J. Chil. Chem. Soc., 63, Nº 3 (2018)

A REVIEW ON DERIVATIVE UV-SPECTROPHOTOMETRY ANALYSIS OF DRUGS IN PHARMACEUTICAL FORMULATIONS AND BIOLOGICAL SAMPLES
REVIEW

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ABSTRACT

The review article deals with theoretical aspects of Derivative UV-Spectrophotometry. The method gains significance using the first and second derivative of the transmission spectra with respect to wavelength. Generated optical derivatives are compared to the known numerical derivatives. The derivative spectra from 1st to 4th are consequently discussed. This provides valuable insight into the uses and limitations of this technique for chemical analysis. Measurement techniques and methods of obtaining derivative spectra are discussed. The degree of polynomial fit on the smoothness of derivative spectra and signal-to-noise ratio is described. Application of UV derivative spectrometry for determination of single and multicomponent analysis is shown. Derivative spectrophotometry possibly improves the selectivity and sensitivity of determination which has been illustrated.

Keywords: Derivative UV-Spectrophotometry, First Order Derivative spectra, Second Order Derivative spectra, Third Order Derivative spectra, Fourth Order Derivative spectra and area under curve.

INTRODUCTION

Derivative UV-spectrophotometry is an analytical technique of enormous implication commonly in obtaining mutually qualitative and quantitative in order from spectra that are of unresolved bands, with respect to qualitative and quantitative analysis, it uses first or higher derivatives of absorbance in accordance with wavelength [1]. Derivative spectroscopy was originally brought in 1950s with its applicability in a lot of features, but because of its complication in producing derivative spectra via UV-Visible spectroscopy the method found less practice. The weakness was conquering in 1970s with microcomputers which gave derivative spectra in more specific, simple, rapid and reproducible way. This made to enlarge applicability of derivative method; Derivatization of spectra augments selectivity by eradicates spectral interferences [2-3].

Derivative Spectroscopy

It is a spectroscopic technique that differentiates spectra's mainly in IR, UV-Visible absorption and Fluorescence spectrometry [4]. The objective with which derivative methods used in analytical chemistry are:

- Spectral differentiation
- Spectral resolution enhancement
- Quantitative analysis

Spectral differentiation

As a qualitative method that distinguish small variation between almost similar spectra's.

Spectral resolution enhancement

Overlapping spectral bands gets resolved to simply estimation the number of bands and their wavelengths.

Quantitative analysis

It facilitates multicomponent analysis and corrects the irrelevant background absorption. Derivative spectroscopy method forms the beginning of differentiation or resolution of overlapping bands; the vital characteristics of derivative process are that broad bands are suppressed relative to sharp bands [4].

Measurement Techniques of the Derivative Spectroscopy

Differentiation of a zero order spectrum of a combination of components shows the way to derivative spectrum of any order. There are many methods are used for discrimination of a spectrum *viz*., by analog or numeric method, spectral differentiation may be deliberate either graphically on paper or registered in a computer memory [5]. Measurement of derivative spectra value is achieved out by three methods *viz*. graphic measurement, numeric measurement, zero crossing technique

Graphic measurement

Graphic measurement is theoretical method for calculate the derivative spectra on paper, its manual method it suffer from disadvantage that it gives inaccurate results because the value can determined numerically can be abolish or diminish beyond restriction [5].

Numeric measurement

The method uses set of points where derivative values is carried out by estimating the derivative value at a given wavelength. It gives derivatives by spectral differentiation using suitable numerical algorithm [5].

Zero crossing technique

The method measures the derivative spectra at a particular wavelength, where the derivative crosses the point at zero line. Interference of one component in determination of other component can be eliminated by zero crossing technique [5].

Derivative Spectra

In quantitative analysis, derivative spectra enlarge difference between spectra to resolve overlapping bands [6]. The digital algorithm method called as Savitzky-Golay is most outstandingly referred for obtaining derivative spectra. In universal technique involves plotting the rate of change of the absorbance spectrum *vs* wavelength [7]. Derivative spectra can obtain by variety of experimental techniques; the differentiation can be done numerically even if the spectrum has been recorded digitally or in computerized readable form. When spectrum is scanned at a constant rate, real time derivative spectra can be recorded either by achieving the time derivative of the spectrum or by wavelength modulation [8]. Wavelength modulation device is used to record the derivative spectra, where a beam of radiation differs in wavelength by a small change (1-2 nm) and difference between the two readings is recorded, computerized method is widely used to obtain derivative curves.

Quantitatively for second or fourth order derivative curves, peak heights are measured of long-wave peak satellite or for short-wave peak satellite [9]. The degree of difficulty of derivative spectra increases with presence of satellite peaks. Second derivative spectra are represented by presence of two sharp peaks and troughs. The solvents have amazing effect over peaks [10]. On the basis of solvents polarity, peaks and troughs shifts either to shorter or longer wavelength (Fig. 1).

The way of obtaining the derivative orders

Derivative spectroscopy accomplishes conversion of a normal or zero order spectrums to its first, second or higher derivative spectrum. It yields considerable changes in shape of derivative achieved. Appropriate selection of derivative order gives useful separation of overlapped signals. Criterion like signals height, their width and distance between maxima in basic spectrum is achieved by optimal derivative order, to attain wide spectrum bands it is expected to use low orders and for narrow spectral bands-higher orders. A Gaussian band represents an ideal absorption band gives clear idea about transformation occurring in the derivative spectra. Plotting absorbance versus wavelength gives a graph ,showing peak with maxima and minima (also points of inflection) that is supposed to passed through zero on the ordinate [10] (Fig. 2).

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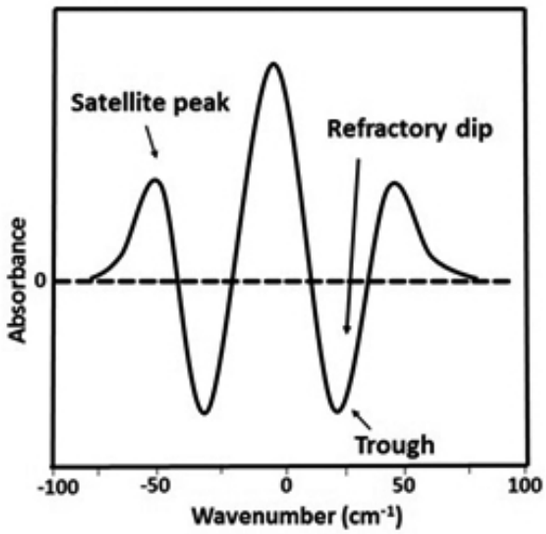

Figure 1: Derivative Spectra.

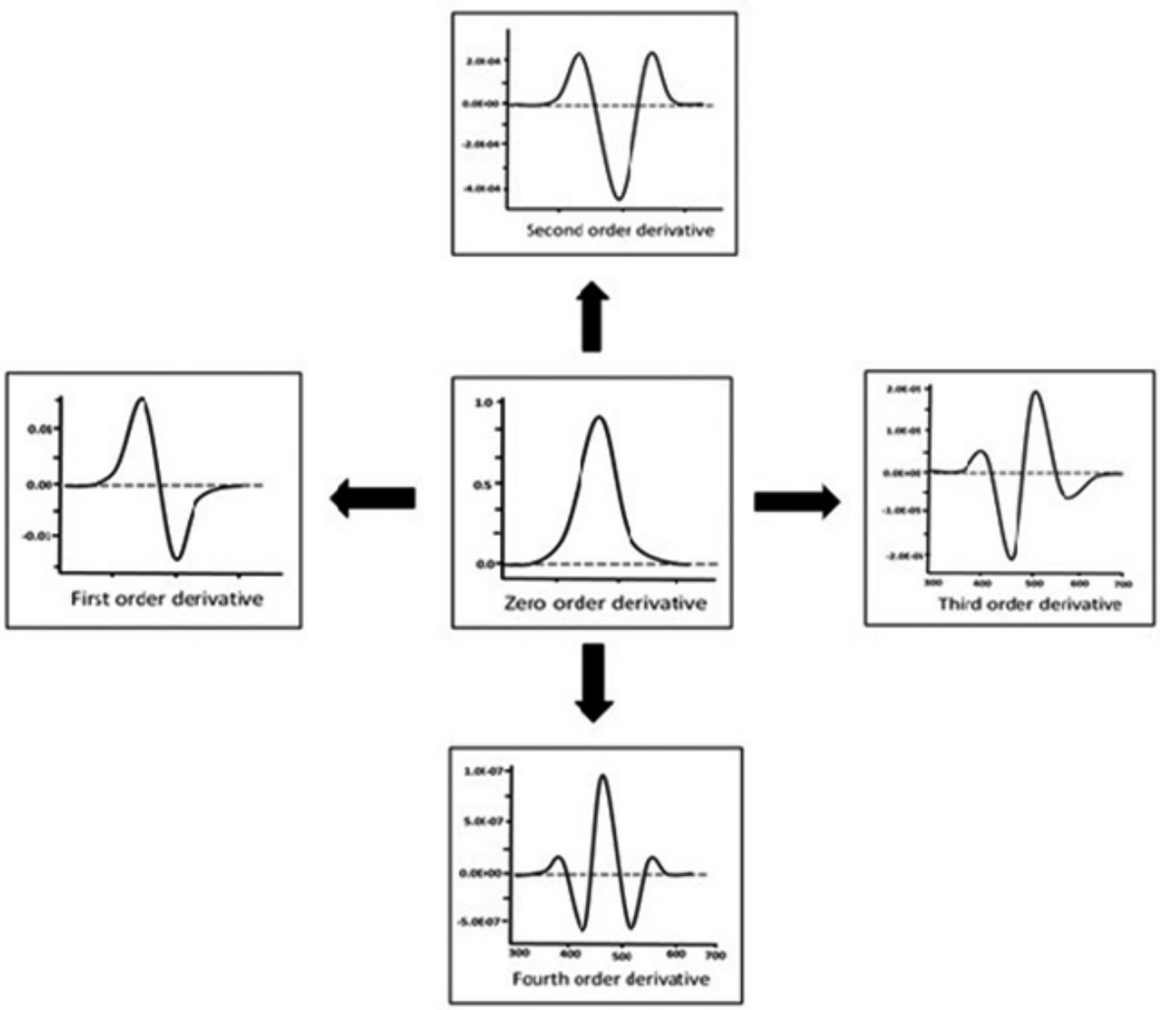

Figure 2: Oder of Derivative Spectra.

Zero order derivative spectrum

Zero order derivative is initial step of giving further derivatives i.e., zeroth order spectrum can give nth order derivative. In derivative spectroscopy, D^0 spectrum i.e. zeroth order is a representative feature of normal absorption spectrum [12]. The 1st, 2nd, 3rd and 4th order derivative spectra can be obtained directly from the zeroth order spectrum. An increase in order of derivatives increases the sensitivity of determination [14]. If a spectrum is expressed as absorbance (A) as a function of wavelength (λ), the derivative spectra is given as,

$A = f(\lambda)$,

First order derivative spectrum

Spectra obtained by derivatizing zero order spectrum once. It is a plot of change of absorbance with wavelength against wavelength[10] i.e. rate of change of the absorbance with wavelength,

$dA/d\lambda = f'(\lambda)$

Even if in derivatized form it is more complex than zero order spectrum. First order spectra passes through zero as λ max of the absorbance band.[6] Absorbance band of first order derivative shows certain positive and negative band with maxima and minima [6]. By scanning the spectrum with a minimum and constant difference between two wavelengths, dual-wavelength spectrophotometer obtains first-derivative spectra [8].

Second order derivative spectrum

Derivatizing the absorbance spectrum twice gives this type of spectra [7]. It is a plot of curvature of absorption spectrum against wavelength [16].

$d^2A/d\lambda^2 = f''(\lambda)$

Second derivative has direct relation with concentration i.e. directly proportional. $d^2A/d\lambda^2$ must be large, large the ratio greater is the sensitivity [8]. The method is useful in obtaining atomic and gas molecular spectra.

Third order derivative spectrum

Unlike second order spectrum third derivative spectrum shows disperse function to that of original curve [11].

$d^3A/d\lambda^3 = f'''(\lambda)$

Fourth-derivative spectrum

Fourth order is inverted spectrum of second order and has a sharper central peak than the original band, Narrow bands are selectively determined by fourth derivative (UV-high pressure) [9].

$d^4A/d\lambda^4 = f'(\lambda)$

Polynomial degree

Polynomial degree has a great impact on number of polynomial points rather than on shape of derivative [5]. The scope of polynomial is less; differentiation of spectra of half-width is used by low degree polynomials and that for spectra of small half -width by higher degree polynomials [5]. Distorted derivative spectrum is a result of inappropriate polynomial degree. In case of multicomponent analysis, the spectral differences of assayed compounds and their selective determination can be increased by the use of different polynomial degrees [2].

Signal-to-noise ratio

Derivative technique becomes difficult when used with higher orders that produce signal-to-noise worse [1]. The result is decrease in S/N with higher orders. The noise is responsible for sharpest features in the spectrum. There are increased demands on low-noise characteristics of the spectrophotometer by negative effect of derivatization on S/N.[5] S/N can be improved prior to derivatization if spectrophotometer would scan spectra and average multiple spectra [6]. Best signal-to-noise ratio can be obtained by taking the difference between the highest maximum and the lowest minimum, but this leads to enhanced sensitivity to interference from other components [2]. Noise of signal is expressed by standard deviation σ. Standard deviation σ_0 expresses the noise of normal spectrum of the absorbance of blank while standard deviation σ_n expresses nth order derivative that can be calculated by σ_0 [1, 2].

Smoothing of spectra

Increase in signal-to-noise ratio generates many worse conditions, to lessen the condition or to decrease the high-frequency noise, technique is used *viz*; low-pass filtering or smoothing. Smoothing is an operation that is performed on spectra separately on each row of the data and acts on adjacent variables [14]. The noise can be lower significantly without loss of the signal of interest when variables are close to each other in the data matrix and contain similar information [12]. Derivative spectrum may be altered with a high degree of smoothing so, care must be taken [1, 6]. The smoothing effect depends upon two variables mainly on: (a) Frequency of smoothing and (b) the smoothing ratio i.e. ratio of width of the smoothed peak to the number M of data points [15].

Advantages and Disadvantages of Derivative UV-Spectrophotometry

Advantages

UV Derivative Spectroscopy has increased sensitivity and selectivity. It has multiple advantages *viz*., single component analysis and simultaneous determination of several components in a mixture, determination of traces in matrix, protein and amino acid analysis, environmental analysis, identification of organic and inorganic compounds [5].

Specific benefits of derivative spectral analysis includes *viz*;

- Even in small wavelength range, in presence of two or more overlapped peaks, absorbance bands can be identified.
- In presence of strong and sharp absorbance peak, weak and small absorbance peak can be identified.
- Broad absorbance spectrum gives clear idea about the particular wavelength at that maximum spectrum.
- Even in presence of existed background absorption, the quantitative analysis can studied as there is linear relationship between the derivative values and the concentration levels [13, 14].

Disadvantages

Even though it is sensitive method still it is highly susceptible to various parameters. The method is limited to particular system only and has limited applications due to its less reproducibility. The method is second choice when existing instrumental method (which measures signal) is absent. It is less accurate in measuring zero-crossing spectra. There is likeness in shape of derivative spectra and zero order spectrum, so small variation in a basic spectrum can strongly modify derivative spectrum. Poor reproducibility can alter results in way when different spectrophotometers used for zero order spectra gives similar results but derivatization of them display different [15].

Applications

a. Single component analysis: Derivative spectrophotometry analyses single component (Table 1) along with Area under Curve (Table 3) in pharmaceutical formulation.

b. Multicomponent analysis: Derivative spectrophotometry in pharmaceutical analysis analyses more than one component in presence of other components i.e. simultaneous determination of two or more compounds. Spectral derivatization can remove the prevalence caused by spectra of disturbing compounds (Table 2) [3]

c. Bioanalytical application: Besides pharmaceutical analysis, derivative spectrophotometry may be applied to different areas. Determination of compounds in various biological samples like plasma, serum, urine and brain tissue [2]. Amphotericine [52] and Diazepam [26] has been determined in human plasma with its order of derivatives.

d. Forensic toxicology: Derivative spectroscopy has its application in toxicology especially of illicit drugs *viz*; amphetamine, ephedrine, meperidine, diazepam, etc. and can also be used in mixtures [1].

e. Trace analysis: Derivative signal processing technique is widely used in practical analytical work in measurement of small amounts of substances in the presence of large amounts of potentially interfering substances [4]. Due to such interference, analytical signals becomes weak, noisy and superimposed on large background signals. The conditions like non-specific broadband interfering absorption, non-reproducible cuvette positioning, dirt or fingerprints on the cuvette walls, imperfect cuvette transmission matching, and solution turbidity results in degraded measurement precision is by sample-to-sample baseline shifts [4]. Baseline shifts may be due to practical errors, either are weak wavelength dependence (small particle turbidity) or wavelength-independent (light blockage caused by bubbles or large suspended particles). So, there is need of differentiation of relevant absorption from these sources of baseline shift [5]. It is expected to suppress broad background by differentiation with a aim that it reduces variations in background amplitude from sample-to-sample. This results in improved precision and measurement in many instances, especially in case if there is a lot of uncontrolled variability in the background and when the analyte signal is small compared to the background [4].

CONCLUSION

Derivative Spectrophotometry is presently available with software's controlling modern spectrophotometers. This makes easy to analyst in obtaining useful information from spectra of respective compounds. The derivatives of UV spectra give applicable information in elucidating compounds in pharmaceutical formulation. This present article provides complete understanding about derivative spectrophotometry technique & its applications.

Table 1: Single Component determination of analyte in Pharmaceutical sample.

Drug	Order of derivative	Wavelength selected(nm)	Linearity (µg/ml)	Year of publication	Reference
Efavirenz	D_0 D_1	239nm 248nm	5-40	2014	16
Carbimazole	D_1 D_2 D_3 D_4	314nm 300nm 289nm 320nm	2-18	2014	17
Aripiprazole	D_0	217nm	1-6	2014	18
Chlorthalidone	D_1 D_2	278nm & 288nm 286nm & 292nm	1-25	2014	19
Famotidine	D_1 D_2	Valley-272.2nm Max.amplitude-287.7nm	4-12	2014	20
Lacosamide	D_1	250nm	5-50	2013	21
Repaglinide	D_0 D_1	293nm 245nm	10-80 10-70	2013	22
Dronedarne	D_0 D_1	290nm 275nm	4-20n	2013	23
Irbesartan	D_3 D_4	224nm 230nm	2-20 2-14	2012	24
Ciprofibrate	D_1	232nm	2-12	2012	25
Diazepam	D_4	306-333nm	2-10	2012	26
Stavudine	D_0 D_1 D_2	265nm 250.8nm 232.8nm	2-20 2-20 2-20	2012	27
Diarcerein	D_1	259.4 & 274.2nm	2-12	2012	28
Neomycin	D_1	277nm	0.10-0.51	2011	29
Fluconazole	D_1	268nm	150-350	2011	30
Nebivolol HCl	D_2 D_3	296nm 290nm	40-80 10-60	2011	31
Ranitidine HCl	D_0 D_1	312nm 332nm	0.5-35.1	2011	32
Ritonavir	D_2	232nm	10-50	2011	33
Alprazolam	Overlain derivative spectroscopy	521nm	5-45	2011	34
Tropicamide	D_3 D_4	263.8nm 255.4nm	10-100 10-100	2010	2
Olanzapine	D_1 D_2	222nm 230nm	2-10 2-10	2010	2
Galanthamine	D_1 zero crossing spectroscopy	277.4nm	30-80	2010	2
Cisapride	D_1 D_2	264,300nm 276,290nm	2-10 2-10	2010	35
Cefuroxime axetil	D_1	281nm	4-30	2010	36
Gemifloxacin mesylate	D_0 D_1 D_2	430nm 480nm 500nm	2-14 1-10 1-15	2010	37
Letrozole	D_0 D_1 D_2	240nm 224nm 241nm	0.25-20	2010	38
Losartan potassium	D_0 D_1	205nm 234nm	3-7 4-16	2010	39
Lopinavir	D_1	220nm	5-35	2010	40
Ropinirole	D_1	262.5nm	4-20	2010	41

Metoprolol	D_0 D_1 D_2 D_3	276nm 265,278,285nm 276,279,287,282nm 275,278,218nm	5-15	2010	42
Venlafaxine HCl	D_3	274nm	40-120	2010	43
Sertraline HCl	D_1	475.72-588.40nm	5-100	2009	2
Estapenem	D_1 D_2	316nm 298nm & 316nm	4-60 2-28	2009	2
Candesartan cilexetil	D_1	270.1nm	6-32	2009	44
Gentamicin sulfate	D_3	281nm	0.004-0.008%	2009	45
Pioglitazone	D_0 D_2	270nm 272-287.4nm	5-20 2-12	2009	46
Benazepril	D_1 D_2 D_3	213nm 219nm 223nm	1.2-12	2009	47
Ezetimibe	D_1 D_2 D_3	259.5nm 269nm 248nm	4-14 4-14 4-16	2008	48
Drotaverine	D_2	247.4nm	4-32	2008	49
Tenofovir	D_0 D_1	260nm 273nm	5-40	2008	50
Prednisolone	D_0	242nm	0.36-50.46	2008	51
Amphotericine	D_0	300nm & 500nm	1.25-5	2008	52
Amoxicillin	D_1 D_2	255.8nm 249.2nm	3.2-48	2008	53
Losartan	D_1	220-320nm	2-50	2004	55

Table 2: Simultaneous determination of two or more compounds in Pharmaceutical sample.

Drug	Order of derivative	Wavelength (nm)	Linearity (µg/ml)	Year	Reference
17-β Estradiol & Drospirenone	D_1 Zero crossing	208nm 282nm	0.5-8 0.5-32	2015	56
Tramadol HCl& Paracetamol	D_1	200-500nm	6-48 25-112	2015	57
Acetaminophen, Diphenhydramine & pseudoephedrine	Zero crossing method	281.5nm 226nm 218nm	5-50 0.25-4 0.5-5	2015	58
Chloramphenicol, Dexamethasone & Naphazoline	D_1	220nm	20-70 6-14 3-8	2015	59
Zofenopril & Fluvastatin	D_1 D_2 D_3 D_1 D_2 D_3	270.85nm 286.38nm 253.90nm 339.03nm 252.57nm 258.50nm	7.65-22.94 5.60-28	2015	60
Nebivolol & Clinidipine	D_1	221.6nm 249nm	4-20 5-25	2012	61
Ibuprofen & Paracetamol	D_1	200-235nm	12-32 20-40	2014	62
Levofloxacin hemihydrate & Ambroxol hydrochloride	D_1 Zero crossing	255.70nm 253nm	5-40 3-10.5	2014	63
Gatifloxacin & Prednisolone	D_1	348nm 263nm	3-21 6-42	2014	64

Diclofenac potassium, Paracetamol & Serratiopeptidase	D_1	252nm 276nm 330nm	2-15 2-30 2-80	2014	65
Rosuvastatin calcium & Fenofibrate	Zero crossing point	224.11nm 243.29nm	16-48 4-12	2013	66
Paracetamol & Etodolac	Zero crossing point	247nm 280nm	5-25 2-18	2013	67
Salbutamol sulphate & Ketotifen fumarate	D_1 D_1	257nm 278nm	5-45 5-35	2013	68
Pioglitazone HCl& Glimepride	D_1 Zero crossing	225nm 248nm	5-30 4-20	2013	69
Levocetrizine HCl& Phenylephrine HCl	D_0	230nm 216nm	3-9 6-18	2013	70
Ofloxacin & Ornidazole	D_1	278nm 293.6nm	0.5-10 2-30	2013	71
Tolperisone & Paracetamol	D_1	261nm 243nm	0-2.5 3-9	2013	72
Paracetamol & Domperidone	D_1	250nm 285nm	5-25 0.8-5	2013	73
Drotaverine & Mefenemic acid	D_1	253.8nm 304nm	4-24	2013	74
Moxifloxacin & Cefixime	1st zero crossing wavelength	200-400nm 287nm & 317.9nm	1-16 1-15	2012	75
Ibuprofen & Famotidine	D_1	249nm 263.6nm	4-20 120-600	2012	76
Telmisartan & Metoprolol	D_2	299.5nm 224nm	3-15	2012	77
Nebivolol & S-Amlodipine	D_0 D_1	280 & 364nm 294 & 279.7nm	10-60 5-30	2012	78
Lamivudine & Zidovudine	D_1	279nm 300nm	10-50	2012	79
Ondansetron & Pantoprazole	D_1	288.5nm 310nm	0.5-25 5-25	2012	80
Drotaverine & Nimesulide	Ratio derivative spectroscopy	254 & 274.68nm 221.09 & 232.067nm	8-24 20-60	2012	81
Metoprolol & Amlodipine	Ratio derivative spectroscopy D_1	277.01nm 235.62nm	50-250 5-25	2012	82
Aceclofenac & Tizanidine	1st by zero crossing method	250nm 313nm	2-20 1-10	2011	83
Atrovastatin calcium & Amlodipine	D_0 D_1	241nm 250nm	0-14 0-7	2011	84
Gemifloxacin mesylate & Ambroxol HCl	D_1	272nm 249.5nm	8-40 6-30	2011	85
Tenofovir disoproxil fumarate &Emtricitabine	D_1	224.38 & 306.88nm	3-21 2-14	2011	86
Simvastatin & Ezetimide	D_1 D_1	219nm 265nm	2-40 1-20	2010	2
Clopidogrel Bisulphate & Aspirin	D_2	254nm 216nm	5-30	2010	2
Atorvastatin calcium & Ezetimibe	D_1	266.6nm 262.2nm	3-15	2010	87
Strychnine & Brucine	D_1 D_1	265.4nm 256.4nm	10-50	2010	88
Pantoprazole sodium & Itopride	D_1	238.5-288nm	3-15 2-38	2010	89

Drotaverine HCL & Paracetamol	D_1	303.5nm 243.5nm	5-50 5-60	2010	90
Triprolidine HCl& Pseudoephedrine HCl	D_2 D_2	321nm 271nm	200-100 10-50	2009	2
Amoxicillin & Cephalexin	D_1 D_2 D_1	226nm 274nm 212nm	10-60	2009	91
Cephalothin & Cefoxitin	D_1	235nm 236.7nm	4-32	2009	92
Tramadol & Ibuprofen	D_1	230.5nm 280nm	5-50	2008	2
Alendronate Na salt, Clodronate disodium salt & Etidronate disodium salt	D_1 D_2 D_3 D_1 D_2 D_3 D_1 D_2 D_3	233nm 245nm 254nm 236nm 261nm 284nm 232nm 243nm 253nm	25-600	2008	93
Doxylamine succinate, Pyridoxine HCl& Folic acid	D_1	270nm 332.8nm 309.2nm	2.5-50 1-40 1-30	2008	94
Nebivolol & Hydrochlorothiazide	D_1	294.6nm 334.6nm	8-40 10-60	2008	95
Metoprolol & Felodipine	D_1	222nm 235nm	20-150 10-60	2007	96
Ranitidine HCl& Ondansetron HCl	D_1	340.8nm 276.0nm	5-500 2-30	2007	97
Ondansetron & Paracetamol	D_1	302nm 246nm	0.5-0.20 20-30	2006	98
Metoprolol & Hydrochlorothiazide	D_3 D_1	281nm 282nm	100-300 12.5-37.5	2006	99
Chlorprothixene & Amitryptyline	D_1 D_2	316nm 261.4nm & 268nm	0.5-50 0.5-75	2005	100
Phenytoin, Barbital & Caffeine	D_1	207nm 210nm 230nm	0.24 0.01-27 0.049-27	2005	101

Table 3: Determination of compounds in pharmaceutical sample along with AUC.

Drug	Order of derivative	Wavelength (nm)	Linearity (µg/ml)	AUC	Year	Reference
Tinidazole	D_1	268nm	5-25	314nm-322nm	2015	102
Ofloxacin	D_1	334nm	2-12	284nm-292nm	2015	103
Azelnidipine	D_1	242.6nm	1-20	250.5nm-258.8nm	2015	104
Finofibric acid	D_1	299nm	5-30	275nm-316nm	2015	105
Fluoxetine HCl	D_0	226nm	5-25	220nm-231nm	2015	106
Ondasatron HCl	D_2	_	2-10	248nm-254nm	2015	107
Ciprofloxacin HCl	D_2	_	2-10	270nm-278nm	2015	108
Ranitidine	D_2	238nm	3-18	310nm-324nm	2015	109
Diclazuriline	D_1	260nm	2-22	300nm-273nm	2014	110
Tadalafil	D_1	297nm	5-50	290nm-304nm	2014	111
Carvedilol HCl	D_1	233.7nm	1-14	240nm-244nm	2014	112
Rosuvastatin	D_1	252nm	5-35	247nm-257nm	2014	113
Aceclofenac	D_0 D_1	274.65nm 259nm	5-30	269nm-279nm	2014	114
Rupatadine fumarate	D_1	214nm	1-30	244nm-255nm	2014	115

Imatimib mesylate	D_1	285nm(maxima) 227nm(minima)	5-30	237nm-277nm	2013	116
Oxolamine citrate	D_1	229.2nm	1-14	228.6nm-246.4nm	2013	117
Darunavir	D_1	248nm	2-24	257nm-267nm	2013	118
Paliperidone	D_0	238nm	3-18	232nm-244nm	2013	119
Isoniazide & Paraamino salicylicacid	D_1	243nm 257nm	2-10	258nm-268nm	2013	120
Glipizide	D_1	286nm(maxima) 263nm(minima)	5-25	255nm-295nm	2012	121
Zolpidem tartrate	D_0 D_1	305nm(maxima) 263nm(minima)	5-50	316nm-263nm	2012	122

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