SciMedCentral

Journal of Drug Design and Research

Review Article

Review article: Spectroscopic, Chromatographic and Electrochemical Analysis of Azithromycin in Different Matrices

Mahmoud M. Sebaiy*, Eslam M. Farouk, Eslam M. Lotfy, Eslam M. Mokhtar, Eslam N. Abd-Elgwad, Eslam Y. Hassan

Medicinal Chemistry Department, Faculty of Pharmacy, Zagazig University, Sharkia, 44519, Egypt

***Corresponding author**

Mahmoud M. Sebaiy, Medicinal Chemistry Department, Faculty of Pharmacy, Zagazig University, Sharkia, 44519, Egypt, Tel: +201062780060, Fax: +20552303266 E-mail: sebaiym@gmail.com, mmsebaiy@zu.edu.eg

Submitted: 23 May 2021

Accepted: 02 June 2021

Published: 04 June 2021

ISSN: 2379-089X

Keywords

- Literature review
- Antibiotic
- Azithromycin
- Degradation products
- Biological samples

Abstract

In this literature review, we are introducing most of up-to-date reported methods that have been developed for determination of an important antibiotic which is azithromycin in its pure form, combined form with other drugs, combined form with degradation products, and in biological samples.

INTRODUCTION

Antibiotics are specific chemical substances, originally produced by living organisms. Their structural analogs can be obtained through synthetic routes and are able to inhibit, even at low concentrations, vital processes of one or more species of bacteria. Nowadays, the main classes of commercially available antibiotics are penicillins, macrolides, cephalosporines (β-lactam antibiotics), tetracyclines, and aminoglycosides [1].

Azithromycin (AZM), chemically known as 9-deoxo-9a-aza-9a-methyl-9a-homoerythromycin is an antibiotic discovered by a Croatian group of researches, initially named XZ-450. It was developed by PLIVA, in the USA, and had its approval for clinical use in 1991 [2]. AZM is an acid stable orally administered macrolide antimicrobial drug, structurally related to erythromycin, with a similar spectrum of antimicrobial activity [3].

The drug is noted for its activity against some Gram-negative organisms associated with respiratory tract infections, particularly Haemophilus influenzae. AZM has similar activity to other macrolides against Streptococcus pneumoniae and Moraxella catarrhalis, and is active against atypical pathogens such as Legionella pneumophila, Chlamydia pneumoniae and Mycoplasma pneumoniae [4].

Due to the current importance of this drug in treatment of pandemic COVID-19, this literature focuses on its mode of action and different analytical methods that have been developed for determination of this drug in different pharmaceutical and biological samples.

Pharmacological action

AZM is a macrolide antibiotic which inhibits bacterial protein synthesis and reduces the formation of biofilm. Accumulating effectively in cells, particularly phagocytes, it is delivered in high concentrations to sites of infection, as reflected in rapid plasma clearance and extensive tissue distribution. AZM is indicated for respiratory, urogenital, dermal and other bacterial infections, and exerts immune-modulatory effects in chronic inflammatory disorders, including diffuse panbronchiolitis, post-transplant bronchiolitis and rosacea [5].

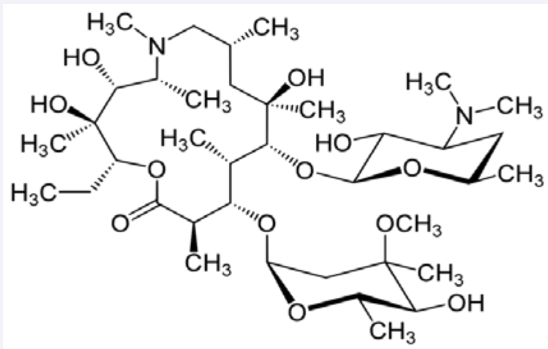

Figure 1 Chemical structure of AZM.

Cite this article: Sebaiy MM, Farouk EM, Lotfy EM, Mokhtar EM, Abd-Elgwad EN, et al. (2021) Review article: Spectroscopic, Chromatographic and Electrochemical Analysis of Azithromycin in Different Matrices. J Drug Des Res 8(2): 1084.

1. Spectroscopic methods:

1.1 Spectrophotometric methods:

Drugs	Matrix	Method or reagent	λ_{max} (nm)	Linearity range	LOD	Ref.
AZM	Tablets	Potassium Permanganate	547	2 - 20 µ	----------	[6]
AZM	Tablets	Ion pair complex with (Mo(V)–thiocyanate)	469	10^{-6} M - 10^{-5} M	2.54 x 10^{-7} M	[7]
AZM	Tablets	UV spectrophotometry	275	1 - 4 m	0.6490 m	[8]
AZM & Clarithromycin	Tablets and Human Plasma	Charge transfer reaction with p-chloranilic acid	530	5 - 50 μ^{-1}	1.2 µ	[9]
AZM		UV spectrophotometry	208	10 - 50 µ	1.6 µ	[10]
AZM		Charge transfer reaction with Quinalizarin	564	4 - 20 m	0.35 mg/L	[11]
AZM & Cefixime	Tablets	UV spectrophotometry	235	10 - 50 µ	1.67 µ	[12]
AZM & Cefpodoxime	Tablets	UV Simultaneous equation	218 & 232	10-50 µ	0.52 & 2.20 µ	[13]
AZM	Tablets	Protonation reaction with sulfuric acid	482	7.5 - 52.5 µ	----------	[14]
AZM	Niosomes	Protonation reaction with 75 % sulfuric acid	482	15 - 45 µ	----------	[15]
AZM	Tablets	Charge transfer complex with 2,4-Dinitrophenol	364	5 - 30 µ	----------	[16]
AZM & Roxithromycin	Tablets	Copper in acidic medium & N-bromosuccinimide	250 & 264	1 - 100 µ 2 - 140 µ	0.76 & 0.69 µ	[17]
AZM	Injections	Protonation reaction with 85 % sulfuric acid	482	20 - 70 m	----------	[18]
AZM	Tablets	Ion pair complex with bromocresol green (BCG), bromocresol purple (BCB), bromophenol blue (BPB), bromothymol blue (BTB)	418 & 409& 415& 414	2 - 20 & 2 - 18 & 2 - 12 & 2 - 14 µ	0.15 & 0.16 & 0.23 & 0.14 µ	[19]
AZM	Tablet	Charge transfer with Alizarin Red	538	10 - 60 µ.	----------	[20]
AZM	Crystals	Protonation reaction with sulfuric acid	483	18 - 72 µ	----------	[21]
AZM	Dispersible tablets	Protonation reaction with 75 % sulfuric acid	482	20 - 80 µ	----------	[22]
AZM & Erythromycin		Charge transfer complex with 1,2-naphthoquinone-4-sulphonate	452	1.5 - 33 µ	0.026 µ	[23]

1.2. Spectrofluorimetric methods:

Drugs	Matrix	Fluorogenic Reagent (Method)	λex (nm)	λem (nm)	Linearity Range	LOD	Ref.
AZM, erythromycin, clarithromycin & roxithromycin	Tablets, capsules and suspension	Cerium in the presence of sulphuric acid	255	348	47.7- 477 n	11.62 n	[24]
AZM	Tablets	9.0 mol L^{-1} HCl	482	515	1 - 8 mg/L	0.23 mg/L	[25]
AZM, erythromycin, clarithromycin & roxithromycin	Tablets, capsules, granules & suspension	Ion pair formation with eosin-G	480	550	0.04 - 2 µ	0.0114 µ	[26]
AZM, erythromycin, clarithromycin & roxithromycin	Tablets, capsules, granules, suspension,	10% (w/v) malonic acid + acetic anhydride	390	448	3 - 40 n	n	[27]
AZM	Tablets & live cells	N,S-CQDs	476	528	2.5–32.3 µM & 37.2–110 µM	0.76 µM	[28]

2. Chromatographic methods:

2.1. HPLC methods:

Drugs	Matrix	Column	Mobile Phase	Detector	Linearity Range	LOD	Ref.
AZM	Tablets	Xterra C_{18} column (150× 4.6 mm; 5µ)	Acetonitrile and phosphate buffer (50:50 v/v)	UV at 215 nm	300 - 700 µ	----------	[29]
AZM	Pharmaceutical dosage forms	C_{18} column (5 µm, 250 mm× 4.6 mm)	Isocratic methanol/buffer (90:10 v/v)	UV at 210 nm	1 - 80 µ	0.3 µ	[30]
AZM and Its Related Compounds	Pharmaceutical dosage forms	reversed-phase C_{18} column	Isocratic elution of phosphate buffer–methanol (20:80)	UV at 210 nm	0.3 - 2.0 m	0.0005 m	[31]

AZM	Pharmaceutical dosage forms	column ODS-3 (250 mm× 4.6 mm x 5 µm)	Methanol: Phosphate buffer (9:1 v/v)	PDA at 210 nm	0.5 - 1.5 m	28.7 µ	[32]
AZM	Tablets	C_{18} column	Mixture of buffer, acetonitrile and methanol (60:20:20)	Amperometric electrochemical detector with dual glass carbon electrodes + UV at 215 nm	0.6 - 3.0 m	----------	[33]
AZM	Oral suspension	Hypersil BDS-C_{18} column (250 mm × 4.6 mm)	Methanol, acetonitrile and phosphate buffer	PDA at 212 nm	1.0 - 50.0 µ	14.40 n	[34]
AZM	Injections, capsules and tablets	G1316 A column 250 mm × 4.6 mm, i.d., 5 µm)	Ammonium acetate (0.05 M, pH=8.0) and acetonitrile (60:40, v/v)	Evaporative light scattering detector (ELSD)	50.93 - 509.30 µ	6.75 µ	[35]
AZM	Tablet	C_8 column (250 mm X 4.6 mm, 5µ)	Phosphate buffer and methanol in the ratio of (20:80 v/v).	UV at 210 nm	10 - 80 ppm	52.246 µ	[36]
AZM	Tablets and Suspensions	XTerra column (250 mm × 4.6 mm i.d., 5 µm particle size)	acetonitrile- KH_2PO_4– tetrabutyl ammonium hydroxide -water (25:15:1:59 v/v/v/v)	UV at 215 nm	50% - 150%	0.02% (20 µg)	[37]
AZM, erythromycin & clarithromycin	fish muscles	Shodex A sahipak column	Acetonitrile and phosphate buffer in the ratio of 60:40 (v/v)	diode array detection at 210 nm	1.2 - 2.8 µ	----------	[38]
AZM, fluconazole & ornidazole	Pharmaceutical dosage forms	C_{18} column (4.6 x 250 mm, 5µ)	mixture of acetonitrile and phosphate buffer (50:50 % v/v)	UV at 210 nm	500 - 1000 µ	5.810 µ	[39]
AZM & Ambroxol Hydrochloride	Tablets	250 mm × 4.6 mm, 5 µm particle size, C_{18} (ODS) column	Methanol: acetonitrile: phosphate buffer in ratio of (50:20:30)	electrochemical, fluorescence, mass spectrometry and UV at 260 nm	25 - 125 µ	----------	[40]
AZM & Dexamethasone	EYE DROPS	GRACE ODS C_{18},(250 x 4.6 mm, 5 µm)	Methanol and 0.0335M Phosphate Buffer (pH 7.5) in the ratio of (80:20 v/v)	UV at 230 nm	0.1 - 12 µ	1.60 µ	[41]
AZM	Raw matrial (Analyte)	Quasar C_{18} (150 x 4.6 mm, 5 µm)	MeOH:Buffer (80:20), (Phosphate, pH 7.5, 0.03 M)	Amperometric electrochemical detection + UV at 210 nm	----------	----------	[42]
AZM	Pharmaceutical dosage forms	C_{18} column, (5µm,250mm× 4.6mm)	Methanol/buffer mobile phase at the ratio of (90:10)	UV at 215nm	1 - 80 µ	----------	[43]
AZM & Artemether	Suppositories	Luna C_8 EC 5mm, 150mm, 4.6 mm	80% methanol and 20% phosphate buffer 15 mM at pH 9.	UV at 210 nm	----------	0.015 g/L	[44]
AZM & Erythromycin	Human Urine	ODB RP_{18} column (250 ×4.6 nm, 5µm)	Acetonitrile –2-methyl-2-propanol– hydrogenphosphate buffer, pH 6.5, with 1.5% triethylamine (33:7: up to 100, v/v/v)	UV at 210 nm	0.25–15 µg/ mL	0.12	[45]
AZM & Cefixime	Tablets	Hypersil C_{18} column (250 mm, 4.6mm, 5µm)	Methanol: Buffer in ratio of (85:15)	PDA at 275 nm	20-80 µ	0.25 µ	[46]
AZM & Levofloxacin	Tablets	Waters symmetry shield Rp_{18} column, (250x4.6x5µ)	Di Potassium Hydrogen Phosphate (60%) and methanol (40%)	UV at 285 nm	50%- 150%	20.50 ppm	[47]
AZM & Cefpodoxime Proxetil	Pharmaceutical dosage forms	C_{18} (150×4.6 mm, 5 µm) column	Acetonitrile: Methanol: Phosphate buffer (40:40:20 v/v)	UV at 235 nm	10-50 µ	2.121 µ	[48]
AZM and Levofloxacin	Pharmaceutical dosage forms	Symmetry C_{18} 4.6×150mm, 5.0 µm	Ammonium acetate buffer pH 6 ±0.02 pH and methanol (30:70 %v/v)	UV at 262 nm	20 - 100µg	0.01 µg	[49]

AZM	Human plasma and urine	Shimpack CLC-C_{18} (250 4.6 mm, 5 mm)	0.01 M KH_2PO_4–ACN (58:42, v/v, final pH 7.5)	UV at 210 nm	0.1–15 m	0.03 m	[50]
AZM & Benzoyl Peroxide	Combined dosage form	Eclipse C_{18} column (Waters XTerra®, 4.6X250 mm, 5µ)	Potassium dihydrogen phosphate and acetonitrile (50:50)	UV-Visible detector and a photodiode array detector	1-5 µ	0.009 µ	[51]
AZM & Cefixime	Pharmaceutical dosage forms	An Agilant Zorbax C_8, 5 µ column having 150 x 4.6mm	Dipotassium Hydrogen Phosphate Buffer: methanol (60:40%v/v)	UV at 230 nm	250–750 µ	----------	[52]
AZM & Spiramycin	Tablets	reversed phase C_{18} ODB column (250×4.6 nm)	Acetonitrile –2-methyl-2-propanol–hydrogenphosphate buffer, pH 6.2, with 1.8% triethylamine (32:8: up to 100, v/v/v)	UV at 210 nm	0.004–4.8 mg/ mL	0.03%	[53]
AZM and its related compounds.	Capsules and suspension	Xterra RP C_{18} column	disodium hydrogen phosphate -methanol-acetonitrile-tetrahydrofuran (40.0 + 30.0 + 30.0 + 0.1, v/v/v/v).	UV at 215 nm	2-1800 µ	----------	[54]
AZM and Levofloxacin	Tablets	C_{18} column (250 mm x 4.6 mm, 5 µm)	Methanol: potassium dihydrogen phosphate buffer (60:40, v/v)	PDA at 279.6 nm	500-1500 µ	2.68 µ	[55]
AZM and Its Related Compounds	Tablets	Shim pack XR ODS, 75×3.0mm, 2.2 µm column	Mobile phase -A consisting 0.01 M dibasic sodium phosphate buffer and mobile phase -B consisting 750:250 (v/v) of acetonitrile and methanol	UV at 210 nm	----------	----------	[56]
AZM	Human Plasma	Shimadzu Shim-pack VP-ODS C_{18} (5 µm, 150 mm × 2.0 mm) column	acetonitrile–water (65:35) (0.5% triethylamine, pH was adjusted to 6.2 with acetic acid)	MS-MS/ESI	5 - 2000 n	2 n	[57]
AZM	-	reversible phase C_8 column (250 × 4.6 mm, 5µ)	Dipotassium hydrogen Phosphate and acetonitrile in the ratio of 65:35	UV at 200 nm	----------	----------	[58]
AZM & cefixime	Pharmaceutical dosage form	Supleco C_{18} (25cm×4.6 mm, 5 µm) column	Na_2HPO_4: Methanol with pH adjusted to 8	U.V at 273 nm	50-150 µ	3 µg /mL	[59]
AZM & Ambroxol Hydrochloride	Combined dosage form	C_{18} phenomenex Gemini (5m, 250cm x 4.6mm)	Acetonitrile and mono basic potassium phosphate buffer of pH 8.5 in the ratio of 65:35 v/v	PDA at 220 nm	96-145 m	31.91 m	[60]
AZM & related compounds	Capsule and suspension	Xterra RP C_{18} column	Disodium hydrogen phosphate (pH 10.5) : methanol : acetonitrile tetrahydrofuran (40: 30.:30 :0.1, v/v/v/v).	UV at 215 nm.	2-1800 µg /mL	0.49 µg / mL	[61]
AZM & Cefpodoxime	Tablets	Hypurity C_{18} column	methanol: Toluene: potassium dihydrogen phosphate buffer (60:30:10, v/v/v)	UV at 218 nm	1-6 µg / mL	0.250 µ	[62]

2.2. HPTLC methods:

Drugs	Matrix	Stationary phase	Mobile phase	Detector	Linearity range	LOD	Ref.
AZM	Pharmaceutical dosage form	Silica gel F254	chloroform-ethanol-ammonia 6:14:0.2 (v/v)	fluorescence indicator at 483nm	0.08 - 1.2 µg/ zone	40 ng/ zone	[63]
AZM & cefixime	Pure compound	silica gel 60F254	mixture of ethyl acetate–methanol–acetone–toluene–ammonia (1:5:7:0.5:0.5, v/v)	UV at 235 nm	50- 250 ng/ band	3.25 ng/ band	[64]
AZM ,Chloroquine, & Paracetamol	Pharmaceutical dosage form	60 F silica gel plate	Mixture of methanol-25% ammonia (100:1.5, v/v)	UV at 254 nm	0.1 – 10 m	----------	[65]

3. Electrochemical methods:					
Drugs	**Matrix**	**Electrode**	**Linearity range**	**LOD**	Ref.
AZM	Tablets & capsules	Glassy carbon	1-15 µ	0.7 µ	[66]
AZM	Capsules	carbon paste	1.57–6.28 ppb 1.57–4.71 ppb 0.785–4.71 ppb 0.471–7.07 ppb	1.544 ppb 0.955 ppb 0.716 ppb 0.463 ppb	[67]
AZM	Capsules & Suspension	Glassy Carbon	1 – 10 µg/mL 0.25 – 2 µg/mL	0.29 µg/mL 0.11 µg/mL	[68]
AZM	Capsules & Urine sample	multi wall carbon nanotubes	0.25–4.0 µg/mL 4.0–10.0 µg/mL	0.07 µg/mL	[69]
AZM	Tablets	Modified carbon paste	1.0×10^{-7} mol/L _ 2.0×10^{-6} mol/L 2.0×10^{-6} mol/L _ 2.0×10^{-5} mol/L	1.1×10^{-8} mol/L	[70]
AZM	Tablets	graphene and ionic liquid composite film	0.49–28.57 µg/mL	0.19 µg/mL	[71]
AZM, Clarithromycin, Roxithromycin	Capsules, Tablets & Urine	renewable silver-Amalgam film	4.81-23.3 µg/mL 1.96-28.6 µg/mL 1.48-25.9 µg/mL	1.544 µg/mL	[72]
AZM	Tablets	glassy carbon	1.0–10.0 mg/L	0.76 mg/L	[73]
AZM & Hydroxychloroquine	Plasma, Tablets & capsules	diamond	0.28 – 30 × 10^{-8} M- 0.84 – 22.5 × 10^{-8} M	0.091 × 10^{-8} M 0.277 × 10^{-8}M	[74]
AZM	Tablets	multilayer film-modified	0.0038 - 62.5 µM	1.27 nM	[75]
AZM	Blood serum	A gold nano urchins/ graphene oxide modified glassy carbon	0.3 - 920.0 nM	0.1 nM	[76]
AZM	Capsules	gold	-----------	3.002×10^{-9} mol/L	[77]
AZM	Urine, Plasma & Tears	Glassy carbon	13.33×10^{-3} - 66.66×10^{-3} µg/mL	0.85×10^{-3} µg/ mL	[78]
AZM	Capsules & Urine	Glassy carbon	0.1 - 10 µM	0.07 - µM	[79]
AZM	Urine & plasma	Modified carbon paste	1.0×10^{-10} _ 4.0×10^{-7} mol/L	2.3×10^{-11} mol/L	[80]
AZM	Pharmaceutical dosage form	Glassy carbon	3.0×10^{-7} - 2.5×10^{-5} mol/L	1.0×10^{-7} mol/L	[81]
AZM, Erythromycin ethylsuccinate, Clarithromycin & Roxithromycin	Capsules & Tablets	Modified carbon paste	0.000471 – 0.00707 µg/mL	0.000463 µg/mL	[82]
AZM	Pharmaceutical dosage form	Screen printed carbon	0.5 - 10.0 µM	0.08 µM	[83]
AZM	Raw material	Glassy carbon	0.075 – 0.675 mg/cm3	0.044 mg/cm3	[84]
AZM	Plasma	Glassy carbon	0.5-3.5 µg/mL	0.2 µgmL	[85]
AZM	Wastewater	Surface of screen-printed carbon	----------	0.08 µM	[86]
AZM	Tablets & Capsules	Coated graphite	1×10^{-2} _5×10^{-7} M 1×10^{-2}_5×10^{-6} M 1×10^{-2}_6×10^{-7} M 1×10^{-2}_2×10^{-6} M	2×10^{-7} M 2×10^{-6} M 5×10^{-7} M 7×10^{-7} M	[87]
AZM, Ciprofloxacin & 5-aminosalicylic acid	Tablets & Capsules	Paraffin impregnated graphite	----------	----------	[88]
AZM, Tetracycline, levomycitin & Streptomycin	Tablets, Capsules, Eye drops, Injectable solution, Urine, Tissue & Blood	Glassy carbon	3.4×10^{-10} _ 1.0×10^{-5} mol/L	----------	[89]
AZM	Raw material	Calomel /Copper /Platinum	----------	----------	[90]
AZM	Pharmaceutical dosage form	Mercury film/ Glassy carbon	0.01_0. 5 x 10^{-6} mole/L	----------	[91]
AZM	Tablets	Glassy carbon	0.235 - 0.588 mg/cm3	----------	[92]
AZM	Raw material	Glassy carbon	1 - 5 mM	----------	[93]

Review of analytical methods

Various techniques were used for the analysis of AZM in pure forms, in their pharmaceutical formulations and in biological fluids. The available reported methods in the literature can be summarized as follows:

CONCLUSION

This literature review represents an up to date survey about all reported methods that have been developed for determination of Azithromycin in its pure form, combined form with other drugs, combined form with degradation products, and in biological samples such as liquid chromatography, spectrophotometry, spectroflourimetry, electrochemistry, etc.

REFERENCES

1. Robaina NF, de Paula CER, Brum DM, de la Guardia M, Garrigues S et al. Novel approach for the determination of azithromycin in pharmaceutical formulations by Fourier transform infrared spectroscopy in film-through transmission mode. Microchem J. 2013; 110: 301-307.
2. Abdullah JH, Yahya TAA, Alkaf AG, Alghorafi MA and Yassin SH. Selective spectrophotometric methods for the determination of azithromycin in pharmaceutical formulation. J Chem Pharm Res. 2014; 6: 202-208.
3. Peters DH, Friedel HA, McTavish D. Azithromycin. A review of its antimicrobial activity, pharmacokinetic properties and clinical efficacy. Drugs. 1992; 44: 750-799.
4. Dunn CJ and Barradell LB. Azithromycin. A review of its pharmacological properties and use as 3-day therapy in respiratory tract infections. Drugs. 1996; 51: 483-505.
5. Parnham MJ, Haber VE, Giamarellos-Bourboulis EJ, Perletti G, Verleden GM. Azithromycin: mechanisms of action and their relevance for clinical applications. Pharmaco& ther. 2014; 143: 225-245.
6. Jayanna BK, Nagendrappa G, Arunkumar NG, Gowda N. Spectrophotometric estimation of azithromycin in tablets. Indian J Pharm Sci. 2012; 74: 365.
7. Rachidi M, Elharti J, Digua K, Cherrah Y, Bouklouze A. New spectrophotometric method for azithromycin determination. Anal Lett. 2006; 39, 1917-1926.
8. Suma B, Thachemperil JM, Venkataramana C. Spectrophotometric method development and validation of azithromycin in tablet formulation. J Dent Orofac Res. 2018. 14: 23-27.
9. El-Adl SM, El-sadek ME, Hassan MH. Spectrophotometric Analysis of Azithromycin and Clarithromycin in Tablets and Human Plasma Using p-Chloranilic Acid. Analytical Chemistry Letters. 2019; 9: 362-372.
10. Bhimani S, Sanghvi G, Pethani T, Dave G, Airao V, et al. Development of the UV spectrophotometric method of azithromycin in API and stress degradation studies. ILCPA. 2016; 68, 49.
11. Paula CERD, Almeida VG, Cassella RJ. Novel spectrophotometric method for the determination of azithromycin in pharmaceutical formulations based on its charge transfer reaction with quinalizarin. J Braz Chem Soc. 2010; 21: 1664-1671.
12. Nyola N, Jeyabalan GS. Simultaneous estimation of Azithromycin and Cefixime in Active Pharmaceutical Ingredients and Pharmaceutical dosage forms by Spectrophotometry. Hygeia. journal for drugs and medicines. 2013; 4: 27-32.
13. Hinge MA, Bhavsar MM, Singh RD, Chavda RN, Patel ES et al. Spectrophotometric and High Performance Liquid Chromatographic Determination of CefpodoximeProxetil and Azithromycin Dihydrate in Pharmaceutical formulation. Pharm Methods. 2016; 7: 8-16.
14. Su-ying MA. Determination of the contents of azithromycin tablets with UV spectrophotometry. J Pediatr Pharmacol Ther. 2007; 4: 53-58.
15. Zhong, WHTQY, Jing-Qing MLHZ. Determination of Drug in Azithromycin Niosomes by Spectrophotometry. Chinese Journal of Spectroscopy Laboratory. 2011.
16. LIU HJ, JIANG Y, XUE N, HAO XH. Spectrophotometric Determination of Azithromycin Basedon Charge-transfer Reaction with 2, 4-Dinitrophenol. Chinese J Pharm Ana. 2005; 25: 308-310.
17. Ibrahim FA, Wahba MEK, Galal GM. Two spectrophotometric methods for the determination of azithromycin and roxithromycin in pharmaceutical preparations. Eur J Chem. 2017; 8: 203-210.
18. WANG JR, LI X, YANG XP. Determination the content of Azithromycin Injection by spectrophotometry. PJCPLA. 2004; 5: 385-386.
19. Abdullah JH, Yahya TAA, Alkaf AG, Alghorafi MA, Yassin SH. Selective spectrophotometric methods for the determination of azithromycin in pharmaceutical formulation. J Chem Pharm Res. 2014; 6: 202-208.
20. Jiang Y, Liu HJ, Xue N, Hao XH. Determination of Azithromycin Tablets by Spectrophotometry Based on Charge-transfer Reaction with Alizarin Red. Chin J Pharm. 2005; 36: 498.
21. HUANG XQ, ZHANG L, XIONG J, YING HJ. Spectrophotometry determination of the contents of azithromycin crystal. Chinese J Pharm Ana. 2009; 4: 672-675.
22. Wan-hong HAO. Determination of the Content of Azithromycin dispersible tablets by Spectrophotometry. Strait Pharmaceutical Journal. 2006; 4: 90-91.
23. Ashour S, Bayram R. Novel spectrophotometric method for determination of some macrolide antibiotics in pharmaceutical formulations using 1, 2-naphthoquinone-4-sulphonate. Spectrochimica Acta A Mol Biomol Spectrosc. 2012; 99: 74-80.
24. Khashaba PY. Spectrofluorimetric analysis of certain macrolide antibiotics in bulk and pharmaceutical formulations. J Pharm Biomed Ana. 2002; 27: 923-932.
25. Almeida VG, Braga VS, Pacheco WF, Cassella RJ. Fluorescence determination of azithromycin in pharmaceutical formulations by using the synchronous scanning approach after its acid derivatization. J Fluoresc. 2013; 23: 31-39.
26. Abdelmageed OH, Kashaba PY, Darwish IA. Spectrofluorimetric determination of macrolide antibiotics using eosin-G dye. Bulletin of Pharmaceutical Sciences. Assiut. 2006; 29: 338-409.
27. El-Rabbat N, Askal HF, Khashaba PY, Attia NN. A validated spectrofluorometric assay for the determination of certain macrolide antibiotics in pharmaceutical formulations and spiked biological fluids. J AOAC Int. 2006; 89: 1276-1287.
28. Guo X, Liu Y, Dong W Hu Q, Li Y, Shuang S. Azithromycin detection in cells and tablets by N, S co-doped carbon quantum dots. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2021; 252: 119506.
29. Dewan I, Amin T, Hossain MF, Hasan M, Chowdhury SF. Development and validation of a new HPLC method for the estimation of azithromycin in bulk and tablet dosage form. Int J Pharm Sci Res. 2013; 4: 282-286.
30. Ghari T, Kobarfard F, Mortazavin SA. Development of a Simple RP-HPLC-UV Method for Determination of Azithromycin in Bulk and Pharmaceutical Dosage forms as an Alternative to the USP Method. Iran J Pharm Res. 2013; 12: 57.

31. Al-Rimawi F, Kharoaf M. Analysis of azithromycin and its related compounds by RP-HPLC with UV detection. J Chromatogr Sci. 2010; 48: 86-90.

32. Al-Hakkani MF. A rapid, developed and validated RP-HPLC method for determination of azithromycin. SN App Sci. 2019; 1: 222.

33. Zubata P, Ceresole R, Rosasco MA, Pizzorno MT. A new HPLC method for azithromycin quantitation. J Pharm Biomed Anal. 2002; 27: 833-836.

34. Singh AP, Chauhan I, Bhardwaj S, Gaur P, Kumar SS, & Jayendra J. HPLC METHOD DEVELOPMENT AND VALIDATION FOR AZITHROMYCIN IN ORAL SUSPENSION. Journal of Applied Pharmaceutical Sciences and Research. 2019; 7-12.

35. Zeng A, Liu X, Zhang S, Zheng Y, Huang P, Du K, et al. Determination of azithromycin in raw materials and pharmaceutical formulations by HPLC coupled with an evaporative light scattering detector. Asian J Pharm Sci. 2014; 9: 107-116.

36. Waghule SN, Jain NP, Patani CJ, Patani AC. Method development and validation of HPLC method for determination of azithromycin. Der PharmaChemica. 2013; 5: 166-172.

37. Okaru AO, Abuga KO, Kamau FN, Ndwigah SN, Lachenmeier DW. A robust liquid chromatographic method for confirmation of drug stability of Azithromycin in bulk samples, tablets and suspensions. Pharmaceutics. 2017; 9: 11.

38. Habibi B, Ghorbel-Abid I, Lahsini R, Ben Hassen DC, Trabelsi-Ayadi M. Development and validation of a rapid HPLC method for multiresidue determination of erythromycin, clarithromycin, and azithromycin in aquaculture fish muscles. Acta Chromatogr. 2019; 31: 109-112.

39. MALOTHU N, KONA SB, MUTHYALA B, KATAMANENI, P. A Simple Liquid Chromatographic Method For Simultaneous Estimation Of Azithromycin, Fluconazole And Ornidazole In Bulk And Pharmaceutical Dosage Forms. Int J Pharm Pharm sci. 2019; 11: 26-34.

40. Venkatesh V, Prabahar AE, Suresh PV, Maheswari CU, Rao NR. RP-HPLC Method for Simultaneous Estimation of Azithromycin and Ambroxol Hydrochloride in Tablets. Asian Journal of Chemistry. 2011; 23: 312.

41. Chandrakanth. Bandapally, Vamshi Y, GirijaSastry V. Method Development And Validation Of Simultaneous Estimation Of Azithromycin And Dexamethasone In Eye Drops By Rp-Hplc. Indo American Journal of Pharmaceutical Research. 2019.

42. Lawson-Wood K, Seer Green UK. HPLC Analysis of the Semi-Synthetic Antibiotic Azithromycin Using a Quasar C18 Column.

43. Ghari T, Kobarfard F, Mortazavi S. Development of a simple RP-HPLC-UV method for determination of azithromycin in pharmaceutical dosage forms as an alternative to the USP method. Research in Pharmaceutical Sciences. 2012; 7: 624.

44. Gaudin K, Kauss T, GaubertA, Viaud V, Dubost JP, et al. Simultaneous determination of artemether and azithromycin in suppositories by reversed phase HPLC. Analytical letters. 2011; 44: 2732-2743.

45. Mahmoudi A, Boukhechem M. Novel liquid chromatographic method for the simultaneous evaluation of erythromycin and azithromycin in human urine. Journal of Materials and Environmental Sciences. 2017; 8: 1953-1959.

46. Nagaraju K. Development and validation of new RP-HPLC method for simultaneous estimation of drug Cefixime and Azithromycin in tablet dosage form. IJRPB. 2016; 4: 2320-3471.

47. Mamatha N, Thangabalan B, Babu SM. Development and validation of RP-HPLC method for azithromycin and levofloxacin combined tablet dosage form. Int J ResPharm Nano Sci. 2014; 3: 200-214.

48. Hinge MA. Spectrophotometric and High Performance Liquid Chromatographic Determination of Cefpodoxime Proxetil l and Azithromycin Dihydrate in Pharmaceutical formulation. Pharmaceutical Methods. 2016; 7: 1-8.

49. Vennela K, Reddy MM, Subramanian S. A New RP-HPLC Method for the Simultaneous Estimation of Azithromycin and Levofloxacin in it's Pure and Pharmaceutical Dosage Form as per ICH Guidelines. International Journal of Pharma Research and Health Sciences. 2014; 2: 507-513.

50. Sharma K, Mullangi R. A concise review of HPLC, LC-MS and LC-MS/MS methods for determination of azithromycin in various biological matrices. Biomed Chromatogr. 2013; 27: 1243-1258.

51. Singh N, Singh Y, Bhadauria RS, Govindasamy J. Analytical Method Development, Optimization and Validation of Combination of Azithromycin and Benzoyl Peroxide By RP-HPLC Using Design of Experiment as Per ICH Guideline. International Journal of Health and Clinical Research. 2019; 2: 26-45.

52. Ramesh M, Durga MK., Sravani A, Snehalatha T, Thimmareddy D. A New Stability Indicating Validated RP-HPLC Method for the Simultaneous Estimation of Azithromycin and Cefixime in Bulk and Pharmaceutical Dosage Forms. Asian J. Research Chem. 2012; 5: 1067-1073.

53. Mahmoudi A. LC determination and stability assessment of macrolide antibiotics azithromycin and spiramycin in bulk and tablet samples. Int Lett Nat Sci. 2015; 47: 1-10.

54. El-Gindy A, Attia KA, Nassar MW, Al Abasawi NM, Al-Shabrawi M. Optimization and validation of a stability-indicating RP-HPLC method for determination of azithromycin and its related compounds. J AOAC Int. 2011; 94: 513-522.

55. Kamble RN, Kumar AP, Mehta PP. RP-HPLC Analytical Method Development and Validation for Azithromycin and Levofloxacin in Tablet Dosage Form. Int J Pharm Sci Rev Res. 2015; 32: 162-165.

56. Bhardwaj SK, Agarwal DD, Sharma V, Budakoti, SK. Development and Validation of RP-UHPLC Method for Azithromycin and Its Related Compounds in Tablet Dosage Form. J Chem Pharm Res. 2016; 8: 113-122.

57. Xu F, Zhang Z, Bian Z, Tian Y, Jiao H, Liu, Y. Azithromycin quantitation in human plasma by high-performance liquid chromatography coupled to electrospray mass spectrometry: application to bioequivalence study. J Chromatogr Sci. 2008; 46: 479-484.

58. Housheh, S. Development of Rapid, Simple and Stability-Indicating Method for Determination of Azithromycin Using RP-HPLC. Asian J Pharm Sci. 2017; 7: 55-59.

59. Nagaraju, K, Chowdary YA. Analytical Method Development and Validation for The Simultaneous Estimation of Azithromycin and Cefixime by Rp-Hplc Method in Bulk and Pharmaceutical Formulations. IJSRST. 2018; 4: 669-674.

60. Raja MS, Shan H, Moorthy S, Perumal P. RP-HPLC method development and validation for the simultaneous estimation of Azithromycin and Ambroxol Hydrochloride in tablet. International Journal of Pharm Tech Research. 2010; 2: 36-39.

61. El-Gindy A, Attia KA, Nassar MW, Al Abasawi NM, Al-Shabrawi, M. Optimization and validation of a stability-indicating RP-HPLC method for determination of azithromycin and its related compounds. J AOAC Int. 2011; 94: 513-522.

62. Afzal SJS, Khan PMAA, Baig MS. RP-HPLC ANALYTICAL METHOD DEVELOPMENT AND VALIDATION FOR AZITHROMYCIN AND CEFPODOXIME IN TABLET DOSAGE FORM. World J Pharm Pharm Sci. 2017; 1427-1436.

63. Kwiecień, A, Krzek J, Biniek Ł. TLC-densitometric determination of azithromycin in pharmaceutical preparations. JPC-J PLANAR

CHROMAT. 2008; 21: 177-181.

64. Gawande VT, Bothara KG, Satija CO. Validated stability-indicating HPTLC method for cefixime and azithromycin with preparative isolation, identification, and characterization of degradation products. ActaChromatographica. 2018; 30: 212-218.

65. Losa F, Mabaya TM, Kakumba JM, Ngoyi MT, Balazirhe F, et al. Development of a Thin Layer Chromatography Method for Simultaneous Detection of Chloroquine, Azithromycin and Paracetamol in Counterfeit Tablets Used Against Covid-19. Am J Biomed Sci. 2020; 8: 126-130.

66. Nigović B, Šimunić B. Voltammetric assay of azithromycin in pharmaceutical dosage forms. J Pharm Biomed Anal. 2003; 32: 197-202.

67. Farghaly OAEM, Mohamed NAL. Voltammetric determination of azithromycin at the carbon paste electrode. Talanta. 2004; 62: 531-538.

68. Nigovic B. Adsorptive stripping voltammetric determination of azithromycin at a glassy carbon electrode modified by electrochemical oxidation. Anal Sci. 2004; 20: 639-643.

69. Ensafi AA, Allafchian AR, Rezaei B. A sensitive and selective voltammetric sensor based on multiwall carbon nanotubes decorated with MgCr2O4 for the determination of azithromycin. Colloids Surf B Biointerfaces. 2013; 103: 468-474.

70. Zhou T, Tao Y, Jin H, Song B, Jing T. Fabrication of a selective and sensitive sensor based on molecularly imprinted polymer/acetylene black for the determination of azithromycin in pharmaceuticals and biological samples. PloS one. 2016; 11: e0147002.

71. Peng JY, Hou CT, Liu XX, Li HB, Hu XY. Electrochemical behavior of azithromycin at graphene and ionic liquid composite film modified electrode. Talanta 2011; 86, 227-232.

72. Vajdle O, Guzsvány V, Škorić D, Csanádi, J, Petković M, Avramov-Ivić M, Bobrowski A. Voltammetric behavior and determination of the macrolide antibiotics azithromycin, clarithromycin and roxithromycin at a renewable silver–amalgam film electrode. ElectrochimicaActa. 2017; 229, 334-344.

73. Palomeque ME, Ortíz, PI. New automatized method with amperometric detection for the determination of azithromycin. Talanta. 2007; 72: 101-105.

74. Mahnashi HM, Mahmoud AM, Alkahtani AS, El-Wekil MM. Simultaneous electrochemical detection of azithromycin and hydroxychloroquine based on VS2 QDs embedded N, S@ graphene aerogel/cCNTs 3D nanostructure. Microchemical Journal. 2021; 163: 105925.

75. Wu B, Guo Y, Cao H, Zhang Y, Yu L, Jia N. A novel mesoporous molecular sieves-based electrochemilumenescence sensor for sensitive detection of azithromycin. Sensors and Actuators B: Chemical. 2013; 186: 219-225.

76. Jafari S, Dehghani M, Nasirizadeh N, Azimzadeh M. An azithromycin electrochemical sensor based on an aniline MIP film electropolymerized on a gold nano urchins/graphene oxide modified glassy carbon electrode. J Electroanal Chem. 2018; 829: 27-34.

77. Lijun L, Chunyan D, Wenyan G, Dachun H, Yanqing L. Electrochemiluminescencial Study on the Determination of Azithromycin using Ru (bpy) _3~(2+) System. J. Chemistry. 2011; 7.

78. Stoian IA, Iacob BC, Dudaş CL, Barbu-Tudoran L, Bogdan D, et al. Biomimetic electrochemical sensor for the highly selective detection of azithromycin in biological samples. Biosens Bioelectron. 2020; 155: 112098.

79. Zhang K, Lu L, Wen Y, Xu J , Duan X, et al. Facile synthesis of the necklace-like graphene oxide-multi-walled carbon nanotube nanohybrid and its application in electrochemical sensing of Azithromycin. Anal Chim Acta. 2013; 787: 50-56.

80. Hu L, Zhou T, Feng J, Jin H, Tao Y, et al. A rapid and sensitive molecularly imprinted electrochemiluminescence sensor for azithromycin determination in biological samples. J Electroanal Chem.. 2018; 813: 1-8.

81. Xia XI, Liang MING. Electrochemical behavior and determination of azithromycin at a multi-wall carbon nanotube modified electrode. Chinese Journal of Analysis Laboratory. 2012; 9.

82. Vajdle O, Šekuljica S, Guzsvány V, Nagy L, Kónya Z, et al. Use of carbon paste electrode and modified by gold nanoparticles for selected macrolide antibiotics determination as standard and in pharmaceutical preparations. J Electroanal Chem. 2020; 87: 114324.

83. Rebelo P, Pacheco JG, Cordeiro MND, Melo A, Delerue-Matos C. Azithromycin electrochemical detection using a molecularly imprinted polymer prepared on a disposable screen-printed electrode. Anal Methods. 2020; 12: 1486-1494.

84. Radosavljević KD, Lović JD, Mijin DŽ, Petrović SD, Jadranin MB, et al. Degradation of azithromycin using Ti/RuO 2 anode as catalyst followed by DPV, HPLC–UV and MS analysis. Chemical Papers. 2017; 71: 1217-1224.

85. Nigovic B. Adsorptive stripping voltammetric determination of azithromycin at a glassy carbon electrode modified by electrochemical oxidation. Anal Sci. 2004; 20: 639-643.

86. Rebelo P. Azithromycin Electrochemical Detection Using A Molecularly Imprinted Polymer On A Disposable Sensor. Book Of. 2020; 7.

87. Abu-Dalo MA, Nassory NS, Abdulla NI, Al-Mheidat IR. Azithromycin-molecularly imprinted polymer based on PVC membrane for Azithromycin determination in drugs using coated graphite electrode. J Electroanal Chem. 2015; 751: 75-79.

88. Komorsky-Lovrić Š, Nigović B. Identification of 5-aminosalicylic acid, ciprofloxacin and azithromycin by abrasive stripping voltammetry. J Pharm Biomed Anal. 2004; 36: 81-89.

89. Pikula N, Slepchenko G. Voltammetric determination of antibiotics in pharmaceuticals. In IV International research conference" Information technologies in Science, Management, Social sphere and Medicine. Atlantis Press; 2017: 317-320

90. Tasić ŽZ, Mihajlović MBP, Radovanović MB, & Antonijević MM. Electrochemical investigations of copper corrosion inhibition by azithromycin in 0.9% NaCl. Journal of Molecular Liquids. 2018; 265, 687-692.

91. Karbainov YA, Puchkovskaya ES, Karbainova SN. Adsorption of azithromycin dehydrate at stationary mercury and solid electrode. Bulletin of the Tomsk Polytechnic University. 2007; 311: 81-84.

92. Bakheit AH, Al-Hadiya BM, Abd-Elgalil AA. Azithromycin. Profiles Drug Subst Excip Relat Methodo. 2014; 39, 1-40.

93. Mandić Z, Weitner Z, Ilijaš M. Electrochemical oxidation of azithromycin and its derivatives. J Pharm BiomedAnal. 2003; 33: 647-654.

Cite this article

Sebaiy MM, Farouk EM, Lotfy EM, Mokhtar EM, Abd-Elgwad EN, et al. (2021) Review article: Spectroscopic, Chromatographic and Electrochemical Analysis of Azithromycin in Different Matrices. J Drug Des Res 8(2): 1084.