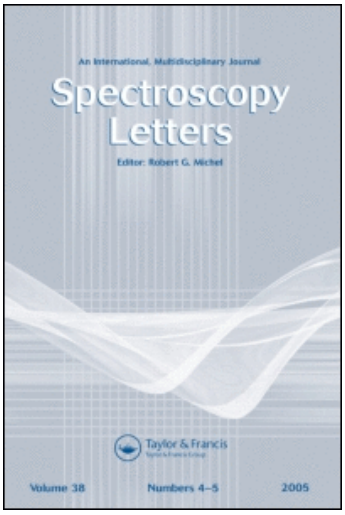

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Use of Cerium (IV) in the Spectrophotometric and Spectrofluorimetric Determinations of Penicillins and Cephalosporins in Their Pharmaceutical Preparations

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USE OF CERIUM (IV) IN THE SPECTROPHOTOMETRIC AND SPECTROFLUORIMETRIC DETERMINATIONS OF PENICILLINS AND CEPHALOSPORINS IN THEIR PHARMACEUTICAL PREPARATIONS

Keywords: Cerium (IV) and (III), Penicillins, Cephalosporins, Spectrophotometry, Spectrofluorimetry.

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ABSTRACT

Spectrophotometric and spectrofluorimetric procedures for the quantitative determination of four penicillins [Amoxycillin (AMX), Bacampicillin (BAC), Piperacillin (PPN) and Sultamcillin (SULT)] and ten cephalosporins [Cefadroxil (CDL), Cefamandole nafate (MAN), Cefuroxime axetil or sodium (CFX), Cefaclor (CFCR), Ceftazidime (CZD), Ceftizoxime (CTIZ),Ceftriaxone (CTRX), Cefoperazone (CPZ), Cefixime (CXIM) and Cefpodoxime proxetil (CFPD)] are described. Both methods are based on the acidic oxidation of the antibiotics with cerium (IV) at elevated temperature.

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The effect of the reagent concentration, volume of the acid,and the heating temperature were studied to optimize the reaction conditions. Each antibiotic was determined by either measuring the absorbance difference at 317 nm or the cerous inherent fluorescence at 256 and 356 nm for excitation and emission wavelengths, respectively. The two procedures have been successfully applied to the assay of these antibiotics in their pharmaceutical dosage forms. The obtained results have been statistically compared with those obtained by the official methods

INTRODUCTION

Penicillins and cephalosporins comprise a family of β-lactam antibiotics commonly used for the treatment of infections caused by Gram-negative and Gram-positive bacteria [1]. Analysis of these compounds according to the USP XXIII [2], BP 1993 [3] and European Pharmacopoeia 1997[4] requires the use of microbiologic, colorimetric, titrimetric or HPLC methods. Several methods have been reported for their quantitative measurements. These include spectrophotometry [5-10] fluorimetry [11-16] electrochemistry [17-19] titrimetry [20,21] and HPLC [22-27].

Cerium (IV) salts have been used as oxidizing agents in the spectrophotometric determination of pencillamine [28,29] trimeprazine [30] and promethazine[31] . Cerium (III) the reduction product of cerium (IV), has native fluorescence properties when irradiated with ultraviolet light. The fluorescence characteristics of cerium (III) have not, however, been widely applied to the determination of organic substances. The few methods found in the literature were confined to the direct fluorimetric determination of cerium (III)[32-35].

Due to the absence of chromophores and/or auxochromes in the penicillins and cephalosporins molecules, they showed no distinct absorption band in the ultraviolet range. Direct UV spectrophotometry is not the method of choice for their determinations. Consequently, the development of simple chemical procedures for their determination in pure and in pharmaceutical dosage forms is necessary.

The present study describes accurate, sensitive, more convenient, less time-consuming and economic spectrophotometric and spectrofluorimetric procedures for the determination of four penicillins and ten cephalosporins in their pharmaceutical

dosage forms. The two procedures are based on the acidic oxidation of the antibiotics with cerium (IV) at elevated temperature followed by measurement of the solution spectrophotometrically at 317 nm or fluorimetrically at 256 and 356 nm for the excitation and emission wavelengths, respectively. The results obtained by applying these procedures were compared with those obtained using the official methods.

EXPERIMENTAL

Apparatus

All absorption spectra were recorded with a Perkin-Elmer double-beam UV-VIS spectrophotometer Model 550S, attached to a Hitachi recorder Model 561, with a fixed slit width of 2 nm and using 1-cm quartz cuvettes. The fluorimetric measurements were performed on a Perkin-Elmer 650-10S fluorescence spectrophotometer equipped with 10-mm quartz cells, a 150-W xenon lamp, excitation and emission grating monochromators and Perkin-Elmer Model 56 recorder. The amplifier gain was adjusted according to the fluorescence intensity.

Materials and Reagents

Amoxycillin and cefadroxil were obtained from Pharco Pharm. Co. (Alexandria-Egypt), Bacampicillin from CID Chemical Co. (Giza-Egypt), Piperacillin and Cefixime from Lederle (England), Sultamicillin and Cefoperazone from Pfizer (USA), Cefaclor from Eli Lilly (Switzerland), Cefuroxime axetil or sodium and Ceftazidime from GLaxo-Wellcome (El Salam City-Egypt), Ceftriazone from Roche (Switzerland), Cefpodoxime proxetil from Roussel Uclaf (France) and Ceftizoxime from El Kahira Chem.Co. (Cairo-Egypt). All the above-mentioned antibiotics were used without further purification and were accompanied by certificates of analysis stating their biological potency. The standard solutions must be stored under light-protected conditions and at about 4°C .

Standard solution of cerium (IV) was prepared by dissolving about 633 mg ammonium cerium (IV) sulphate (Prolabo, Paris-France) in 1 liter of 1 M sulfuric acid to give a 1 X 10^{-3} M final concentration. Futher diluation was made with sulfuric acid to obtain a final concentration of 4 X 10^{-4} M .1M sulfuric acid (Ulbichem,

Hampshire-England) was prepared by diluting 56 ml of concentrated sulfuric acid to 1 liter with distilled water. Freshly double distilled water was used throughout the study.

Preparation of the standard solutions

An accurate weight of the powder of each antibiotic (expressed as anhydrous substance) was transferred into a 50-ml volumetric flask and diluted to volume with water. For cefixime and cefpodoxime the powder was first dissolved in 0.1 M sodium hydroxide,while for sultamicillin in 0.1 M hydrochloric acid, then diluation was made to volume with water in both cases. The standard solutions were freshly prepared and stored under light-protected conditions at about 4°C.

General procedure and constrution of calibration curve

An accurate volume of the standard solution of each antibiotic, corresponding to the linearity range stated in Table 1 was transferred into a series of 10-ml volumetric flasks. Then 1 ml 1 M sulfuric acid was added and diluted to volume with $4x10^{-4}$ M ammonium cerium (IV) sulfate. The flasks were kept in a boiling water bath for the specified time in Table 2, then cooled and the decrease in absorbance of each solution was measured at 317 nm. The fluorescence intensity at excitation and emission maxima 256 and 356 nm, respectively, was measured against a blank solution prepared similarly.

Assay of the pharmaceutical preparations

- ***For vials.*** The powder content of a vial was transferred into a 100-ml volumetric flask then dissolved in and diluted to volume with distiled water. Further dilutions were made and proceed as described under the construction of the calibration graphs.
- ***For tablets and capsules.*** Ten tablets or the powder content of ten capsules were weighed. A suitable weight of the powder was dissolved in 0.1 M sodium hydroxide (CXIM and CFPD), 0.1 M hydrochloric acid (SULT) or water (the other drugs) and diluted to volume with water (filter if necessary) and suitable aliquots were treated as described under the construction of the calibration graphs.

RESULTS AND DISCUSSION

In general, penicillins and cephalosprins are not fluorescent compounds and at the same time they are easily oxidisable species. Cerium (IV) is a non-fluorescent metal ion from the lanthanide series. In sulfuric acid medium, cerium (III) shows inherent

TABLE 1

Concentration range, relative sensitivity and detection limit for the spectrophotometric and spectrofluorimetric procedures.

Analyte	Spectrophotometric		Relative Sensitivity*	Spectrofluorimetric	
	Conc. Range ($\mu g\ ml^{-1}$)	Calculated Detection Limit		Conc. Range ($\mu g\ ml^{-1}$)	Calculated Detection Limit
AMX	1.5-2.9	2.86	9.93	0.146-0.256	2.88
BAC	3.3-4.7	2.57	7.18	0.279-0.466	3.58
PPN	3.1-7.2	13.22	14.69	0.310-0.722	9.00
SULT	1.5-4.5	8.96	12.14	0.178-0.446	7.38
CDL	0.9-1.5	1.39	6.81	0.087-0.145	1.23
MAN	1.2-2.7	3.11	16.99	0.116-0.194	1.83
CFX	1.0-2.4	4.26	12.31	0.102-0.306	1.92
CFCR	1.5-4.0	8.13	15.67	0.147-0.405	9.06
CZD	1.8-3.5	9.37	18.52	0.175-0.350	5.06
CTIZ	0.9-3.1	4.70	9.55	0.092-0.276	4.92
CTRX	0.9-1.7	1.50	7.35	0.066-0.155	2.04
CPZ	1.5-4.1	8.88	20.60	0.258-0.413	4.31
CXIM	0.9-2.7	3.53	21.01	0.109-0.254	1.68
CEPD	0.9-2.7	2.72	16.28	0.086-0.188	1.67

* Calculated relative to the fluorimetric procedure.

(NB) The calculated detection limits for the spectrophotometric and spectrofluorimetric procedures were multiplied by 10^2 and 10^3, respectively

TABLE 2

Optimum heating time in boiling water-bath.

Antibiotic	Time (min)	Antibiotic	Time (min)
Amoxycillin (AMX)	25	Cefoperazone (CPZ)	45
Bacampicillin (BAC)	15	Cefadroxil (CDL)	15
Piperacillin (PPN)	15	Cefuroxime (CFX)	35
Sultamicillin (SULT)	35	Cefaclor (CFCR)	25
Ceftazidime (CZD)	15	Cefamandole (MAN)	35
Ceftriaxone (CTRX)	45	Cefixime (CXIM)	15
Ceftizoxime (CTIZ)	45	Cefpodoxime (CFPD)	15

fluorescence. Because cerium (IV) is easily reduced to cerium (III), it seemed probable that this system would offer good methods for the spectrofluorimetric and indirect spectrophotometric determinations of penicillins and cephalosporins. The effect of cerium (IV) concentration, heating temperature,and time were investigated. An excess amount of cerium (IV),equivalent to almost double the amount of the oxidised drug was found suitable for oxidation. The optimum heating temperature and time for the oxidation of the antibiotics are stated in Table 2 and clearly illustrated in Figs 1&2 (a,b&c). It was found that boiling water-bath temperature with variable heating time (Table 2) in an acidified solution of cerium (IV) is sufficient for complete oxidation of the above mentioned antibiotics. It gave the highest absorbance differences at 317 nm or the highest relative fluorescence intensity. Figure 3 indicates that only cerium (IV) exhibits maximum absorbance at 317 nm while none of the assayed antibiotics or the cerium (III) moiety showed any absorbance in this region. The antibiotics when added in increasing amounts consumed more cerium (IV) with a corresponding fall in its concentration. This was observed as a proportional decrease in the absorbance of the reaction mixture. Therefore, the absorbance difference at 317 nm was used for the

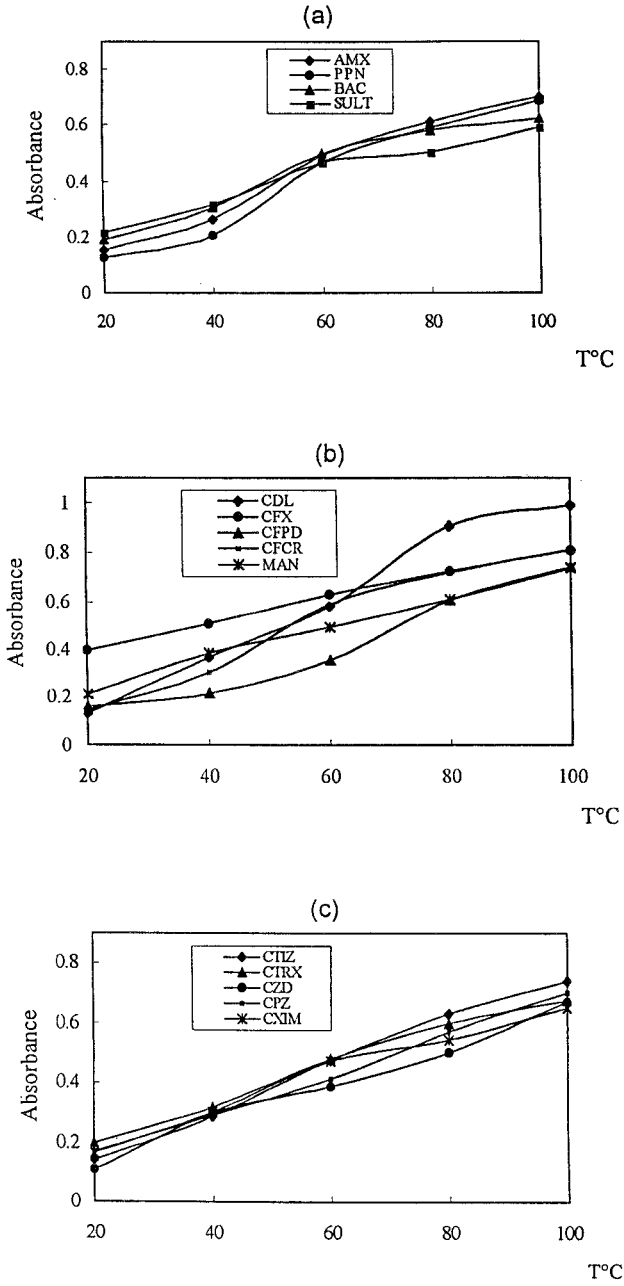

Fig. 1 Effect of temperature on the absorbance of different β-lactams in their determination using ammonium cerium (IV) sulfate.

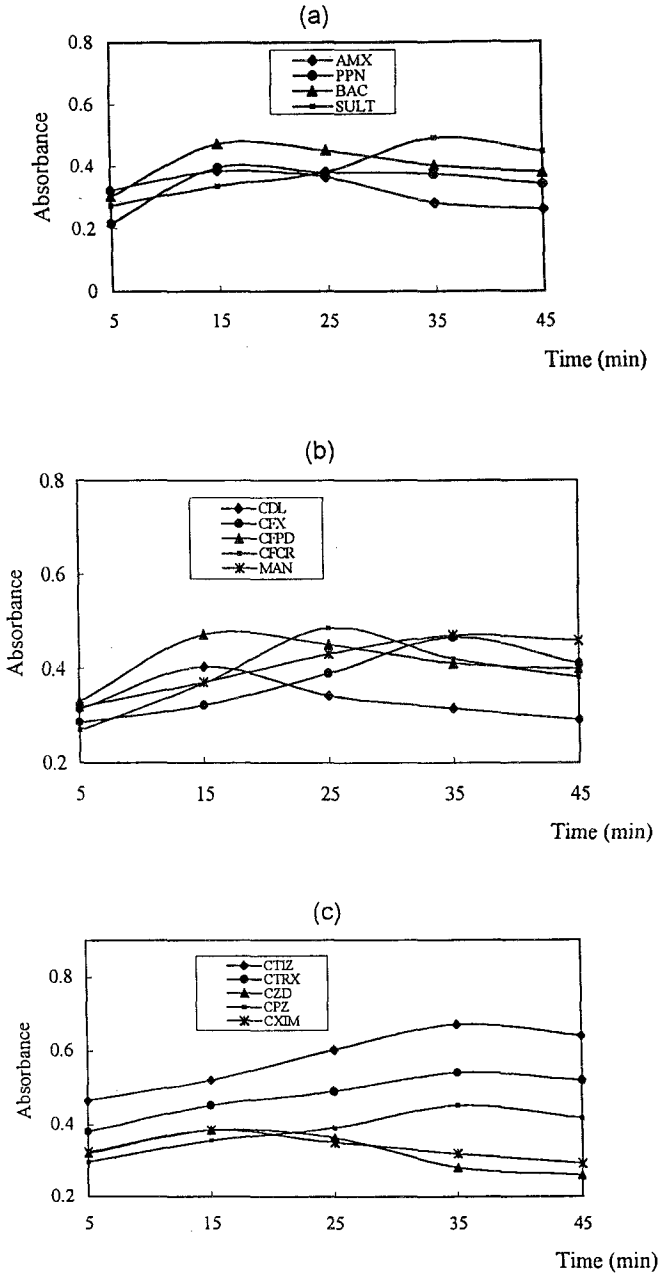

Fig. 2 Effect of heating time on the absorbance of different β-lactams in their determination using ammonium cerium (IV) sulfate.

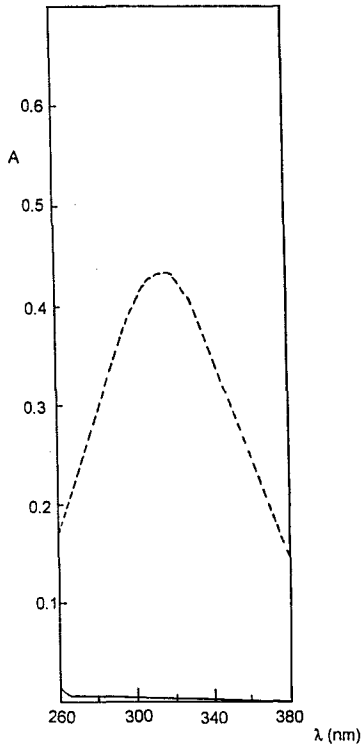

Fig. 3 Absorption spectra of 1.4 μg ml^{-1} CTRX reacted with cerium (IV) ammonium sulfate and 10 μg ml^{-1} cerium (III) in 1 M sulfuric.

spectrophotometric determination of these antibiotics. At the same time, while cerium (IV) concentration decreases, the generated cerium (III) ions were increased.

The resulting cerium (III) ion in dilute sulfuric acid medium has its excitation and emission maximum at 256 nm and 356 nm respectively (Fig.4). These wavelengths were used for the quantitation of the mentioned antibiotics spectrofluorimetrically.

The differential absorbance values at 317 nm or the relative fluorescence generated from the cerium (III) ions were plotted versus the increasing concentrations of the studied antibiotics to obtain the calibration graphs. Beer's law was obeyed, over the

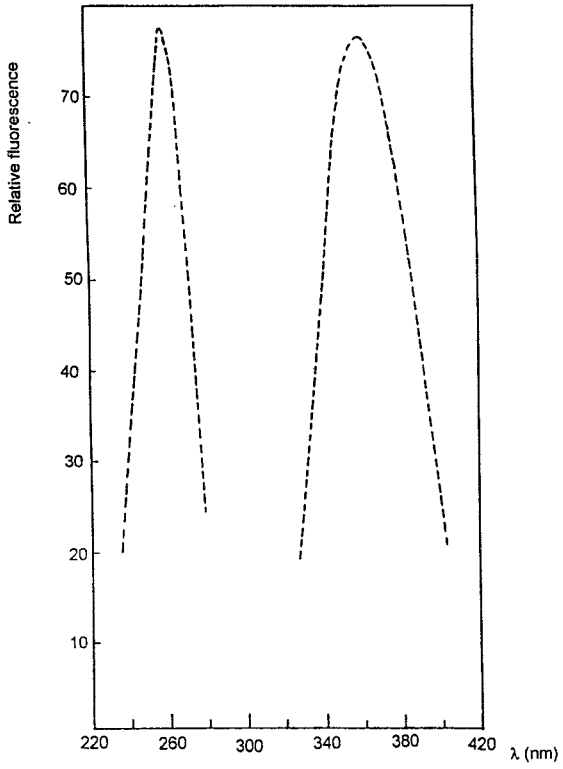

Fig. 4 Spectrofluorimetric properties of the product of 0.256 μg ml^{-1} AMX following its reaction with cerium (IV) ammonium sulfate.

concentration ranges stated in Table1 ,with excellent correlation coefficients. Linearity was also assessed by the RSD% of the slopes ($S_{b}rel\%$) [36] (Tables 3&4).

The linearity was better in the spectrofluorimetric procedures (Tables 3&4) than that of the spectrophotometric procedures. The values of the detection limits and the variances are evidence for the sensitivity of the procedures and the negligible scatter of the points with respect to the lines of regressions (Table 1,3&4).

In order to determine the precision of both procedures, solutions containing three different concentrations of the studied antibiotics were prepared and analyzed in five

TABLE 3

Comparative analytical data for the determination of the antibiotics spectrophotometrically.

Analyte	Slopes $b \pm tS_b$*	Intercept $a \pm tS_a$**	(r)***	(S_o^2)****	Linearity S_b rel (%)
AMX	0.196±4.82	0.079±1.03	0.9998	0.57	0.958
BAC	0.166±3.89	0.008±1.52	0.9998	0.33	0.898
PPN	0.115±4.68	0.014±2.36	0.9994	4.21	1.581
SULT	0.209±8.04	-0.002±2.39	0.9997	6.38	1.495
CDL	5.4E-4±0.15	5.4E-4±0.02	0.9994	0.80	1.202
MAN	0.318±2.89	0.048±1.49	0.9997	1.77	0.911
CFX	0.306±13.1	-0.010±2.16	0.9998	3.31	1.606
CFCR	0.208±0.09	0.034±0.02	0.9994	5.18	1.591
CZD	0.163±5.59	-2.2E-4±2.02	0.9996	4.25	1.331
CTIZ	0.286±7.42	-0.017±1.59	0.9997	3.27	1.009
CTRX	0.311±7.72	-0.016±1.03	0.9998	0.40	0.963
CPZ	0.218±8.57	0.188±2.47	0.9994	6.80	1.530
CXIM	0.304±7.87	0.010±1.57	0.9997	2.10	1.005
CFPD	0.333±6.72	-0.009±1.17	0.9998	1.49	0.785

* Confidence intervals of the slope ($p<0.05$).

** Confidence intervals of the intercept values ($p<0.05$).

*** (r) = Correlation coefficient

**** S_o^2 = Variance of the regression equation.

(NB) The values for tS_b, tS_a and S_o^2 are multiplied by 10^3, 10^2 and 10^5, respectively.

TABLE 4

Comparative analytical data for the determination of the antibiotics spectrofluorimetrically

Analyte	Slopes $b \pm tS_b^*$	Intercept $a \pm tS_a^{**}$	$(r)^{***}$	$(S_o^2)^{****}$	Linearity S_b rel (%)
AMX	210.21±6.84	0.03±1.39	0.9995	6.68	1.26
BAC	74.06±1.74	-0.11±0.64	0.9998	1.27	0.91
PPN	47.49±1.31	0.61±0.86	0.9998	3.32	1.07
SULT	75.40±2.61	0.05±0.86	0.9995	5.63	1.33
CDL	341.47±0.09	-0.08±1.07	0.9996	0.03	1.07
MAN	122.56±3.36	4.27±0.55	0.9997	0.91	1.15
CFX	122.15±0.01	0.42±0.03	1.0000	0.01	0.45
CFCR	73.64±3.16	0.13±0.88	0.9999	7.73	1.71
CZD	98.98±3.26	-6.37±0.87	0.9996	4.55	1.28
CTIZ	177.87±5.91	-1.86±1.14	0.9996	13.93	1.29
CTRX	113.28±3.28	0.10±0.39	0.9997	0.96	1.13
CPZ	109.86±3.75	0.95±1.27	0.9996	4.07	1.33
CXIM	161.29±2.39	-0.56±0.44	0.9995	1.34	0.58
CFPD	153.01±2.96	-0.35±0.41	0.9999	1.19	0.75

* Confidence intervals of the slope ($p<0.05$).

** Confidence intervals of the intercept values ($p<0.05$).

*** (r) = Correlation coefficient

**** S_o^2 = Variance of the regression equation.

TABLE 5

Evaluation of the accuracy and precision of the proposed spectrophotometric and fluorimetric procedures for the determination of the stated antibiotics .

	Spectrophotometric				Spectfofluorimetric			
	Added[a]	Found ± SD[b]	RSD(%)[c]	SAE[d] (X 10^4)	Added[a]	Found ± SD[b]	RSD(%)[c]	SAE[d] (X 10^4)
AMX	1.500	1.514±0.0014	0.92	6.26	0.1500	0.1498±0.1047	0.70	468
	2.000	0.001±0.0015	0.73	6.57	0.2000	0.2006±0.0534	0.27	239
	2.500	2.502±0.0019	0.81	7.11	0.2500	0.2500±0.1763	0.71	788
		Mean 0.0016	0.81	7.11		Mean 0.115	0.58	498
BAC	3.500	3.513±0.0015	0.42	6.48	0.300	0.3007±0.1255	0.42	561
	4.000	4.026±0.0021	0.53	9.53	0.350	0.3488±0.1627	0.47	726
	4.500	4.518±0.0026	0.58	1.18	0.400	0.3982±0.2927	0.74	1309
		Mean 0.0021	0.51	9.27		Mean 0.1935	0.54	865
PPN	4.000	4.009±0.0007	0.17	3.13	0.400	0.4011±0.1270	0.32	568
	5.000	5.012±0.0008	0.16	3.64	0.500	0.5014±0.1738	0.35	777
	6.500	5.993±0.0009	0.15	3.90	0.600	0.6006±02335	0.39	1044
		Mean 0.0008	0.16	3.56		Mean 0.1781	0.35	796
SULT	2.000	2.019±0.0012	0.59	5.37	0.200	2.0211±0.1137	0.57	508
	3.000	0.024±0.0013	0.30	4.04	0.300	0.2991±0.09818	0.31	411
	4.000	4.024±0.0019	0.32	5.68	0.400	4003±0.1903	0.48	851
		Mean 0.0011	0.40	5.03		Mean 0.1319	0.45	590
CDL	1.000	1.001±0.0004	0.38	1.69	0.0900	0.0903±0.1047	0.95	384
	1.200	1.203±0.0007	0.62	3.35	0.1100	0.1107±0.0534	0.86	428
	1.400	1.408±0.0009	0.65	4.11	0.1300	0.1303±0.1763	0.48	278
		Mean 0.0007	0.55	3.05		Mean 0.0812	0.76	363
MAN	1.500	1.501±0.0014	0.46	3.08	0.1200	0.1198±0.1075	0.90	481
	2.000	2.009±0.0015	0.54	4.83	0.1500	0.1498±0.1432	0.96	640
	2.500	2.509±0.0019	0.85	9.57	0.1800	0.1806±0.1161	0.64	519
		Mean 0.0013	0.62	5.83		Mean 0.1223	0.83	547
CFX	1.000	1.000±0.0005	0.51	2.29	0.1000	0.1007±0.0687	0.68	307
	1.500	1.501±0.0005	0.31	2.08	0.2000	0.2006±0.0766	0.38	343
	2.000	1.997±0.0007	0.33	0.98	0.3000	0.2500±0.10.6	0.35	463
		Mean 0.0006	0.39	2.45		Mean 0.0830	0.47	371
CFCR	1.500	1.501±0.0005	0.33	2.22	0.2000	0.2007±0.0879	0.44	393
	2.500	2.502±0.0005	0.21	2.40	0.3000	0.3007±0.0677	0.23	303
	3.500	3.496±0.0008	0.22	3.47	0.24000	0.3994±0.0688	0.17	308
		Mean 0.0006	0.26	2.70		Mean 00748	0.28	335
CZD	2.000	1.996±0.0016	0.78	6.98	0.2000	0.2001±0.0814	0.41	364
	3.500	3.006±0.0014	0.47	6.35	0.2500	0.2507±0.0495	0.20	221
	4.000	4.007±0.0016	0.40	7.25	0.3000	0.2997±0.0685	0.23	305
		Mean 0.0015	0.55	6.86		Mean 0.0664	0.28	297
CTIZ	1.000	1.005±0.0005	0.46	2.08	1.5000	0.1499±0.1036	0.69	463
	2.000	2.005±0.0007	0.34	3.02	2.0000	0.2010±0.0614	0.31	275
	3.000	3.004±0.0009	0.30	4.07	2.5000	0.2518±0.1448	0.58	648
		Mean 0.0007	0.37	3.00		Mean 0.1033	0.52	462

(continued)

TABLE 5. Continued.

CTRX	1.000	1.002±0.0002	0.21	9.26	0.08000	0.0804±0.0568	0.71	254
	1.400	1.400±0.0004	0.27	1.70	0.1000	0.1005±0.0321	0.38	169
	1.700	1.701±0.0003	0.19	1.41	0.1200	0.1204±0.0422	0.27	144
		Mean 0.0003	0.22	1.35		Mean 0.0422	0.45	189
CPZ	2.000	2.003±0.0009	0.44	3.92	0.3000	0.3006±0.0814	0.41	549
	3.500	3.007±0.0008	0.27	3.63	0.3500	0.3519±0.0495	0.51	804
	4.000	4.005±0.0013	0.33	5.90	0.4000	0.3986±0.0685	0.29	522
		Mean 0.0010	0.35	4.48		Mean 0.1398	0.40	625
CXIM	1.000	1.002±0.0004	0.41	1.83	1.5000	0.1505±0.1028	0.68	460
	1.500	1.508±0.0008	0.54	3.64	0.2000	0.1955±0.0472	0.24	221
	2.000	2.012±0.0008	0.40	3.59	0.2500	0.2513±0.1244	0.50	556
		Mean 0.0007	0.45	3.02		Mean 0.0915	0.47	409
CDPD	1.000	1.004±0.0005	0.50	2.25	0.1000	0.2001±0.0746	0.74	0.03
	1.500	1.497±0.0004	0.27	1.78	0.1200	0.1197±0.0766	0.64	0.03
	2.000	2.007±0.0007	0.34	3.08	0.1400	0.1405±0.1161	0.83	0.05
		Mean 0.0005	0.37	2.37		Mean 0.0891	0.73	0.04

a - Final concentratio in $\mu g\ m^{-1}$
b - Mean ± standard deviation of five determinations
c - RSD = Relaive standard deviation
d - SAE = Standard analytical error

replicates. Results, obtained from the investigations are summarized in Table 5. The standard deviation (SD), the relative standard deviation (RSD%),and the standard analytical error (SAE) can be considered very satisfactory.

In order to apply the suggested procedures to the analysis of pharmaceutical dosage forms, the influence of commonly used excipients and additives was investigated before the determination of the antibiotics in their dosage forms. No interference could be observed when including up to tenfold weight concentration of lactose, microcrystalline cellulose, talc, magnesium stearate, or starch in the original antibiotics containing powders. The proposed procedures were applied to the determination of the stated antibiotics in their pharmaceutical dosage forms (tablets, capsules and vials). The results shown in Table 6 elucidate acceptable correlations between the labelled values and the results obtained by the proposed procedures. The same batches of the antibiotics pharmaceutical products were analysed with the reference method. The results from both procedures and the reference method were compared statistically using Student's t- and Variance F-ratio tests. The calculated t and F values did not exceed the tabulated ones.

TABLE 6

Determination of the stated antibiotics in commercial dosage forms using the proposed procedures compared statistically with the reference method (USP XXIII)[2].

Antibiotic	Commercial Preparation	Recovery ±SD[a]		
		SPEC	USP	FLUO
AMX	Hiconcil cap	100.04±0.25 t[b] = 0.5059 F[c] = 1.44	100.12±0.30	100.34±0.20 t = 1.7391 F = 2.25
BAC	Penglobe tab	99.79±0.37 t = 0.2136 F = 1.2885	99.84±0.42	99.95±0.51 t = 0.341 F = 1.4745
PPN	Pipril vial	100.48±0.33 t = 0.2359 F = 2.7778	100.53±0.55	99.95±0.82 t = 1.1183 F = 2.2228
SULT	Unasyn tab	100.21±0.65 t = 0.1459 F = 1.2961	100.15±0.74	100.57±0.41 t = 1.6196 F = 3.2576
CDL	Duricef cap	100.09±0.24 t = 1.581 F = 2.25	99.85±0.36	99.53±0.46 t = 1.0998 F = 1.6327
MAN	Mandole vial	99.86±0.62 t = 0.918 F = 1.4633	99.50±0.75	99.60±0.63 t = 0.2510 F = 1.4172
CFX	Zinnat vial	99.77±0.35 t = 0.4065 F = 1.5625	99.86±0.28	99.99±0.53 t = 0.3978 F = 3.5829
CFCR	Ceclor cap	100.27±0.42 t = 0.4517 F = 1.3611	100.15±0.36	100.13±0.59 t = 0.0536 F = 2.6860
CZD	Fortum vial	100.01±0.21 t = 1.6563 F = 2.7778	100.23±0.35	99.60±0.50 t = 1.9921 F = 2.0408

(continued)

TABLE 6. Continued.

CTIZ	Cefizox vial	100.04±0.30 t = 1.0013 F = 1.2844	99.85±0.34	99.73±0.33 t = 0.5749 F = 1.0615
CTRX	Rocephin vial	99.87±0.30 t = 0.7378 F = 1.21	100.01±0.33	100.05±0.34 t = 0.186 F = 1.0615
CPZ	Cefobid vial	99.85±0.17 t = 1.767 F = 1.6747	100.04±0.22	100.43±0.30 t = 2.0553 F = 1.8595
CXIM	Suprax tab	100.09±0.32 t = 0.7905 F = 1.3061	99.93±0.28	100.17±0.34 t = 1.116 F = 1.4745
CFPD	Orelox tab	99.89±0.56 t = 0.1694 F = 1.3473	99.95±0.65	99.61±0.42 t = 1.2799 F = 2.3951

a - Mean ± standard deviation of five determinations.
b -Tabluated t-value for p = 0.05 and 8 degreesof freedom= 2.306 [37]
c - Tabluated F-value for p = 0.05 and $F_1 = F_2 = 4 = 6.39$

CONCLUSION

The described procedures are universal methods that can be applied for the spectrophotometric and spectrofluorimetric determinations of those substances which have a clear reducing character,i.e. substances with a standard oxidation potential (E°) less than 1.44 V in sulfuric acid. The proposed procedures can be successfully applied for the spectrophotometric and spectrofluorimetric determinations of the studied antibiotics either in pure form or in such pharmaceutical formulations in which the co-existing excipients probably do not show redox activity or affect the system studied. The proposed procedures represent simple and inexpensive methods for the determination of the antibiotics, in their pharmaceutical preparations showing high accuracy and precision as required for routine quality control.

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