope 2B (C2B) and chromotrope 2R (C2R) were obtained from Aldrich (USA). Stock solutions (2×10^{-3} M) of chromotrope 2B ($M_w = 513.37$) and chromotrope 2R ($M_w = 468.37$) were prepared by dissolving 0.1027 and 0.0937 g, respectively, in 100 mL bidistilled water. The chromotropic acid azo dyes aqueous solutions were stable for several months.

2.3. General procedure

Into a 50-mL separating funnel, 3 mL of 2×10^{-3} M C2B or C2R was transferred, a volume containing 43.6–523.2 μg mL^{-1} of PiCl, 37–481.5 μg mL^{-1} of DEX and 43.4–607.6 μg mL^{-1} of DvCl, respectively, 4 mL of 1 M HCl in the case of PiCl and 3 mL of 1 M HCl in the case of DEX or DvCl using C2B and C2R, respectively, were added and the volume was made up to 10 mL with distilled water. The formed ion associates were extracted with 5 mL chloroform in the case of PiCl or DEX and 5 mL methylene chloride in the case of DvCl by shaking for 3 min, then repeating the extraction step by using new 5 mL aliquots of the extractant. The reaction mixture was allowed to separate into two phases. The organic layer was collected into 10 mL calibrated measuring flask and the volume was made up to the mark with the extractant solvent. The absorbance of the extracts was measured at the recommended maximum wavelength (Table 1), against a reagent blank prepared in the same manner without the addition of the drug. All measurements were carried out at room temperature (25 ± 2 °C).

2.4. Determination of PiCl in Selgon, DEX in Tussilar and DvCl in Do-Spa tablets

The contents of 20 tablets (Selgon, 20 mg PiCl per tablet, Tussilar 10 mg DEX per tablet and Do-Spa, 40 mg DvCl per tablet) were powdered, and an accurately weighed portion equivalent to 20 mg PiCl, 10 mg DEX and 40 mg DvCl was mixed with 50 mL doubly distilled water, shaken in a mechanical shaker for about 6 h and then filtered into a 100 mL measuring flask. The

Table 1
Spectral characteristics of the colored products of PiCl, DEX and DvCl with C2B and C2R reagents

Parameters	C2B			C2R		
	PiCl	DEX	DvCl	PiCl	DEX	DvCl
Extracted solvent	Chloroform	Chloroform	Methylene chloride	Chloroform	Chloroform	Methylene chloride
λ_{max} (nm)	528	540	532	526	517	522
Beer's law limits (μg mL^{-1})	4.36–52.32	3.7–48.15	4.34–60.76	4.36–39.24	3.7–40.74	4.34–47.74
Ringbom optimum range (μg mL^{-1})	6.5–50.2	7.0–44.5	6.5–56.5	6.5–35	7.0–37	6.5–45
Molar absorbitivity ($\times 10^4$ L mol^{-1} cm^{-1})	1.023	0.7145	0.6235	0.9062	0.9035	0.639
Sandell's sensitivity (ng cm^{-2})	42.6	51.8	70	48.1	41	67.9
Detection limits (μg mL^{-1})	0.07	0.065	0.105	0.114	0.068	0.034
Regression equation[a]						
Slope, *b*	0.0252	0.0213	0.0155	0.0191	0.023	0.0153
Intercept, *a*	−0.0323	−0.0364	−0.022	0.0243	0.0096	−0.0094
Correlation coefficient, *r*	0.9991	0.9982	0.9993	0.9991	0.9990	0.9995

[a] $A = a + bC$, where A is the absorbance, a the intercept, b the slope and C is the concentration of drug in μg mL^{-1}.

solution was completed to the mark with distilled water, and the container was shaken. One milliliter of this solution was used for color development with each reagent and extracted as reported under general procedure.

2.5. Determination of PiCl in Selgon drops

The contents of five bottles (Selgon drops, 40 mg PiCl mL^{-1}) were mixed and the average volume for one bottle was determined. An aliquot of the solution equivalent to 40 mg PiCl was quantitatively transferred to 50 mL measuring flask and made up to the mark with doubly distilled water. One milliliter of this solution was used for color development with each reagent and extracted as reported under general procedure.

3. Results and discussion

Several parameters such as acidity, type and amount of acid added, reagent concentration, sequence of addition and effect of extracting solvent were optimized to achieve high sensitivity, stability, low blank reading and reproducible results.

3.1. Effect of acidity

In a trial to elucidate the optimum medium for the quantitative determination of PiCl, DEX and DvCl, the effect of sulphuric, acetic and hydrochloric acids was examined. The highest absorbance value was obtained in the presence of 1.0 M HCl. It was found that on using 4 mL 1.0 M HCl in the case of PiCl or 3 mL 1.0 M HCl in the case of DEX and DvCl using C2B and C2R, respectively, maximum absorbance values and high stability were achieved.

3.2. Effect of the reagent concentration

The effect of reagent concentration was tested by using varying amounts 1–5 mL of 2×10^{-3} M solution of each reagent with 1 mL of 1×10^{-3} M of PiCl, DEX and DvCl. The results show that 3 mL of 2×10^{-3} M of C2B and C2R were sufficient for the production of maximum and reproducible color intensity as shown in (Fig. 2).

3.3. Effect of sequence of mixing

The most favorable sequence was reagent–drug–acid for the production of the highest color intensity and the shortest time for developing maximum absorbance, while the other sequences require longer time and produce lower absorbance values.

3.4. Effect of time and temperature

The effect of time on the formation and stability of the ion-associates was studied by measuring the absorbencies of the extracted ion-associates at increasing time intervals. The results show that the ion-associates were formed almost instantaneously in all cases at room temperature (25 + 2 °C). In the case of PiCl the developed color remained stable for 12 and 14 h using C2B and C2R, respectively. In the case of DEX, the developed color remained stable for 20 and 18 h using C2B

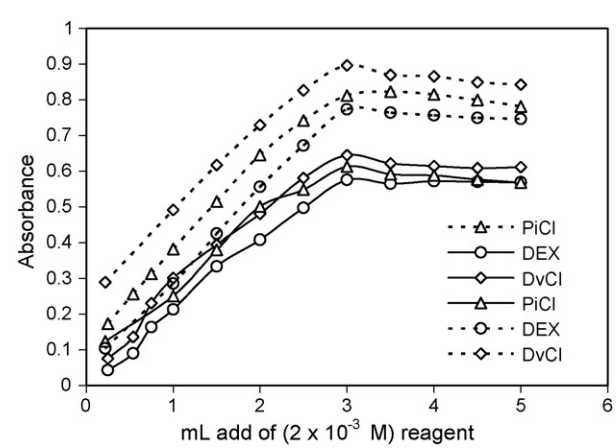

Fig. 2. Effect of reagent concentration on the formation of the colored ion-pairs for PiCl, DEX and DvCl using (2×10^{-3} M) C2R (—) and C2B (- - -) reagents.

and C2R, respectively. In the case of DvCl, the developed color remained stable for 14 and 16 h using C2B and C2R, respectively. After these intervals, a slight decrease in color intensity occurred.

3.5. Effect of extracting solvent

The polarity of the solvents affects both extraction efficiency and absorptivity of the ion associates. Several water-immiscible organic solvents including benzene, toluene, carbon tetrachloride, chloroform, methylene chloride, 1,2-dichloroethane, ether and nitrobenzene were tried. The most convenient solvent found to produce the highest absorbance, extraction power and stability of color of the formed ion-associates was chloroform for DEX or PiCl and methylene chloride for DvCl. The study revealed that a volume ratio of 1:1 (aqueous:organic) was the most suitable for the ion-associate extraction.

3.6. The stoichiometric ratio of the ion-associate

The stoichiometry of the ion-associates formed between the drugs under investigation and the reagents was investigated by applying the continuous variation attributable to Job and modified by Vosburgh and Coober [51] and the molar ratio [52] methods at the wavelengths of maximum absorbance. The results obtained show that the stoichiometric ratio of the ion-associates is 1:2 (reagent:drug) in all cases.

3.7. Analytical data

Beer's law was verified from 4.36–52.32 and 4.36–39.24 $\mu g\,mL^{-1}$ for PiCl, 3.7–48.15 and 3.7–40.74 $\mu g\,mL^{-1}$ for DEX and 4.34–60.76 and 4.34–47.74 $\mu g\,mL^{-1}$ for DvCl, respectively, with C2B and C2R, respectively. The molar absorbitivity (ε) was calculated and found to be 1.023×10^4,

Table 2
Evaluation of accuracy and precision of the proposed methods for determination of PiCl, DEX and DvCl with C2B and C2R reagents

Drug	C2B			C2R		
	Taken ($\mu g\,mL^{-1}$)	Found	Recovery (%)	Taken ($\mu g\,mL^{-1}$)	Found	Recovery (%)
PiCl-pure solution (μg)	10	9.995	99.95	10	10.02	100.20
	20	20.08	100.40	20	20.06	100.30
	30	29.805	99.35	25	24.983	99.93
	50	50.025	100.05	35	34.913	99.75
Mean recovery ± R.S.D.[a]		99.94 ± 0.437			100.05 ± 0.251	
Selgon tablets	10	9.954	99.54	10	10.04	100.4
	20	19.96	99.80	20	19.97	99.85
	30	30.25	100.83	25	24.93	99.72
	50	50.14	100.28	35	50.08	100.16
Mean recovery ± R.S.D.[a]		100.11 ± 0.567			100.03 ± 0.307	
Selgon drops	10	9.988	99.88	10	10.019	100.19
	20	20.03	100.15	20	19.986	99.83
	30	30.03	100.10	25	24.978	99.91
	50	50.135	100.27	35	34.63	98.95
Mean recovery ± R.S.D.[a]		100.10 ± 0.163			99.72 ± 0.538	
DEX-pure solution (μg)	10	10.07	100.70	10	9.952	99.52
	20	20.08	100.40	20	20.04	100.20
	30	29.92	99.73	30	30.03	100.10
	40	39.97	99.92	35	34.99	99.97
Mean recovery ± R.S.D.[a]		100.19 ± 0.442			99.95 ± 0.3	
Tussilr tablets	10	10.08	100.80	10	9.92	99.20
	20	19.82	99.10	20	20.12	100.60
	30	29.91	99.70	30	29.94	99.80
	40	39.84	99.60	35	35.109	100.31
Mean recovery ± R.S.D.[a]		99.80 ± 0.716			99.98 ± 0.615	
DvCl-pure solution (μg)	10	9.993	99.93	10	10.008	100.08
	20	19.89	99.45	20	20.20	101.00
	30	30.018	100.06	30	29.805	99.35
	40	40.136	100.34	40	39.936	99.84
Mean recovery ± R.S.D.[a]		99.95 ± 0.372			100.07 ± 0.692	
Do-Spa tablets	10	10.05	100.50	10	10.025	100.25
	20	19.872	99.36	20	20.164	100.82
	30	29.955	99.85	30	30.021	100.07
	40	39.988	99.97	40	39.964	99.91
Mean recovery ± R.S.D.[a]		99.92 ± 0.468			100.27 ± 0.397	

[a] Relative standard deviation for six determinations.

Table 3
Application of the proposed methods to the determination of PiCl, DEX and DvCl in dosage forms

Samples	Supplier, nominal value (mg)	Official methods	C2B	C2R
PiCl-pure solution	EIPICO, Egypt			
$X \pm$ S.D.		100.08 ± 1.06	99.83 ± 0.94	99.67 ± 1.13
t-Value (2.57)*			0.395	0.592
F-value (5.05)*			1.27	1.14
Tablets (Selgon)	20 mg			
$X \pm$ S.D.		99.70 ± 1.163	100.02 ± 1.24	100.13 ± 1.34
n			0.421	0.594
t-Value (2.57)*			1.14	1.33
F-value (5.05)*				
Drops (Selgon)	40 mg mL^{-1}			
$X \pm$ S.D.		100.50 ± 1.364	99.76 ± 1.186	99.94 ± 1.42
t-Value (2.57)*			0.916	0.636
F-value (5.05)*			1.32	1.084
t				
F				
DEX-pure solution	Kahira Pharm. & Chem. Ind. Company, Egypt			
$X \pm$ S.D.		99.53 ± 0.768	99.02 ± 0.681	100.07 ± 0.731
t-Value (2.57)*			1.109	1.139
F-value (5.05)*			1.272	1.104
Tussilar tablet	10 mg			
$X \pm$ S.D.		98.92 ± 0.852	99.45 ± 0.914	99.26 ± 0.827
t-Value (2.57)*			0.95	0.64
F-value (5.05)*			1.151	1.06
DvCl-pure solution	Alexandria Co. for Pharm. and Chem. Ind., Egypt			
$X \pm$ S.D.		99.22 ± 1.39	100.02 ± 1.12	99.85 ± 1.50
t-Value (2.57)*			1.002	0.69
F-value (5.05)*			1.54	1.165
Tablets (Do-Spa)	40 mg			
$X \pm$ S.D.		100.90 ± 1.425	100.25 ± 1.26	100.17 ± 1.38
t-Value (2.57)*			0.764	0.823
F-value (5.05)*			1.28	1.07

* Theoretical value at $P = 0.05$ at 95% level. Average of six determinations.

0.7145×10^4 and 0.6235×10^4 using C2B and 0.9062×10^4, 0.9035×10^4 and 0.639×10^4 using C2B for PiCl, DEX and DvCl, respectively. Sandell sensitivity (s) was also calculated and found to be 42.6, 51.8 and 70 ng cm^{-2} using C2B and 48.1, 41 and 67.9 ng cm^{-2} using C2R for PiCl, DEX and DvCl, respectively, indicating high sensitivity of the reagents under investigations for the determination of the above cited drugs. The regression equations ($A = a + bC$, where A is the absorbance, a the intercept, b the slope and C is the concentration in μg mL^{-1}), calculated from the calibration graph according to the Kaleidagraph, were evaluated and recorded in (Table 1). The intercept of the lines were very small indicating that there is no systematic difference between determined and expected concentration within the investigated range using the present methods. For more accurate results, Ringbom concentration range was determined by plotting log(drug) in μg mL^{-1} against $\%T$ from which the linear portion of the curve gave accurate range of the determination of the drugs under investigation (Table 1). In order to determine the accuracy and precision of the present methods, solutions containing five different concentrations of each drug were prepared and six replicate determinations, covering the usable concentration range, were carried out for the pure form and the pharmaceutical preparation of the drugs under investigation. The recovery values almost reach 100% recovery, revealing a high accuracy of the results (Table 2). The mean values obtained and the calculated standard deviations are compared with those obtained by the pharmacopoeial methods for PiCl and DEX [1 and 20] (based on potentiometric titration using 0.1 M sodium hydroxide) and for DvCl with the spectrophotometric method [38] by applying the *t*- and *F*-tests [53] (Table 3). Such comparison showed that there is no significant difference, at 95% confidence level, between the mean values or variances obtained by the proposed and the reference methods. This indicates the high accuracy and precision of the present methods.

3.8. Interference

A systematic quantitative study was undertaken by measuring the absorbance of solutions containing 1 mL of 1×10^{-3} M drug together with varying excess of different additives and excipients which may be present in the pharmaceutical preparations using the recommended methods of such reagents for PiCl, DEX and DvCl. No significant interference was observed from the excipients commonly used such as glucose, lactose,

fructose, starch and magnesium stereate. This shows that the method is applicable in the case of pharmaceutical preparations of the investigated drugs.

4. Conclusions

The proposed method for the estimation of PiCl, DEX and DvCl using chromotrope 2B and chromotrope 2R are advantageous over many of the reported methods due to its sensitivity, rapidity and good agreement with the pharmacopoeial methods. The high recovery percentage and low relative standard deviation reflect the high accuracy and precision of the proposed methods, moreover, the methods are easy, applicable to a wide range of concentration, beside being less time consuming and depend on simple reagents which are available, thus offering economic and acceptable methods for the routine determination of the cited drugs.

References

[1] J.E.F. Reynolds (Ed.), Martindale, The Extra Pharmacopoeia, 30th ed., Pharmaceutical Press, London, 1993, p. 8140.
[2] S.S. Zarapker, R.V. Rele, V.M. Shah, Indian Drugs 24 (1987) 445.
[3] S.S. Zarapker, R.V. Rele, V.J. Doshi, Indian Drugs 24 (1987) 560.
[4] R. El-Shiekh, F. Zahran, A.A.E. Gouda, Spectrochim. Acta Part A (2006) in press.
[5] H.D. Revanasiddappa, P.G. Ramappa, Indian Drugs 32 (1995) 73.
[6] H.D. Revanasiddappa, P.G. Ramappa, Indian Drugs 32 (1995) 534.
[7] Y.M. Issa, A.F. Shoukry, R.M. El-Nashar, J. Pharm. Biomed. Anal. 26 (2001) 379.
[8] N.T. Abdel-Ghani, A.F. Shoukry, R.M. E-Nashar, Analyst 126 (2001) 79.
[9] M.B. Melwanki, J. Seetharamappa, S.P. Masti, Anal. Sci. 17 (2001) 1121.
[10] United States Pharmacopoeia, 25th Review, The National Formulary, 19th Review, The United States Pharmacopoeia Convention, Rockville, MD (2002) p. 975.
[11] L.A. Shervington, Anal. Lett. 30 (1999) 927.
[12] B. Mistry, J. Leslie, N.E. Eddington, J. Pharm. Biomed. Anal. 16 (1998) 1041.
[13] Y.Q. Li, Z.X. Tian, W. Zhao, J.H. Zhu, Yaowu. Fenxi. Zazhi. 20 (2000) 97.
[14] M.L. Wilcox, J.T. Stewart, J. Pharm. Biomed. Anal. 23 (2000) 909.
[15] E.K. Bendriss, N. Markoglou, I.W. Wainer, J. Chromatogr. B: Biomed. Sci. Appl. 754 (2001) 209.
[16] V. Tantishaiyakul, C. Poeaknapo, P. Sribun, K. Sirisuppanon, J. Pharm. Biomed. Anal. 17 (1998) 237.
[17] S. Ajay, T. Piyush, Indian Drugs 36 (1999) 444.
[18] S. Gangwal, P. Trivedi, Indian Drugs 36 (1999) 568.
[19] M.S. Bratio, S.G. Kaskhedikar, S.C. Chaturvedi, Indian Drugs 36 (1999) 702.
[20] S.G. Ji, Y.F. Chai, Y.T. Wu, D.S. Liang, Z.M. Xu, X. Li, Yaowu. Fenxi. Zazhi. 18 (1998) 170.
[21] L. Suntornsuk, Electrophoresis 22 (2001) 139.
[22] M.R. Gomez, R.A. Olsina, L.D. Martinez, M.F. Silva, J. Pharm. Biomed. Anal. 30 (2002) 791.
[23] A.P. Argekar, S.V. Raj, S.U. Kapadia, Indian Drugs 35 (1998) 24.
[24] M. Statheropoulos, N. Tzamtzis, K. Mikedi, J. Chromatogr. B: Biomed. Sci. Appl. 706 (1998) 245.
[25] Y.J. Wu, Y.Y. Cheng, S. Zeng, M.M. Ma, J. Chromatogr. B: Analyt. Technol. Biomed. Life Sci. 784 (2003) 219.
[26] D.R. Jones, J.C. Gorski, M.A. Hamman, S.D. Hall, J. Chromatogr. B: Biomed. Sci. Appl. 678 (1996) 105.
[27] S.S. Vengurlekar, J. Heitkamp, F. McCush, P.R. Velagaleti, J.H. Brisson, S.L. Bramer, J. Pharm. Biomed. Anal. 23 (2000) 909.
[28] R.D. Bolden, S.H. Hoke, T.H. Eichhold, D.L. McCauley-Myers, K.R. Wehmeyer, J. Chromatogr. B: Analyt. Technol. Biomed. Life Sci. 772 (2002) 1.
[29] R.A. Sodhi, J.L. Chawlak, R.T. Sane, Indian Drugs 34 (1997) 433.
[30] D.M. DiGregorio, H.D. Harnett, J. Sherma, Acta. Chromatogr. 9 (1999) 72.
[31] Z. Meszaros, P. Szentmiklosi, G. Czibula, US Patent 3,337,539 (1967).
[32] J.K. Lalla, M.U. Shah, M.B. Jain, A.H. Sharma, J. Pharm. Biomed. Anal. 11 (1993) 385.
[33] O.O. Bolaji, C.O. Onyeji, F.O. Ogungbamila, F.A. Ogunbona, E.O. Ogunlana, J. Chromatogr. Biomed. Appl. 622 (1993) 93.
[34] E.H. Girgis, J. Pharm. Sci. 82 (1993) 503.
[35] J. Jezkova, J. Musilova, K. Vytras, Electroanalysis 9 (1997) 1433.
[36] K.U. Ushbaev, V.A. Katasov, Gyogyszereszer 22 (1978) 424.
[37] V.A. Knaub, V.A. Kartashov, Farmatsiya (Moscow) 38 (1989) 46.
[38] H.G. Daabees, Anal. Lett. 23 (2000) 639.
[39] J. Geher, E. Szabo, J. Pharm. Biomed. Anal. 6 (1988) 757.
[40] H. Ibrahim, Y.M. Isaa, H.M. Abu-Shawish, Anal. Lett. 38 (2005) 111.
[41] Y.M. Isaa, H. Ibrahim, H.M. Abu-Shawish, Microchim. Acta 150 (1) (2005) 47.
[42] M. Fulop, K. Kaloy, A. Toth, Magy Kem Foly 92 (1982) 468.
[43] S. Shibata, A. Uchiumi, S. Sasaki, K. Goto, Anal. Chim. Acta 44 (1969) 345.
[44] S.B. Dabhade, S.P. Sangal, Microchem. J. 14 (1969) 190.
[45] Y.M. Issa, A.S. Amin, Mikrochim. Acta 124 (1996) 203.
[46] A.S. Amin, Y.M. Issa, Anal. Lett. 30 (1997) 69.
[47] A.S. Amin, Y.M. Issa, Mikrochim. Acta 130 (1999) 173.
[48] N.T. Abdel-Ghani, A.F. Shoukry, Y.M. Issa, O.A. Wahdan, J. Pharma. Biomed. Anal. 28 (2002) 373.
[49] Y.M. Issa, A.S. Amin, Anal. Lett. 34 (2001) 1163.
[50] A.F. Shoukry, N.T. Abdel-Ghani, Y.M. Issa, O.A. Wahdan, Anal. Lett. 34 (2001) 1689.
[51] P. Job, Ann. Chim. 9 (1928) 133.
[52] J.H. Yoe, A.L. Jones, Ind. Eng. Chem. Anal. Edn. 16 (1944) 111.
[53] J.C. Miller, J.N. Miller, Statistics for Analytical Chemistry, Ellis Horwood, Chichester, 1993.