Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 159 (2016) 219–222

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

Stability-indicating methods for the analysis of ciprofloxacin in the presence of its acid induced degradation product: A comparative study

Khalid A.M. Attia [a], Mohammed W.I. Nassar [a], Mohamed B. El-Zeiny [b], Ahmed Serag [a,*]

[a] Pharmaceutical Analytical Chemistry Department, Faculty of Pharmacy, Al-Azhar University, 11751 Nasr City, Cairo, Egypt
[b] Analytical Chemistry Department, Faculty of Pharmacy, Modern University for Technology and Information (MTI), 12582 Al Hadaba Al Wosta, Cairo, Egypt

ARTICLE INFO

Article history:
Received 4 December 2015
Received in revised form 26 January 2016
Accepted 29 January 2016
Available online 4 February 2016

Keywords:
Ciprofloxacin
Stability-indicating
Ratio derivative
Ratio difference
Mean centering
Dual wavelength

ABSTRACT

Four rapid, simple, accurate and precise spectrophotometric methods were used for the determination of ciprofloxacin in the presence of its acidic degradation product. The methods under study are ratio derivative, ratio difference, mean centering and dual wavelength. All the methods were validated according to the ICH guidelines and the obtained accuracy, precision and repeatability were found to be within the acceptable limits. The selectivity of the proposed methods was tested using laboratory prepared mixtures and assessed by applying the standard addition technique. So, they can be used for the routine analysis of ciprofloxacin in quality-control laboratories.

1. Introduction

Ciprofloxacin (CIP), [1-cyclopropyl-6-fluoro-1, 4-dihydro-4-oxo-7-(piperazinyl)-quinolone-3-carboxylic acid] Fig. 1 is a widely used second generation fluoroquinolone, useful for the treatment of a number of bacterial infections. It has been used in the treatment of infections including anthrax, biliary-tract, bone, joint, ear, nose and throat infections. It is also used for urinary-tract infections including chronic bacterial prostatitis [1]. Several methods have been reported for the estimation of CIP in pharmaceutical and biological samples. These methods include spectrophotometry [2–7], spectrofluorimetry [8–10], HPLC with UV detection [11–13], HPLC with fluorescence detection [14,15], liquid chromatography/mass spectroscopy [16], capillary electrophoresis [17,18] and HPTLC [19]. In the present work a comparative study was done between four methods namely ratio derivative [20], ratio difference [21], mean centering [22] and dual wavelength [23] for the determination of CIP in the presence of its acidic degradation product listing the advantages and the disadvantages of these methods.

2. Experimental

2.1. Materials and Reagents

a) CIP (certified to contain 99.25%) was kindly supplied by Minapharm for pharmaceuticals, Cairo, Egypt.
b) Pharmaceutical Preparation: "Ciprobay® 250 mg tablets batch no. 051, manufactured by Bayer Pharmaceutical Company
c) Methanol; Analytical grade, El-NASR Pharmaceutical Chemicals Co., Egypt
d) Hydrochloric acid prepared as 2 N aqueous solution
e) Sodium hydroxide prepared as 2 N aqueous solution

2.2. Instruments

SHIMADZU dual beam UV–visible spectrophotometer (Kyoto/Japan), model UV-1800 connected to a compatible IBM and an HP1020 laser jet printer. The spectral band was 2 nm and scanning speed is 2800 nm/min with 1 nm interval.

2.3. Software

The bundled software, UV-Probe personal spectroscopy software version 2.43 (SHIMADZU) was used. Mean centering was done with our own written code in Matlab 8.2.0.701 (R2013b). The *t*-test and *F*-test were performed using Microsoft Excel. One way ANOVA test was performed using Graph Pad Prism version 5 (Graph Pad, San Diego, CA).

2.4. Standard Solutions

2.4.1. Preparation of CIP Standard Solution

A. CIP standard stock solutions; 200 μg/mL in methanol
B. CIP standard working solutions; 50 μg/mL in methanol

* Corresponding author.
E-mail address: Ahmedserag777@hotmail.com (A. Serag).

http://dx.doi.org/10.1016/j.saa.2016.01.056
1386-1425/

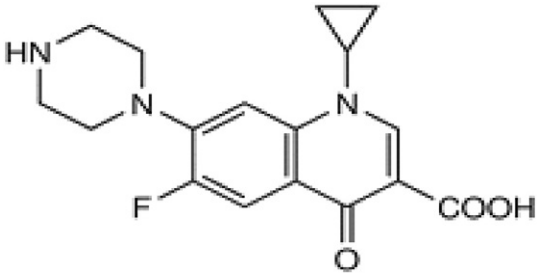

Fig. 1. Chemical structure of ciprofloxacin.

2.4.2. Preparation of the Degradation Product (DCIP)

20 mg of pure ciprofloxacin hydrochloride powder was transferred to a 100-mL flask to which 20 mL of 2 N HCl was added. The solution was heated under reflux for 48 h. After cooling, the solution was neutralized with 2 N sodium hydroxide and evaporated to dryness under vacuum. The obtained residue was extracted with methanol into a 100-mL volumetric flask and diluted to volume with methanol to obtain a stock solution labeled to contain degradate derived from 0.2 mg/mL of CIP [6]. Working solution of degradate (50 μg/mL) was obtained by further dilution of the stock solution with the same solvent. Aliquots of different concentrations of ciprofloxacin degradation product (DCIP) were accurately transferred into series of 10-mL volumetric flasks and the volumes were completed to the mark with methanol. These solutions were scanned in range 200–400 nm and stored in the computer.

3. Procedure

3.1. Linearity and Construction of Calibration Curves

3.1.1. Ratio Derivative Method

Aliquots from CIP working standard solution were accurately measured, transferred into a set of 10-mL volumetric flasks and completed to volume with methanol to give (1–10 μg/mL). The zero order absorption spectrum of each solution was recorded versus methanol as a blank, divided by the spectrum of DCIP (10 μg/mL) used as a divisor concentration. The first derivative corresponding to each ratio spectrum was recorded, using $\Delta\lambda = 8$ nm and scaling factor = 2. The amplitude values were measured at 276 nm and plotted against the corresponding concentrations in μg/mL of CIP.

3.1.2. Ratio Difference Method

The ratio spectra obtained as before. Then the amplitudes difference of the ratio spectra at 282 and 310 nm ($\Delta P_{282\text{-}310}$) were plotted against the corresponding concentrations in μg/mL of CIP.

3.1.3. Mean Centering (MC)

The ratio spectra obtained as before in the range of 220–350 nm were mean centered. The calibration curve was constructed by relating the values of the amplitudes at 282 nm to the corresponding concentrations of CIP.

3.1.4. Dual Wavelength Method

Zero order absorption spectra of CIP were obtained as in Section 3.1.1. The differences in the absorbance were measured at 275 and 342 nm. The calibration curve was constructed relating these differences to the corresponding concentrations of CIP.

3.2. Application to Laboratory Prepared Mixtures

Accurate aliquots of CIP and DCIP were transferred from their working solutions into a series of 10-mL volumetric flasks to prepare mixtures containing different ratios of both. The volumes were completed with methanol. The spectra of the prepared series from 200 to 400 nm were recorded and stored. The concentrations of CIP were calculated as described under linearity for each of the proposed methods.

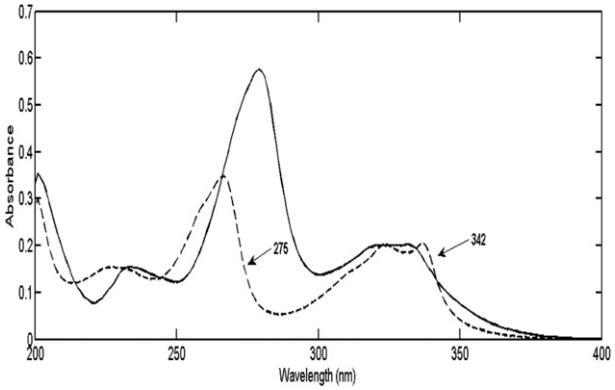

Fig. 2. Zero order spectra of (5 μg/mL) CIP (—) and (5 μg/mL) DCIP (.....).

3.3. Application to Pharmaceutical Preparation

Ten tablets were weighed and finely powdered. Appropriate weight of powder equivalent to 20 mg CIP was accurately transferred to 100-mL volumetric flask and the volume was made up to 75 mL with methanol. The solution was shaken vigorously for 15 min then sonicated for 30 min. The volume was completed to 100 mL with solvent then filtered through Whatman filter paper no. 41.

Necessary dilutions of the filtrate were made with methanol to obtain different concentrations of CIP samples as stated under linearity. To assess the accuracy of the proposed methods, standard addition technique was applied.

4. Results and Discussion

The zero-order absorption spectra of ciprofloxacin hydrochloride and its acidic degradate, as shown in Fig. 2, show severe overlap, which does not permit direct determination of ciprofloxacin hydrochloride in the presence of its degradate. To overcome this interference many manipulations have been done allowing the determination of CIP in the presence of its acidic degradation product.

4.1. Ratio Derivative Method

In this method, different divisors were examined and the divisor giving the best results was chosen (DCIP 10 μg/mL). The absorption spectra

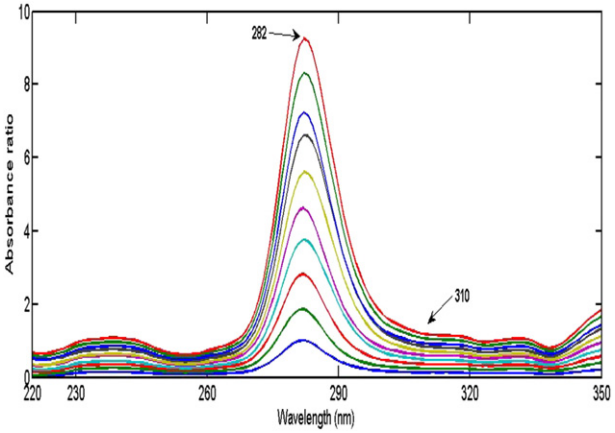

Fig. 3. Ratio spectra of CIP (1–10 μg/mL) using (10 μg/mL) of DCIP as a divisor.