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Analytical determination of donepezil hydrochloride in pharmaceutical formulations and urine samples

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ABSTRACT

Ion – associate complexes of Donepezil hydrochloride with [cadmium(II), cobalt(II) thiocyanate], sodium cobaltinitrite and ammonium reineckate were precipitated and the excess unreacted metal complex was determined. A new method was given for the determination of Donepezil drug in pure solutions, in pharmaceutical formulations and urine samples using atomic emission and atomic absorption spectrometry. The drug can be determined by the affort method in the range 0.83 - 91.50 μg mL^{-1}.

KEYWORDS

Atomic emission;
Atomic absorption;
Ion-associate complexes;
Pharmaceutical analysis.

INTRODUCTION

Donepezil hydrochloride; (DzCl) is a reversible inhibitor of the enzyme acetyl cholinesterase (AchE) approved for use in Alzheimer·s disease[1,2]. The pathogenesis of Alzheimer·s disease attributed some of them to a deficiency of cholinergic neurotransmission. Therefore, AChE inhibitors, which prevent the hydrolysis of acetylcholine, may exert their therapeutic effect by enhancing cholinergic function. The first AChE inhibitor (tacrine) has been used, however, associated with a high incidence of gastrointestinal (GI) side effects and hepatotoxicity[3]. Donepezil is a potent and more selective AChE inhibitor in the centeral nervous system with little effect on peripheral tissue, therefore, it has a lower incidence of GI and cardiovascular adverse effects[1]. The drug produces modest improvements in cognitive scores and has a long half-life allowing once daily dosing[4].

Donepezil is slowly absorbed from the GI tract. Its maximal plasma concentrations were reached within 3-4 hours. Its relative oral bioavailability is 100 % and food did not affect its absorption[5-10]. The starting dose of donepezil is 5 mg once daily in the evening. The higher dose may not provide a significant greater benefit, it may cause higher incidence of cholinergic adverse events[1]. Treatment with a dose of 10 mg should not be given until patients have been on a daily dose of 5 mg for 4-6 weeks. Adverse effects of donepezil include, diarrhea, nausea, vomiting, insomnia, muscle cramp, fatigue and anorexia which were often mild in intensity or transient and resolving during continued medication[1-3]. Donepizil is well tolerated in patients with mild hepatic impairment and moderately to severely impaired renal function[5]. Overdose can result in cholinergic crisis required atropine as an antidote.

Donepezil is a very important pharmaceutical compound. Therefore, we found it important to prepare new

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ion-associates containing this drug and to study and elucidate their chemical structures. Also the work present a new rapid method for the determination of this drug after transformation into the ion-associates.

The chemical name of Donepezil is 2-[(1- benzyl-4-piperidyl) methyl] -5, 6-dimethoxy-2, 3-dihydroinden-1-one hydrochloride. The chemical structure of Donepezil drug is shown in Figure 1.

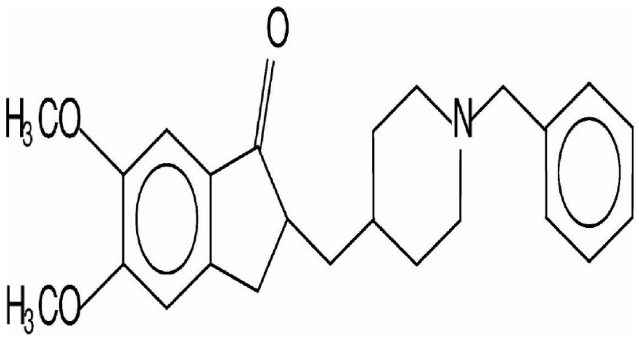

Figure 1 : Chemical structure of donepezil

In the literature HPLC, HPTLC, LC-MS and few Spectrophotometric methods for the determination of Donepezil in pharmaceutical formulations and biological matrix were reported[11-27].

The use of simpler, faster, less expensive and sensitive method is desirable.

Although, Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) and Atomic Absorption Spectrometry (AAS) are rapid methods and have a very low detection limits which can not be reached by most of other methods. The present study includes new ICP-AES and AAS methods for the determination of the investigated drug. The method is based on the precipitating the ion-associates formed as a result of the combination of this drug with an excess of $[Cd(SCN)_4]^{2-}$, $[Co(SCN)_4]^{2-}$, $[Co(NO_2)_6]^{3-}$ and $[Cr(NH_3)_2(SCN)_4]^{1-}$. The equilibrium concentration of the metal ion present as the soluble inorganic complex ion in the supernatant solution was determined using atomic emission and absorption.

MATERIALS AND METHODS

Doubly-distilled water and analytical grade reagents were used in the preparation of all solutions. Donepezil was obtained from Sigma Chemical Co. USA Alzil tablets containing (5 mg Donepezil hydrochloride / tablet) as pharmaceutical produuct of brand Intas Ltd., (Gujarat, India) and Aricept tablets containing (10 mg Donepezil hydrochloride / tablet)as a product of Eisai Co., Ltd (Japan) were purchased from local market.Cadmium(II) chloride, cobalt(II)chloride, potassium thiocyanate, sodium cobaltinitrite and ammonium reineckate were from BDH Chemicals (UK).

Apparatus

The pH of the solutions was measured using an Orion Research Model 701A digital pH-meter. Inductively coupled plasma atomic emission measurements were carried out using ICPE- 9000 Shimadzu plasma atomic emission spectrometer and atomic absorption measurements were made on AA-6650 Shimadzu atomic absorption spectrophotometer. Conductimetric measurements were carried out using conductivity measuring bridge type M.C.3 model EBB/10 (K_{cell} = 1); [Chertsey, Surry, England]. The IR absorption spectra were obtained by applying the KBr disk technique using a Pye Unicam SP – 300 infrared spectrometer.

Preparation of the standard solutions

Standard solutions of cadmium, chromium and cobalt were prepared by weighing 1.0 g of a high-purity sample (chromium shot,cadmium and cobalt metals, respectively), transferring it to a 1-liter measuring flask and then adding 50 ml of concentrated HNO_3. After complete dissolution, the solution was filled to the mark with distilled water. The 1000 µg mL-1 solution was stored in plastic bottles which had been presoaked in dilute HNO_3. The solutions were stable for approximately one year.

Emission and absorption measurements

Analytical Parameters for the Measurement of Cd,Cr and Co Using ICP-AES are listed in Table 1. Using AAS the Co (II) was measured at wavelength 240.7 nm, slit 0.2 nm, relative noise 1.0, sensitivity 0.018 µg $mL^{-1}$and linear range 1.0 µg mL^{-1}. The instruments were equally adequate for present purposes and were used according to availability. The atomic spectrometry was calibrated as in the previously reported work[28-30].

Determination of solubility of the ion – associates

The solid ion-associate was added in excess to a

TABLE 1 : Analytical parameters for the emission measurement of Cr, Cd and Co Using ICP-AES

Element	Wavelength (nm)	Order	Plasma position	DL (mg/L)	LDR (mg/L)	BEC (mg)	RSD x BEC (%)
Cr	267.71	84	0	0.01	0.1-1000	0.4	7 x 0.7
Cd	214.43	105	0	0.005	0.05-300	0.4	1 x 1.0
Co	236.37	95	0	0.02	0.2-1000	0.8	1 x 0.7

Note. DL, detection limit; LDR, linear dynamic range; BEC, background equivalent concentration; RSD, relative standard deviation. For all elements: state, ion; entrance slits, 50 x 300 µm; exit slits, 100 x 300 µm

TABLE 2 : Elemental analysis, composition and some physical properties of Donepezil ion - associates

Ion-associate composition	m. p. ^{0}c	Molar ratio	Color	% Found (calcula ted) C	H	N	Metal (Cd, Cr or Co)
$(C_{24}H_{29}NO_3)_2[Cd(SCN)_4]$	296	2 : 1	white	56.53 (56.56)	5.22 (5.26)	7.58 (7.61)	10.14 (10.19)
$(C_{24}H_{29}NO_3)_2[Co(SCN)_4]$	305	2 : 1	blue	59.39 (59.43)	5.47 (5.52)	7.96 (8.00)	5.57 (5.62)
$(C_{24}H_{29}NO_3)[Cr(NH_3)_2(SCN)_4]$	365	1 : 1	pink	48.14 (48.18)	4.96 (5.02)	14.01 (14.05)	7.42 (7.46)
$(C_{24}H_{29}NO_3)_3[Co(NO_2)_6]$	398	3 : 1	yellow	58.64 (58.59)	5.85 (5.90)	8.51 (8.55)	3.96 (4.00)

solution of the optimum pH and ionic strength. The solution was shaken for 4-6 h and left to stand for a weak to attain equilibrium. Then the saturated solution was filtered into a dry beaker (rejecting the first few ml of filtrate). The equilibrium concentration of the metal ion present in the form of a soluble inorganic complex was measured using atomic spectrometry. Hence, the solubility (S) of the precipitate was evaluated, from which the solubility product of the ion-associate was calculated.

Conductometric measurements

The stoichiometry of the ion-associates was elucidated also by conductometric titrations[31] of the drugs with $[Cd(SCN)_4]^{2-}$, $[Co(SCN)_4]^{2-}$, $[Co(NO_2)_6]^{3-}$ and $[Cr(NH_3)_2(SCN)_4]^{1-}$ solutions.

Analytical determination of donepezil in aqueous solutions

Aliquots (0.05 - 5.5 mL) of 0.001 mol L^{-1} drug solutions were quantitatively transferred to 25 mL volumetric flasks. To each flask 1.0 mL of 0.01 mol L^{-1} standard solution of $[Cd(SCN)_4]^{2-}$, $[Co(SCN)_4]^{2-}$, $[Co(NO_2)_6]^{3-}$ and $[Cr(NH_3)_2(SCN)_4]^{1-}$ was added and the volume was completed to the mark with the aqueous solutions of the optimum pH and ionic strength (prepared from HCl and NaOH). The solutions were shaken well and left to stand for 15 min then filtered through Whatman P/S paper (12.5 cm). The equilibrium metal ion concentration in the filtrate was determined using ICP-AES or AAS. The consumed metal ion (Cd, Cr or Co) in the formation of ion-associates was calculated, and the drug concentration was determined indirectly.

Analytical determination of donepezil in pharmaceutical preparations and urine samples

The Donepezil - containing pharmaceutical preparations (Alzil 5 mg and Aricept 10 mg tablets) were

TABLE 3 : Solubility and solubility product of Donepezil ion-associates at their optimum conditions of pH and ionic strength (µ) values ate 25° C

Dz- Ion – associate	pH	µ	p^s	pk_{sp}
$(C_{24}H_{29}NO_3)_2[Cd(SCN)_4]$	4.0	0.6	9.10	26.71
$(C_{24}H_{29}NO_3)_2[Co(SCN)_4]$	3.0	0.5	9.07	26.62
$(C_{24}H_{29}NO_3)[Cr(NH_3)_2(SCN)_4]$	5.0	0.4	10.44	20.88
$(C_{24}H_{29}NO_3)_3[Co(NO_2)_6]$	3.0	0.7	8.26	31.62

p_s : -log solubility; p^k_{sp} : -log solubility product

successfully assayed using the present method. Sampling were made by grinding (12 and 8 tablets), respectively then taking 1.25 - 85.25 and 3. 50 - 86.50 µg / ml of Alzil 5 mg and Aricept 10 mg tablets, respectively. Urine samples were obtained from 20 patients after 2 – 6 hours of taking dose. In all cases the tablets and urine samples were analyzed at the optimum condition solution applying the above described procedure.

RESULTS AND DISCUSSION

The results of elemental analysis (TABLE 2) of the produced solid ion associates reveal that two donepezilinium cations form ion associates with one $[Cd(SCN)_4]^{2-}$ or $[Co(SCN)_4]^{2-}$ and three $[Co(NO_2)_6]^{3-}$, while only one pethidinium cation combines with $[Cr(NH_3)_2(SCN)_4]^{1-}$ to form a 1:1 ion associate. These results are comparable to the previously reported results[32-34].

Conductometric titrations of the investigated inorganic complexes with Dz HCl were performed to give insight into the stoichiometric compositions of the ion-associates formed in solutions. In case of ion associates with $[Cd(SCN)_4]^{2-}$ or $[Cd(SCN)_4]^{2-}$, the charac-

TABLE 4 : Determination of Donepezil in aqueous solutions, pharmaceutical preparations and urine samples by ICP-AES and AAS

Sample	Amount taken (µg)	Mean recovery (%)	Mean RSD (%)
Using [$Cd(SCN)_4$]$^{2-*}$			
Pure Dz solution	0.83 - 91.50	98.91	0.6
Alzil tablets [a] (5 mg Dz / tablet)	1.25 - 85.25	98.92	0.5
Aricept tablets[b] (10 mg Dz / tablet)	3.50 - 86.50	98.93	0.7
Urine after 2 hs	18.56 - 58.25	98.94	0.6
Urine after 4 hs	35.25 - 66.50	98.95	0.5
Urine after 6 hs	6.15 - 19.75	98.96	0.4
Using [$Co(SCN)_4$]$^{2-**}$			
Pure Dz solution	0.83 - 91.50	99.95	0.8
Alzil tablets [a] (5 mg Dz / tablet)	1.25 - 85.25	99.96	0.7
Aricept tablets[b] (10 mg Dz / tablet)	3.50 - 86.50	99.97	0.6
Urine after 2 hs	18.56 - 58.25	99.93	0.8
Urine after 4 hs	35.25 - 66.50	99.96	0.7
Urine after 6 hs	6.15 - 19.75	99.95	0.5
Using [$Cr(NH_3)_2(SCN)_4$]$^{1-*}$			
Pure Dz solution	0.83 - 91.50	100.02	0.7
Alzil tablets [a] (5 mg Dz / tablet)	1.25 - 85.25	100.04	0.5
Aricept tablets[b] (10 mg Dz / tablet)	3.50 - 86.50	100.05	0.6
Urine after 2 hs	18.56 - 58.25	100.03	0.6
Urine after 4 hs	35.25 - 66.50	100.06	0.5
Urine after 6 hs	6.15 - 19.75	100.01	0.7
Using [$Co(NO_2)_6$]$^{3-*}$			
Pure Dz solution	0.83 - 91.50	99.94	0.6
Alzil tablets [a] (5 mg Dz / tablet)	1.25 - 85.25	99.95	0.5
Aricept tablets[b] (10 mg Dz / tablet)	3.50 - 86.50	99.93	0.9
Urine after 2 hs	18.56 - 58.25	99.92	0.8
Urine after 4 hs	35.25 - 66.50	99.96	0.7
Urine after 6 hs	6.15 - 19.75	99.96	0.7

RSD : Relative Standard Deviation (sex determinations) * By ICP-AES ** By AAS; [a] Brand Intas Pharmaceuticals Ltd., (Gujarat, India); [b] Eisai Co., Ltd., (Japan).

teristic curves break at a molecular ratio ($[Dz]/[x]^{n-}$) of about 2, confirming the formation of 2:1 ($Dz : x^{2-}$) ion associates but in the case of the reineckate anion where the curve exhibits a sharp break at the 1:1 molecular ratio and in the case of $[Co(NO_2)_6]^{3-}$ anion the curve exhibits a sharp break at the 3 :1 molecular ratio. The results obtained coincide with the elemental analysis of the precipitated ion- associates.

The optimum pH and ionic strength values (TABLE 3) have been elucidated by determining the solubility of the ion-associates in HCl-NaOH solutions of different pH values and ionic strengths. The best were those exhibiting lowest solubility values.

Analytical determination of donepezil in aqueous solutions, pharmaceutical preparations and urine samples

Donepezil HCl was determined precisely and accurately in aqueous solutions at their optimum conditions of pH and ionic strength (TABLE 4), in pharmaceutical preparations and urine samples using the present method. The results given in Table 4 reveal that recoveries were in the range 98.91 - 100.06 %, reflecting the high accuracy in addition to the high precision indicated by the very low values of the relative standard deviation.

Generally, the present method is as good as those reported before where, 0.83 - 91.50 μg mL^{-1} solutions of Donepezil using $[Cd(SCN)_4]^{2-}$, $[Co(SCN)_4]^{2-}$, $[Co(NO_2)_6]^{3-}$ and $[Cr(NH_3)_2(SCN)_4]^{1-}$ was determined, respectively, which means that this method is applicable over a wider concentration range than that of the previously reported Spectrophotometric methods[17, 25-27], where Donepezil was determined in the ranges 2 – 35, 2-14, 5-25 and 1-30 μg mL^{-1}, respectively and RP-HPLC method[21] in which Donepezil was determined in the range 50-150 μg mL^{-1}.

In pharmaceutical analysis it is important to test the selectivity toward the excipiences and the fillers added to the pharmaceutical preparations. Fortunately, such materials mostly do not interfere. It is clear from the results obtained for the pharmaceutical preparations (TABLE 4) that these excipiences do not interfere.

In order to establish whether the proposed method exhibits any fixed or proportional bias, a simple linear regression[35] of observed drug concentration against the theoretical values (five points) was calculated. The student's *t-test*[35] (at 95% confidence level) was applied to the slope of the regression line which showed that it did not differ significantly from the ideal value of unity. Hence, it can be concluded that there are no systematic differences between the determination and the true concentration over a wide range. The standard deviations (SD) can be considered satisfactory at least for the level of concentrations examined.

CONCLUSION

The present method is as good as those reported before where, 0.83 - 91.50 μg mL^{-1} solution of Donepezil using $[Cd(SCN)_4]^{2-}$, $[Co(SCN)_4]^{2-}$, $[Co(NO_2)_6]^{3-}$ and $[Cr(NH_3)_2(SCN)_4]^{1-}$ were determined, respectively, which means that this method is applicable over a wider concentration range than that of the previously reported Spectrophotometric methods[17,25-27], where Donepezil was determined in the ranges 2 – 35, 2-14, 5-25 and 1-30 μg mL^{-1}, respectively and RP-HPLC method[21] in which Donepezil was determined in the range 50-150 μg mL^{-1}.

Although the present method is more time consuming than some other methods, it exhibits fair sensitivity and accuracy. Moreover, the reproducibility of the results is superior to those obtained with other methods.

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