http//dx.doi.org/10.14500/aro.10761

New Fluorescence Quenching Approach for Determination of Valsartan in Certain Tablets and Spiked Biological Fluids

Layth I. Abd Ali

Department of Chemistry, Faculty of Science and Health, Koya University,
Daniel Mitterrand Boulevard, Koya KOY45 AB64, Kurdistan Region – F.R. Iraq

***Abstract*—A new, simple, selective, sensitive, fast, economical, and reliable fluorescence quenching method for the quantitation of valsartan was investigated using basic fuchsin act as a fluorometric dye. The method was depended on the detection quenching influence of valsartan on the fluorescence intensity of basic fuchsin and the reaction between valsartan and basic fuchsin in a McIlvaine buffer medium at pH = 6 to yield a new basic fuchsin–valsartan non-fluorescent complex. The excitation and emission of basic fuchsin fluorescence signal were identified at 535 and 728 nm, respectively. A fluorescence quenching value (ΔF) displayed a very good linear relationship ($R^2 = 0.9992$) with valsartan concentration ranging from 0.003 to 3 μg/mL, a detection limit as low as 0.0009 μg/mL with a high precision and accuracy (RSD% <3). Significantly, no interference effect was found due to the presence of other ingredients commonly found in medical formulations. The acquired data were statistically compared with those acquired from reported chromatographic method and were observed to be in excellent agreement at a 95% confidence level; the planned fluorescence quenching procedure was subsequently utilized to detected the concentration of valsartan in spiked biological fluids and commercial medical tablets.**

***Index Terms*—Basic fuchsin, Fluorescence quenching, Pharmaceutical analysis, Valsartan.**

I. Introduction

In recent years, cardiovascular diseases have begun to be recognized as the principal causes of death in the majority of countries worldwide (Kaabipour, et al., 2020). Cardiovascular diseases are associated with heart failure, ischemic heart disease, rheumatic heart disease, cerebrovascular disease, coronary heart disease, high cholesterol levels, and high blood pressure (Kumar, et al., 2015). High blood pressure is classified as a principal reason for an array of cardiovascular diseases. The control and treatment of higher blood pressure are significant in the avoidance of the effects of cardiovascular diseases (Shah, et al., 2017).

Valsartan is taken by mouth as well as highly active is a non-peptide angiotensin II receptor antagonist and potentials through preventing the actions of angiotensin II, beside a high ability to suppress the type I angiotensin receptor (Azadi and Ahmadi, 2019), so is utilized as an antihypertensive drug (Gadepalli, et al., 2014; Shah, et al., 2017). Chemically, Valsartan is labeled as"*N*-(1-oxopentyl)-*N*-[[2′-(1H-tetrazol-5-yl)[1,1′-biphenyl]-4-yl]methyl]-L-aline"($C_{24}H_{29}N_5O_3$) (Gadepalli, et al., 2014; Qader, Salih and Tahir, 2018), as shown in Fig.1.

In a review of associated scientific articles, numerous previous analytical methods have been developed and used for the quantitation of valsartan in samples containing biological fluids and pharmaceutical products. Published methods involve the separation and determination of valsartan by various analytical approaches either with or without other drugs such as high-performance liquid chromatography (HPLC) through different detectors such as UV detectors (Kumar, et al., 2015; Pebdani, et al., 2016; Babarahimi, et al., 2018; Shaikh, et al., 2020; Marghany, et al., 2020), fluorescence detection (Macek, Klima and Ptacek, 2006; del Rosario Brunetto, et al., 2009), as well as diode-array detection (Farajzadeh, Khorram and Pazhohan, 2016); a modern class of separation system based on "ultra-high-performance liquid chromatography" (UPLC) (Krishnaiah, et al., 2010; Vojta, et al., 2015; Moussa, et al., 2018); liquid chromatography–tandem mass spectrometry (LC–MS/MS) (Selvan, et al., 2007, Koseki, et al., 2007 , Annadi, El Sheikh and Mohamed, 2019); electroanalytical voltammetry methods (Eisele, et al., 2014; Mansano, et al., 2015); and UV-vis spectrophotometry (Satana, et al., 2001; Erk, 2002; Lotfy, et al., 2015; Eissa and Abou Al Alamein 2018; Meselhy, et al., 2020; Kamal, Marie and Hammad 2020). As well the fluorescence determination of valsartan, several procedures have been described in previous articles for its determination were including native fluorescence, a first derivative fluorescence and the synchronous fluorescence (Cagigal, et al., 2001; Shaalan and Belal, 2010; El-Shaboury, et al., 2012; El-Kosasy, et al., 2015; Dinc, Ertekin and Buker, 2017; Ragab, et al., 2017).

ARO-The Scientific Journal of Koya University
Vol. VIII, No.2 (2020), Article ID: ARO.10761, 9 pages
DOI:10.14500/aro.10761
Received: 03 November 2020; Accepted: 20 December 2020
Regular research paper: Published: 27 December 2020
Corresponding author's e-mail: layth.imad@koyauniversity.org

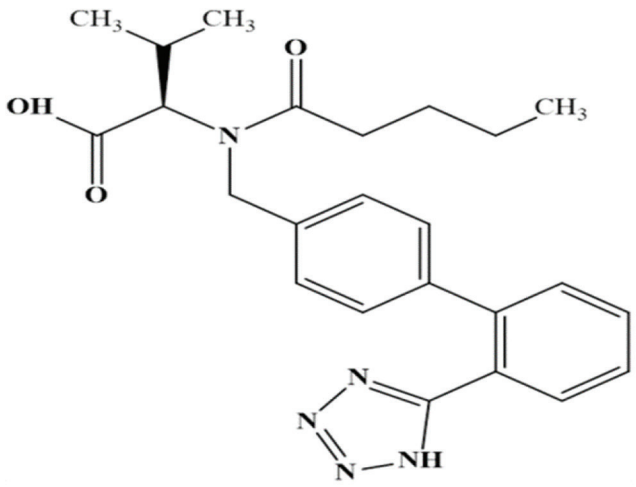


Fig. 1. Chemical structure of valsartan.

Basic fuchsin dye is recognized as a member of triphenylmethane group, with a chemical formula of $C_{20}H_{20}ClN_3$; it is also known as Magenta II because it is also known as Magenta II because it is a mix of pararosaniline, rosaniline, as well as Magenta II dyes. Fuchsin itself is inflammable, as well as having various properties such as being bactericidal, fungicidal and an anesthetic. It is commonly employed as coloring reagent for different industrial products such as textile, leather, fibers, paper, and cotton; it can also be used to stain collagen, muscle, mitochondria, and the tubercle bacillus (Pathrose, et al., 2014; Pathrose, et al., 2014; Pathrose, et al., 2016; Graham, et al. 2017; Ning, et al., 2018).

To the best of our knowledge, basic fuchsin has not been applied before for the analysis of drugs. In the current paper, a new quenching spectrofluorimetric procedure has been developed for the quantitative analysis of valsartan employing basic fuchsin as a fluorescence reagent. The developed method is simple, inexpensive, accurate, selective, and highly sensitive. It was applied for the determination of valsartan in pharmaceutical tablets and spiked biological fluids. Furthermore, the experimental conditions for an advanced spectrofluorimetric method were optimized.

II. Experimental

A. Apparatus

The fluorescence spectra and measurements were carried out using a Cary Eclipse fluorescence spectrophotometer (Agilent Technologies, USA) equipped with a xenon flash lamp, where the slit width was fixed at 5 nm. All fluorescence measurements were achieved in 1 cm quartz cell. The pH of the buffer systems was determined through an S-25 pH meter (Wincom Company Ltd., China).

B. Chemicals and Reagents

Valsartan standards were provided from Awamedica Drugs Company, Erbil-K. R. of Iraq, where a standard solution of 1 mg/mL was prepared by dissolving 50 mg of standard valsartan powder in 50 mL ethanol (Merck, Germany) with carefully mixing, and was subsequently stored in a refrigerator. Every day, working standard solutions of valsartan were prepared using the appropriate dilution of the standard solution with ethanol.

Basic fuchsin was purchased from Sigma-Aldrich, USA. Solutions of basic fuchsin were prepared at a concentration of 5×10^{-4} mol/L by dissolving 8.4 mg of basic fuchsin in 50 mL ethanol (Merck, Germany).

According to a previous procedure reported (El-Kosasy, et al., 2015), diverse buffer systems with pH values ranging from 1 to 11 were prepared, respectively. For pH 1, the standard Citrate buffer solution was created through 0.1 mole/L sodium citrate (Sigma-Aldrich, USA), then regulated for desired pH using 0.1 mole/L hydrochloric acid (Sigma-Aldrich, USA). For a pH scale between 2 and 8, the standard McIlvaine buffer solutions were preparation by mixing numerous volumes from 0.2 mol/L disodium hydrogen phosphate solution (Merck, Germany) as well as 0.1 mol/L citric acid solution (Merck, Germany). For a pH scale between 11 to 9, borate buffer solutions were created, by mixing several volumes from 0.1 mol/L sodium hydroxide solution (Sigma-Aldrich, USA) with several volumes of 0.05 mol/L sodium tetraborate solution (Sigma-Aldrich, USA).

All reagents and solvents were of extra pure grade. Valsartan tablets, Diovan® (Novartis International AG. Switzerland), Valsartan Awa® (Awamedica Drugs Company, Erbil-K. R. of Iraq), and Arbiten® (JOSWE medical. Jordan) containing 160 mg of active ingredient were purchased from a local pharmacy.

C. Sample Preparation

Ten tablets from three different brands of pharmaceutical products were carefully weighed, ground, and mixed to produce appropriate powders, after which exact weights of powders were placed in 50 mL volumetric flasks and dissolved using 40 mL of ethanol and sonication for 15 min. The solutions so obtained were filtrated by Whatman® quantitative filter paper, ashless, Grade 41 (Merck, Darmstadt, Germany), before washing and diluting to 50 mL using ethanol.

D. Procedure for Spiked Urine and Serum Samples (Gong and Zhu, 2013)

Initially, the drug-free serum and urine samples were obtained from Rizgary Hospital (Erbil-K. R. of Iraq) and kept at −20°C until analysis and thawed to lab temperature before use. The serum and urine samples were individually diluted by 1000- and 500-fold using deionized water. A 1 mL serum or urine sample was spiked with an appropriate concentration of valsartan standard solution, giving final valsartan concentrations of 0.5, 1, and 3 μg/mL.

E. Recommended Procedure

To detect a content of valsartan, 1.5 mL basic fuchsin (5×10^{-4} mol/L), 2 mL McIlvaine buffer solution (pH 6), and Aliquot volumes of the working standard or sample solutions over concentration range 0.003–3 μg/mL of

http//dx.doi.org/10.14500/aro.10761

valsartan were diluted to 10 mL, then mixed thoroughly for 15 min at lab temperature. The fluorescence intensity of basic fuchsin was recorded versus a blank solution at an excitation wavelength of 535 nm as well as emission at 728 nm.

III. Results and Discussion

A. Quenching Excitation and Emission Spectra of Basic Fuchsin with Valsartan

Basic fuchsin has high native fluorometric signal with excitation/emission wavelengths of 535/728 nm (Fig. 2a), whereas valsartan does not appear to have any fluorescence emission properties. Furthermore, under experimental conditions the fluorescence spectra of basic fuchsin were acquired from reaction with a 1 μg/mL concentration of valsartan (Fig. 2b). From Fig. 2, it can be observed that the fluorescence signal of basic fuchsin was quenched rapidly when a drug was added though no change to both the position and shape of the emission peak. The acquired data showed that there was an interaction between valsartan and basic fuchsin. Hence, basic fuchsin could be used as a quenching fluorescent reagent for spectrofluorimetric determination of valsartan.

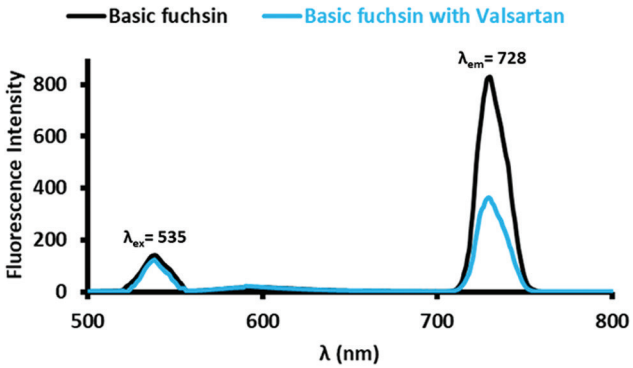


Fig. 2. Fluorescence excitation as well emission spectra of (a) Basic fuchsin (5 × 10−5 mol/L). (b) Basic fuchsin (5 × 10−5 mol/L) in the presence of valsartan (1 μg/mL), McIlvaine buffer solution (pH 6).

B. Influence of the Type and Volume Buffer Systems

The influence of the buffer solutions from pH = 1 to 11 on fluorescence quenching (ΔF) was assessed. For pH1 was utilized citrate buffer solution, whereas for the pH range 2–8 was used McIlvaine buffer solutions, finally for the pH range 9–11 was used borate buffer solutions. The acquired data exhibited that the ΔF reached a maximum value when the McIlvaine buffer (pH 6) solution was used (Fig. 3a). The McIlvaine buffer and pH 6 were selected as optimum values for further studies. From Fig. 3b, it can be seen that ΔF reached a maximum when the volume of buffer solution was 2 mL; accordingly, a 2 mL volume of McIlvaine buffer medium was nominated as the best volume for the optimized fluorescence method.

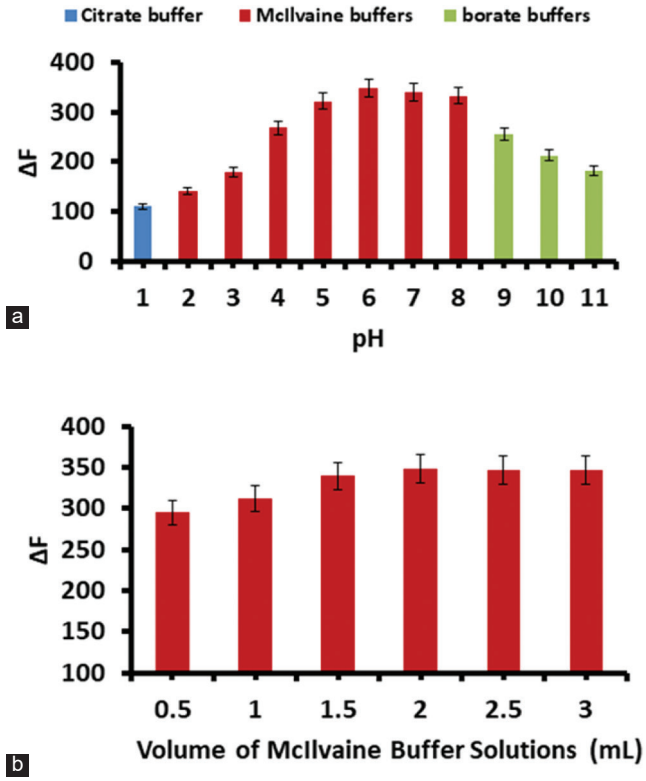


Fig. 3. Influences of (a) various buffer systems on fluorescence quenching (ΔF). (b) McIlvaine buffer volume on fluorescence quenching (ΔF) of the Basic fuchsin (5 × 10−5 mol/L) in the presence of valsartan (1 μg/mL).

C. Influence of Basic Fuchsin Concentration

The influence of different concentrations of basic fuchsin reagent (1, 2, 3, 4, 5, and 6 × 10^{-5} mol/L) on fluorescence quenching (ΔF) signal was determined. The fluorescence quenching was maximum signal after the molar concentration of basic fuchsin = 5 × 10^{-5} mol/L (Fig. 4); hence, this molar concentration was selected for following optimization tests.

D. Influence of the Time Reaction

The optimized reaction time was investigated by following the fluorescence intensity at 728 nm at lab temperature. From Fig. 5, it was determined that the complex formed and was stabilized after 5 min of mixing, and the associated fluorescence quenching, ΔF, remained stable for at least 150 min.

E. Fluorescence Quenching Spectrum and the Standard Calibration Curve for Determination of Valsartan

Under optimum experimental conditions, the fluorescence quenching value, ΔF, of the basic fuchsin reactions with different concentrations of valsartan (0.003–3 μg/mL) were determined. From Fig. 6a, it can be observed that fluorescence quenching decreased progressively with increase of valsartan concentrations in the solution, in a manner proportional to the concentration of the valsartan. Thus, basic fuchsin can be used to determine the concentration of valsartan.

Under optimum fluorescence experimental conditions, a standard calibration curve was created using various external standard concentrations (Fig. 6b). The correlation coefficient was 0.9992, demonstrating excellent linearity

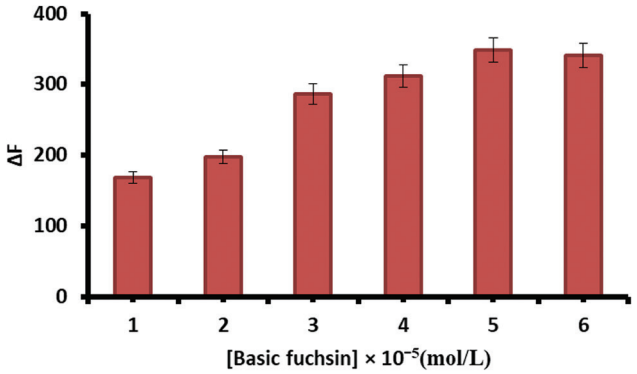


Fig. 4. Influence of various molar concentrations of basic fuchsin (1, 2, 3, 4, 5, and 6 × 10−5 mol/L) on fluorescence quenching (ΔF) in the presence of valsartan (1 µg/mL), McIlvaine buffer solution (pH 6).

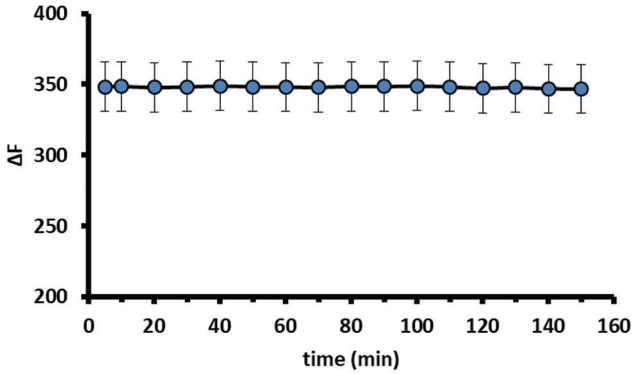


Fig. 5. Influence of the time reaction on fluorescence quenching (ΔF) of basic fuchsin (5 × 10−5 mol/L) in the presence of valsartan (1 µg/mL), McIlvaine buffer solution (pH 6).

over a concentration range of 0.003–3 µg/mL, as achieved through the equation ΔF = 104.6 C_{VAL} (µg/mL) + 100.63. According to the "International Union of Pure and Applied Chemistry (IUPAC) principles," a detection limit (DL) term correspond with a formula (3.3 × SD_{blank} /F) and quantification limit (QL) term correspond with a formula (10 × SD_{blank}/F), respectively, wherein SD_{blank} represents a standard deviation of six blank determinations, whereas F represents a slope of the constructed calibration graph. From optimum quenching method, the DL value of valsartan was 0.0009, whereas the QL value of valsartan was 0.0028 µg/mL.

F. Selectivity of the Proposed Procedure

The selectivity of the planned fluorescence procedure was assessed through determining the standard solution of valsartan (1 µg/mL) in the presence of pharmaceutical tablet materials such as citric acid, glucose, sucrose, lactose, silica, and other coexisting ionic species, the results of which are displayed in Table I. It was established that the limit of the concentrations of pharmaceutical tablet excipients that could be tolerated should produce an error of < ± 4% in the analysis of the valsartan. Furthermore, these results

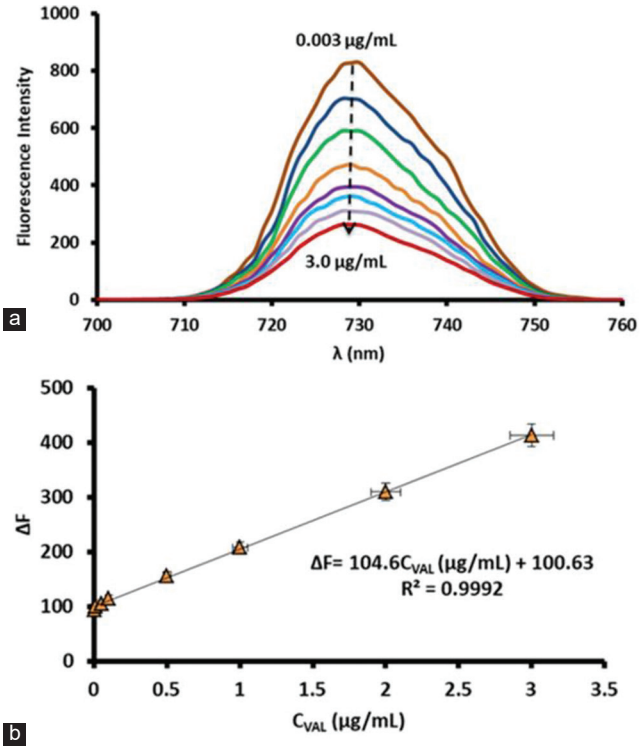


Fig. 6. (a) Influence of diverse standard concentrations of valsartan (0.003, 0.01, 0.05, 0.1, 0.5, 1.2, and 3 µg/mL) on a quenching signal (ΔF) of basic fuchsin (5 × 10−5 mol/L), McIlvaine buffer solution (pH 6). (b) Standard calibration graph for the spectrofluorometric determination of valsartan using basic fuchsin.

TABLE I
SELECTIVITY IN THE ANALYSIS OF VALSARTAN BY BASIC FUCHSIN

Tablet excipients species	Tolerance conc. (µg/mL)	Error [a]%
Citric acid	500	−3.10
Glucose	500	2.11
Sucrose	500	1.85
Lactose	500	−1.50
silica	500	1.34
Ca^{2+}	25	1.26
Mg^{2+}	100	1.47
Zn^{2+}	15	1.18
SO_4^{2-}	400	−1.83
CH_3COO^-	500	−1.66

[a]Average of five analyses

indicate no significant interference from that pharmaceutical tablet excipients and that the proposed procedure is highly selective.

G. Precision and Accuracy of the Proposed Procedure

Six measurements at three different concentrations of valsartan representing low, medium, and high concentrations from a range of the linearity were taken. The low value of the relative standard deviation percentage (RSD % < 3) points to high precision of the recommended procedure for quantitative measurements of the fluorescence quenching intensity of valsartan. Likewise, the very good percentage of recoveries of standard valsartan indicates the high accuracy of the method (Table II).

http//dx.doi.org/10.14500/aro.10761

H. Stoichiometry of the Spectrofluorimetric Reaction

The molar ratio procedure was applied to conclude the composition ratio of the fluorescence reaction between valsartan and basic fuchsin was represented as a fluorometric dye. Fig. 7 shows a plot of molar ratio [BF]/[VAL] against ΔF. From this, it was established that the stoichiometry ratio of the valsartan:basic fuchsin complex was 1:1. Correspondingly, the planned mechanism for fluorescence quenching reaction through a construction of a basic fuchsin–valsartan complex was illustrated by Scheme 1.

TABLE II
PRECISION AND ACCURACY FOR THE DETERMINATION OF VALSARTAN VIA BASIC FUCHSIN

Conc. of VAL (µg/mL)	Found Conc. (µg/mL)	Recovery	RSD [a]%
0.5	0.48	94.00	2.58
1.0	1.06	106.0	1.94
3.0	3.08	102.6	1.57

[a]*Average of six determinations*

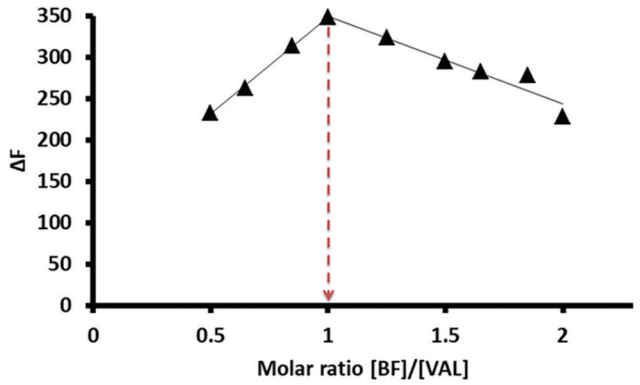


Fig. 7. Molar ratio plot for the stoichiometry of reaction quenching between basic fuchsin and valsartan.

I. The type of Fluorescence Quenching and Effect of Temperature

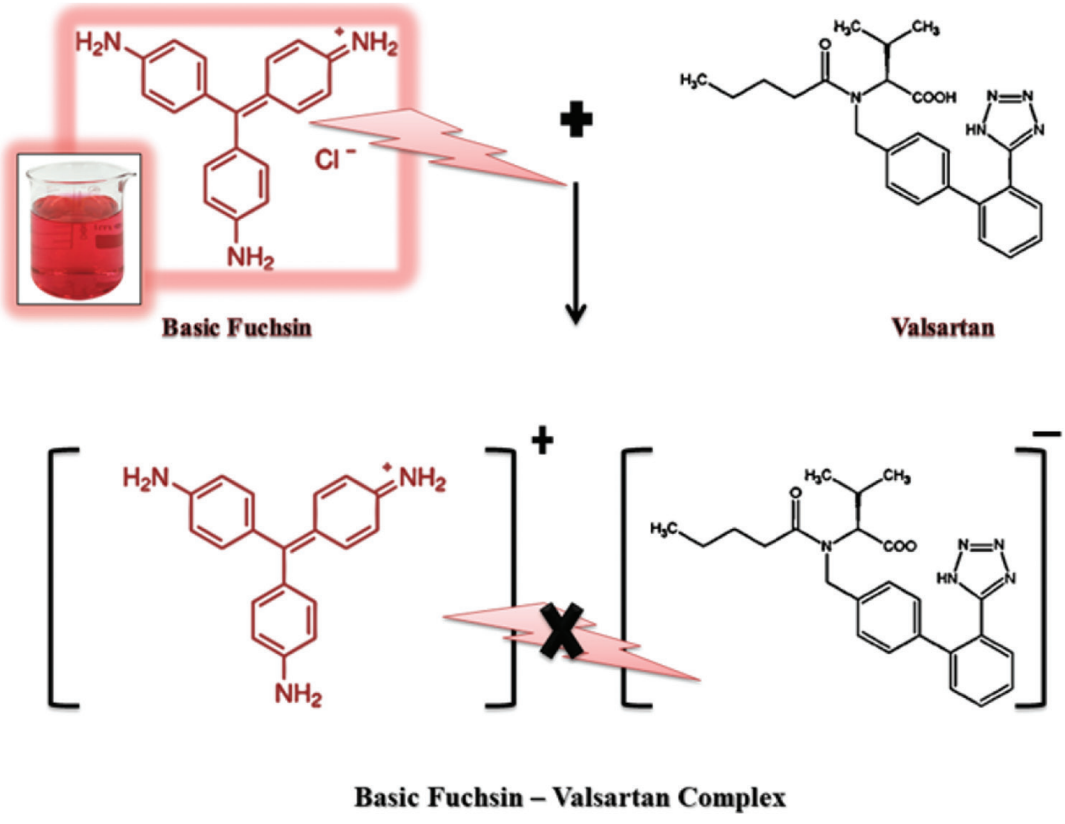
Often, fluorescence quenching types generally contain dynamic and static modes of quenching. The actual form of quenching process can be described by the Stern–Volmer equation (Lakowicz, 2013):

$$F_0/F = 1 + R_{sv}\,[VAL]$$

F_0 and F are characterized as the intensities of fluorescence of basic fuchsin dye with and without valsartan, respectively; R_{sv} refers to the Stern–Volmer quenching constant; whereas VAL indicate to a valsartan concentration act as the quencher.

The results obtained from the curve of the Stern–Volmer equation in linear form indicates the type of quenching that occurs in single static or dynamic mode, whereas a more curved form indicates a type of quenching that incorporates both static and dynamic modes.

However, the type of quenching cannot be discriminated from a plot of the Stern–Volmer equation, so one of the significant approaches to identifying static and dynamic



Scheme 1: Schematic illustration of fluorescence quenching of basic fuchsin by valsartan through construction of a basic fuchsin–valsartan complex.

TABLE III
QUANTITATIVE MEASUREMENTS OF VALSARTAN IN COMMERCIAL PHARMACEUTICAL TABLETS THROUGH THE PROPOSED FLUORESCENCE QUENCHING AND A REPORTED HPLC METHOD

Valsartan Brands (160 mg/tablet)	Results from Proposed method	Results from HPLC method[c]	Recovery %	Error %[a]	t and F values[b]
Diovan	162.23	159.36	101.80	1.80	t = 1.15, F = 1.02
Valsartan Awa	164.57	161.11	102.14	2.14	t = 1.76, F = 1.18
Arbiten	161.49	160.27	100.76	0.76	t = 0.94, F = 1.07

[a]Results average were obtained by five determinations. [b]Statistical analysis (t = 2.78, F = 6.39, confidence level = 95% and n = 5). [c]HPLC (Tatar and Saglik 2002)

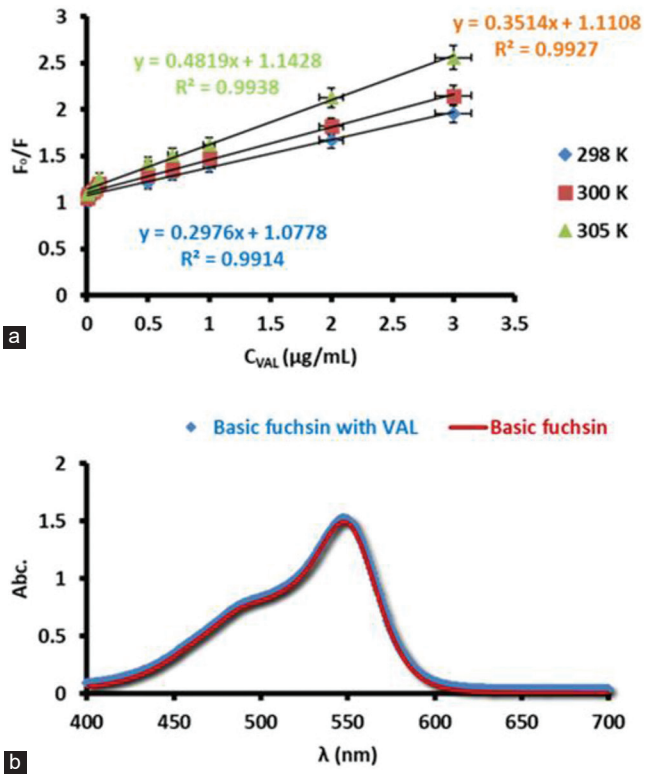


Fig. 8. (a) Stern–Volmer graphs for quenching process at various temperatures (298, 300, and 305 K), basic fuchsin (5 × 10−5 mol/L), McIlvaine buffer solution (pH 6). (b) Influence of valsartan (1 µg/mL) on UV absorption spectra of basic fuchsin (5 × 10−5 mol/L), McIlvaine buffer solution (pH 6).

modes comes from the study of the effect of temperature and the assessment of quenching constant values (R_{sv}). For the dynamic mode, the values of R_{sv} are improved with an enhanced quenching reaction temperature, whereas for the static mode the opposite influence was detected (Lakowicz, 2013).

The R_{sv} constants at three temperatures (298, 300, and 305 K) are presented in Fig. 8a. The linear function of F_0/F against [VAL] showed whether a quenching mode was dynamic or static through a single process. Fig. 8a shows that the values of R_{sv} were increased with increasing reaction temperature, demonstrating the probable fluorescence mechanism of basic fuchsin through valsartan was taking place via a dynamic quenching process.

The validation of a dynamic quenching process was establishing by the ultraviolet (UV) spectra of basic fuchsin in the presence of valsartan as a quenching reagent (Fig. 8b).

For the dynamic mode, there were no observed changes to the UV spectra of basic fuchsin dye with or without valsartan at pH 6 (Gong and Zhu, 2013).

The investigation proved that there was practically no change between the absorption spectra of basic fuchsin fluorescence dye alone and that of basic fuchsin in combination with valsartan. From this study, it can be construed that the fluorescence quenching of basic fuchsin fluorescence dye introduced using valsartan is dynamic in nature.

TABLE IV
QUANTITATIVE MEASUREMENTS OF VALSARTAN IN SPIKED SERUM AND URINE SAMPLES USING THE PROPOSED FLUORESCENCE QUENCHING METHOD

Sample	VAL spiked (µg/mL)	VAL found (µg/mL)	Recovery (%)[b]	RSD (%)
Serum	0.0	N.D[a]	–	–
	0.5	0.52	104.00	3.67
	1.0	1.06	106.00	2.26
	3.0	3.17	105.66	1.79
Urine	0.0	N.D	–	–
	0.5	0.54	108.00	3.84
	1.0	0.97	97.000	2.94
	3.0	3.23	107.66	2.13

[a]ND: No determined. [b]The average value from five measurements

J. Application of the Fluorescence Quenching Method

A fluorescence quenching method through basic fuchsin as a fluorometric dye was effectively utilized to determine valsartan concentrations in various pharmaceutical products. To validate the suggested procedure, a data listed in Table III were compared with those gained by a reference HPLC method (Tatar and Saglik, 2002), and the comparison data were analyzed using statically theoretical factors (t test and F test), where these data indicate good agreement with the reference method.

The proposed quenching procedure was also applied to the detection of valsartan concentrations in spiked serum and urine samples (Table IV) with a very good recovery percentage range (97−108%).

Table V compares valsartan drug concentrations determined in various samples in this proposed approach with those reported from the previous approaches. Compared with classical analytical approaches, the method advocated here is simple, takes very little time, and is of very low cost for an analytical system, and which returns very good precision and accuracy.

TABLE V
COMPARISON OF THE PROPOSED METHOD WITH OTHER PREVIOUS ANALYTICAL METHODS FOR VALSARTAN DETERMINATION

Analytical Method	DL (µg/mL)	QL (µg/mL)	REF.
HPLC[a]	1.0	-	(Carlucci, Carlo and Mazzeo, 2000)
HPLC	0.0148	0.0449	(Kumar, et al. 2015)
LC–MS/MS[b]	0.005	-	(Shah, et al. 2017)
LC–ESIMS/ MS[c]	0.0005	0.001	(Gadepalli, et al. 2014)
HPLC	-	0.098	(Macek, Klima, and Ptacek 2006)
HPLC	0.001	0.003	(del Rosario Brunetto, et al. 2009)
SB-DLLME–HPLC–DAD[d]	0.0003	0.001	(Farajzadeh, Khorram, and Pazhohan, 2016)
HPLC–UV	0.15	0.50	(Ibrahim, et al., 2018)
HPLC–UV	8.01	24.2	(Shaikh, et al., 2020)
HPLC–UV	0.053	0.16	(Marghany, et al., 2020)
UV Spectrophotometry	0.51	1.70	(Satana, et al., 2001)
Ratio derivative spectrophotometry	0.628	2.09	(Dinc, Uslu, and Özkan 2004)
Spectrofluorimetric	0.40	0.50	(Cagigal, et al., 2001)
Spectrofluorimetric	0.001	0.004	(Shaalan and Belal, 2010)
Spectrofluorimetric	0.002	0.005	(El-Shaboury, et al., 2012)
Spectrofluorimetric	0.004	0.013	(El-Kosasy, et al., 2015)
First derivative fluorimetry (D1)	0.0435	0.1318	(Ragab, et al., 2017)
Direct Spectrofluorimetric	0.0442	0.1339	(Ragab, et al., 2017)
First Derivative Synchronous Spectrofluorimetric	0.027	0.083	(Shalan, El-Enany and Belal, 2015)
Voltammetry	0.0033	0.01002	(Ragab, et al., 2019)
Fluorescence Quenching	0.0009	0.0028	This work

[a]HPLC: High-performance liquid chromatography. [b]LC–MS/MS: Liquid chromatography–tandem mass spectrometry. [c]LC–ESIMS/MS: Liquid chromatography–electro spray ionization/tandem mass spectrometry. [d]SB-DLLME–HPLC–DAD: Solid based-disperser liquid–liquid micro-extraction–high-performance liquid chromatography–diode array detector

IV. Conclusion

In this research, a newly advanced fluorescence quenching procedure using basic fuchsin as a fluorescence dye was devised and confirmed for the determination of valsartan. The interaction of the valsartan with basic fuchsin resulted in the production of an ion-associated complex related to the quenching of basic fuchsin fluorescence dye using a dynamic quenching mode. By the utilize of optimized model for studding the essential empirical variables, to acquire experimental results and assessment valsartan recovery value. Furthermore, the significant benefits of the new quenching method are that it is sensitive, simple, cheap, and fast, permitting the effective determination of valsartan at a parts-per-million concentration with a DL of 0.0009 and QL 0.0028 (µg/mL). An advanced procedure was employed for the quantitative measurement of valsartan in various brands of medical tablets, with a very good recovery percentage of between of 100.76 and 102.14, without any significant interference from common tablet excipients. Further, this fluorescence quenching method was applied to determine the concentration of valsartan in spiked human serum and urine samples. Hence, the results suggest that basic fuchsin could act as an efficiently type of a fluorometric dye for applications in clinical and pharmacological fields.

Acknowledgment

This research has been supported by Koya University, Science and Health Research Center, Faculty of Science and Health, and by Chemistry Department. The author wish to acknowledge and appreciate to “Dr Mark Watkins,” University of Leicester, for English language editing and proofreading this article.

References

Annadi, A.M., El Sheikh, R. and Mohamed, A.A., 2019. Development and validation of a LC-MS/MS method for the determination of valsartan in human plasma after protein precipitation or liquid-liquid extraction. *Analytical Chemistry Letters*, 9(4), pp.504-517.

Azadi, A. and Ahmadi, S., 2019. Simultaneous magnetic dispersive micro solid phase extraction of valsartan and atorvastatin using a CMC-coated Fe_3O_4 nanocomposite prior to HPLC-UV detection: Multivariate optimization. *New Journal of Chemistry*, 43, pp.16950-16959.

Babarahimi, V., Talebpour, Z., Haghighi, F., Adib, N. and Vahidi, H., 2018. Validated determination of losartan and valsartan in human plasma by stir bar sorptive extraction based on acrylate monolithic polymer, liquid chromatographic analysis and experimental design methodology. *Journal of Pharmaceutical and Biomedical Analysis*, 153, pp.204-213.

Cagigal, E., Gonzalez, L., Alonso, R.M. and Jimenez, R.M., 200. Experimental design methodologies to optimise the spectrofluorimetric determination of Losartan and Valsartan in human urine. *Talanta*, 54(6), pp.1121-33.

Carlucci, G., Carlo, V.D. and Mazzeo, P., 2000. Simultaneous determination of valsartan and hydrochlorothiazide in tablets by high-performance liquid chromatography. *Analytical Letters*, 33(12), pp.2491-2500.

del Rosario Brunetto, M., Contreras, Y., Clavijo, S., Torres, D., Delgado, Y., Ovalles, F., Ayala, C., Gallignani, M., Estela, J.M. and Martin, V.C., 2009. Determination of losartan, telmisartan, and valsartan by direct injection of human urine into a column-switching liquid chromatographic system with fluorescence detection. *Journal of Pharmaceutical and Biomedical Analysis*, 50(2), pp.194-199.

Dinc, E., Ertekin, Z.C. and Buker, E., 2017. Multiway analysis methods applied to the fluorescence excitation-emission dataset for the simultaneous quantification of valsartan and amlodipine in tablets. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 184, pp.255-261.

Dinc, E., Uslu, B. and Özkan, S.A., 2004. Spectral resolution of a binary mixture containing valsartan and hydrochlorothiazide in tablets by ratio spectra derivative and inverse least square techniques. *Analytical Letters*, 37(4), pp.679-693.

Eisele, A.P.P., Mansano, G.R., de Oliveira, F.M., Casarin, J., Tarley, C.R.T. and Sartori, E.R., 2014. Simultaneous determination of hydrochlorothiazide and valsartan in combined dosage forms: Electroanalytical performance of cathodically pretreated boron-doped diamond electrode. *Journal of Electroanalytical Chemistry*, 732, pp.46-52.

Eissa, M.S. and Abou Al Alamein, A.M., 2018. Innovative spectrophotometric methods for simultaneous estimation of the novel two-drug combination: sacubitril/valsartan through two manipulation approaches and a comparative statistical study. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 193, pp.365-374.

El-Kosasy, A.M., Tawakkol, S.M., Ayad, M.F. and Sheta, A.I., 2015. New methods for amlodipine and valsartan native spectrofluorimetric determination, with factors optimization study. *Talanta*, 143, pp. 402-413.

El-Shaboury, S.R., Hussein, S.A., Mohamed, N.A. and El-Sutohy, M.M., 2012. Spectrofluorimetric method for determination of some angiotensin II receptor antagonists. *Journal of Pharmaceutical Analysis*, 2(1), pp.12-18.

Erk, N., 2002. Spectrophotometric analysis of valsartan and hydrochlorothiazide. *Analytical Letters*, 35(2), pp.283-302.

Farajzadeh, M.A., Khorram, P. and Pazhohan, A., 2016. Simultaneous determination of atorvastatin and valsartan in human plasma by solid-based disperser liquid-liquid microextraction followed by high-performance liquid chromatography-diode array detection. *Journal of Chromatography B*, 1017, pp.62-69.

Gadepalli, S.G., Deme, P., Kuncha, M. and Sistla, R., 2014. Simultaneous determination of amlodipine, valsartan and hydrochlorothiazide by LC–ESI-MS/MS and its application to pharmacokinetics in rats. *Journal of Pharmaceutical Analysis*, 4(6), pp.399-406.

Gong, A.Q. and Zhu, X.S. 2013. Determination of epristeride by its quenching effect on the fluorescence of L-tryptophan. *Journal of Pharmaceutical Analysis*, 3(6), pp.415-420.

Graham, J.P., Rauf, M.A., Hisaindee, S. and Alzamly, A., 2017. Spectral behavior and computational studies of fuchsin in various solvents. *Journal of Molecular Liquids*, 238, pp.193-197.

Ibrahim, F.A., El-Brashy, A.M., El-Awady, M.I. and Abdallah, N.A., 2018. Fast simultaneous quantitation of valsartan and amlodipine besylate using an eco-friendly micellar HPLC-UV method: Application to spiked human plasma and content uniformity testing for amlodipine. *Analytical Methods*, 10(43), pp.5227-5235.

Kaabipour, M., Khodadoust, S. and Zeraatpisheh, F. 2020. Preparation of magnetic molecularly imprinted polymer for dispersive solid-phase extraction of valsartan and its determination by high-performance liquid chromatography: Box-Behnken design. *Journal of Separation Science*, 43, pp.912-919.

Kamal, A.H., Marie, A.A. and Hammad, S.F., 2020. Validated spectrophotometric methods for simultaneous determination of nebivolol hydrochloride and valsartan in their tablet. *Microchemical Journal*, 155, p.104741.

Koseki, N., Kawashita, H., Hara, H., Niina, M., Tanaka, M., Kawai, R., Nagae, Y. and Masuda, N., 2007. Development and validation of a method for quantitative determination of valsartan in human plasma by liquid chromatography-tandem mass spectrometry. *Journal of Pharmaceutical and Biomedical Analysis*, 43(5), pp.1769-1774.

Krishnaiah, C., Reddy, A.R., Kumar, R. and Mukkanti, K., 2010. Stability-indicating UPLC method for determination of Valsartan and their degradation products in active pharmaceutical ingredient and pharmaceutical dosage forms. *Journal of Pharmaceutical and Biomedical Analysis*, 53(3), pp.483-489.

Kumar, L., Sreenivasa Reddy, M., Managuli, R.S. and Pai, K.G., 2015. Full factorial design for optimization, development and validation of HPLC method to determine valsartan in nanoparticles. *Saudi Pharmaceutical Journal*, 23(5), pp.549-555.

Lakowicz, J.R. 2013. *Principles of Fluorescence Spectroscopy*. Springer Science and Business Media, Berlin, Germany.

Lotfy, H.M., Hegazy, M.A., Mowaka, S. and Mohamed, E.H., 2015. Novel spectrophotometric methods for simultaneous determination of amlodipine, valsartan and hydrochlorothiazide in their ternary mixture. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 140, pp.495-508.

Macek, J., Klima, J. and Ptacek, P., 2006. Rapid determination of valsartan in human plasma by protein precipitation and high-performance liquid chromatography. *Journal of Chromatography B*, 832(1), pp.169-172.

Mansano, G.R., Eisele, A.P.P., Dall'Antonia, L.H., Afonso, S. and Sartori, E.R., 2015. Electroanalytical application of a boron-doped diamond electrode: Improving the simultaneous voltammetric determination of amlodipine and valsartan in urine and combined dosage forms. *Journal of Electroanalytical Chemistry*, 738, pp.188-194.

Marghany, K.A., Abdelsalam, R.A. and Haddad, G.M., 2020. HPLC method transfer study for simultaneous determination of seven angiotensin II receptor blockers. *Journal of Separation Science*, 43, pp.1398-1405.

Meselhy, E.M., Aboul Kheir, A.A., El Henawee, M.M. and Elmasry, M.S., 2020. Simultaneous determination of Nebivolol hydrochloride and Valsartan in their binary mixture using different validated spectrophotometric methods. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 230, pp.118083.

Moussa, B.A., Hashem, H.M.A., Mahrouse, M.A. and Mahmoud, S.T., 2018. A validated RP-HPLC method for the determination of rosuvastatin in presence of sacubitril/valsartan in rat plasma: Application to *in vivo* evaluation of OATP-mediated drug interaction potential between rosuvastatin and sacubitril/valsartan. *Microchemical Journal*, 143, pp.31-38.

Ning, J., Wang, M., Luo, X., Hu, Q., Hou, R., Chen, W., Chen, D., Wang, J. and Liu, J., 2018. SiO_2 stabilized magnetic nanoparticles as a highly effective catalyst for the degradation of basic fuchsin in industrial dye wastewaters. *Molecules*, 23(10), pp.2573.

Pathrose, B., Nampoori, V.P.N., Radhakrishnan, P., Sahira, H. and Mujeeb, A., 2016. Effect of femtosecond laser ablated silver nanoparticles in the thermo-optic properties of basic fuchsin dye. *Optik*, 127(7), pp.3684-3687.

Pathrose, B., Nampoori, V.P., Radhakrishnan, P. and Mujeeb, A., 2014. Measurement of absolute fluorescence quantum yield of basic fuchsin solution using a dual-beam thermal lens technique. *Journal of Fluorescence*, 24(3), pp.895-898.

Pathrose, B., Sahira, H., Nampoori, V.P., Radhakrishnan, P. and Mujeeb, A., 2014. Variations in fluorescence quantum yield of Basic Fuchsin with silver nanoparticles prepared by femtosecond laser ablation. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 128, pp.522-526.

Pebdani, A.A., Dadfarnia, S., Shabani, A.M.H., Khodadoust, S. and Haghgoo, S., 2016. Application of modified stir bar with nickel: Zinc sulphide nanoparticles loaded on activated carbon as a sorbent for preconcentration of losartan and valsartan and their determination by high performance liquid chromatography. *Journal of Chromatography A*, 1437, pp.15-24.

Qader, A., Salih, M., Tahir, T., 2018. Quantitativ e Quenching of Fluorescein Based Method for Determination of Valsartan in Some Pharmaceutical Product. In: Proceeding of the 2018 International Conference on Pure and Applied Science, Koya University, 23-24 April 2018. Available from: http://www.conferences.koyauniversity.org/index.php/pas/2018/paper/view/92>. [Last accessed on 2020 Oct 10].

Ragab, M.A.A., Galal, S.M., Korany, M.A. and Ahmed, A.R., 2017. First derivative emission spectrofluorimetric method for the determination of LCZ696, a newly approved FDA supramolecular complex of valsartan and sacubitril in tablets. *Luminescence*, 32(8), pp.1417-1425.

Ragab, M.A.A., Korany, M.A., Galal, S.M. and Ahmed, A.R., 2019. Voltammetric study of valsartan-Ni complex: Application to valsartan analysis in pharmaceuticals and in vivo human urine profiling. *Chemical Papers*, 73(5), pp.1209-1219.

Satana, E., Altinay, S., Goger, N.G., Ozkan, S.A. and Senturk, Z., 2001.

Simultaneous determination of valsartan and hydrochlorothiazide in tablets by first-derivative ultraviolet spectrophotometry and LC. *Journal of Pharmaceutical and Biomedical Analysis*, 25(5-6), pp.1009-1013.

Selvan, P.S., Gowda, K.V., Mandal, U., Solomon, W.D. and Pal, T.K., 2007. Simultaneous determination of fixed dose combination of nebivolol and valsartan in human plasma by liquid chromatographic-tandem mass spectrometry and its application to pharmacokinetic study. *Journal of Chromatography B*, 858(1-2), pp.143-150.

Shaalan, R.A. and Belal, T.S., 2010. Simultaneous spectrofluorimetric determination of amlodipine besylate and valsartan in their combined tablets. *Drug Testing and Analysis*, 2(10), pp.489-493.

Shah, J.V., Parekh, J.M., Shah, P.A., Shah, P.V., Sanyal, M. and Shrivastav, P.S., 2017. Application of an LC–MS/MS method for the analysis of amlodipine, valsartan and hydrochlorothiazide in polypill for a bioequivalence study. *Journal of Pharmaceutical Analysis*, 7(5), pp.309-316.

Shaikh, J.S.A., Raut, S., Abdul, A. and Pathan, M., 2020. High performance liquid chromatographic assay of amlodipine, valsartan and hydrochlorothiazide simultaneously and its application to pharmaceuticals, urine and plasma analysis. *Journal of Chromatography B*, 1155, pp.122295.

Shalan, S., El-Enany, N. and Belal, F., 2015. Simultaneous determination of amlodipine besylate and valsartan using a micelle-enhanced first derivative synchronous spectrofluorimetric method and application in their co-formulated tablets. *Analytical Methods*, 7(19), pp.8060-8068.

Tatar, S. and Saglik, S., 2002. Comparison of UV-and second derivative-spectrophotometric and LC methods for the determination of valsartan in pharmaceutical formulation. *Journal of Pharmaceutical and Biomedical Analysis*, 30(2), pp.371-375.

Vojta, J., Jedlicka, A., Coufal, P. and Janeckova, L., 2015. A new, rapid, stability-indicating UPLC method for separation and determination of impurities in amlodipine besylate, valsartan and hydrochlorothiazide in their combined tablet dosage form. *Journal of Pharmaceutical and Biomedical Analysis*, 109, pp.36-44.