WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 14, Issue 6, 627-660. Review Article ISSN 2277–7105

A COMPREHENSIVE REVIEW OF DRUGS DETERMINED BY SPECTROPHOTOMETRY USING NQS AS A CHROMOGENIC REAGENT IN THE PAST DECADE

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Article Received on
28 Jan. 2025,

Revised on 17 Feb. 2025,
Accepted on 09 March 2025

DOI: 10.20959/wjpr20256-35928

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ABSTRACT

Spectrophotometry with NQS (N-(1-Naphthyl)ethylenediamine dihydrochloride) is commonly used to measure the concentration of substances like nitrites or certain drugs in a solution. When the analyte (such as nitrites) reacts with the NQS reagent, it forms a colored complex. This complex absorbs light at a specific wavelength, and the intensity of this absorption is directly related to the concentration of the analyte. A spectrophotometer is used to measure how much light the solution absorbs at that wavelength. By comparing this absorbance to a known calibration curve, the concentration of the analyte can be determined. This method is effective and precise for measuring substances that react with the NQS reagent.1,2-Naphthoquinone-4-sulfonic acid sodium salt (NQS) is a widely used chromogenic reagent in analytical chemistry, particularly for the spectrophotometric determination of pharmaceutical amines. Its popularity stems from its efficient reactivity with both primary and secondary amines, forming colored complexes that can be quantitatively analyzed.

KEYWORDS: Spectrophotometry**,** 1, 2 Napthaquinone 4-sulphonate sodium (NQS).

INTRODUCTION

One of the most flexible and popular analytical methods in pharmaceutical sciences is spectrophotometry, which allows for the qualitative and quantitative evaluation of

medications and their constituents. Measuring the intensity of light absorbed by a chemical at a particular wavelength is the foundation of spectrophotometry. The compound's concentration in the sample determines this absorbance, which is essential for figuring out the stability, purity, and content of the medicine. Spectrophotometric techniques are frequently chosen because they are easy to use, economical, and can yield precise findings with little sample preparation.[1] Reagents are essential to these techniques because they react with pharmaceutical chemicals to create colored complexes that absorb visible or ultraviolet light, enabling accurate analyte measurement.[2] The broad use of spectrophotometric techniques in the pharmaceutical sector for drug development, quality assurance, and regulatory compliance accounts for their significance. This technique's adaptability is increased by the ability to target particular functional groups or chemical structures of drug molecules with various reagents, which makes it appropriate for a wide range of applications, including impurity profiling and drug assay. It is also essential for routine pharmaceutical examination since spectrophotometry provides a non-destructive method of analysis that preserves samples while yielding useful information on concentration, purity, and degradation.[3] Because regulatory bodies need exact analytical techniques for drug approval and monitoring throughout the product's lifecycle, its importance goes beyond guaranteeing drug safety and efficacy.[4]

Principle of spectrophotometry

The measuring of a substance's absorption of light as a function of wavelength forms the basis of spectrophotometry. A portion of the light is absorbed by the molecules in a solution when it travels through them, while the remainder is transmitted. The concentration of the material and its chemical structure's capacity to absorb light at a specific wavelength determine how much absorption occurs.[4] Beer-Lambert's Law quantifies this relationship by stating that a substance's absorbance (A) is directly proportional to its concentration (c), sample cell path length(1) and molar absorptivity (ε), a constant that indicates how strongly a substance absorbs light at a specific wavelength.[5] Different light wavelengths are passed through a sample in spectrophotometry to ascertain its absorbance at each wavelength, usually in the visible (Vis) or ultraviolet (UV) spectrum. The λmax, or wavelength at which maximum absorbance occurs, is indicative of the material under study and aids in compound identification. The concentration of the analyte in a sample can be ascertained by comparing its absorbance values to a calibration curve made from standards with known concentrations.[6]

Reagents Used in Spectrophotometric Techniques

Complexing agents

Principle: Pharmaceutical analytes and complexing agents combine to generate stable, colorful complexes that increase the analyte's absorbance at a particular wavelength. This makes the spectrophotometric approach more sensitive and makes it possible to quantify the analyte in the sample.[7-9]

Significance in the Field of Pharmaceuticals: These agents are essential for the detection and measurement of metal ions and medicinal compounds that do not naturally absorb heavily in the UV-visible spectrum, which makes them important in the pharmaceutical industry. They are frequently employed in the assay of medications that contain metals or that have the ability to combine with metal ions, assisting in ensuring the effectiveness and purity of pharmaceutical compositions.

Examples

1. Ethylene diamond tetra acetic acid (EDTA)
2. Dimercaprol
3. Cyanide (CN^-)
4. Oxalate ($C_2O_4^{-2}$)
5. Ammonia (NH_3) and Ammines
6. Thiosulfate ($S_2O_3^{-2}$)
7. Thiourea ($Sc(NH)_2)_2$)
8. Tartarate ($C_4H_4O_6^{-2}$)
9. 1, 10 phenanthroline

Table -1: The Significance of Reagents in Spectrophotometric Analysis.

Reagent categorization	Principle	Significance in the pharmaceutical Industry
Metal ion chelators	These reagents are also known as complexing agents. Generate vibrant, stable complexes with analytes, increasing absorbance intensity and analytical sensitivity.	Crucial for detecting metal ions and non-chromophoric drugs, ensuring drug purity and efficacy.
Redox Reagents	These reagents are also known as electron acceptor or oxidizing agents. Cause oxidation or reduction of the analyte, producing a measurable change in absorbance	Useful for stability testing and analyzing drugs that lack inherent chromophores
Acid base sensors	These reagents are also known as protonation indicators or pH indicators.	Essential for determining drug solubility, stability, and acid-base equilibria in

	Change color in response to pH changes, allowing detection of acidic or basic drug compounds	formulations
Electrophilic substitution Reagents	These reagents are also known as Diazotization reagents or Azo dye precursor. Convert primary amines into diazonium salts, which couple with reagents to form-colored azo compounds	Important for analyzing drugs with primary amines and ensuring the absence of harmful by-products**.**

Oxidizing/reducing agents

Principle: Reducing agents can also alter the oxidation state of the analyte, producing a detectable color shift, while oxidizing agents cause the drug molecule to oxidize, forming a product with distinct absorbance characteristics that are frequently detectable in the visual range.[10-12]

Significance in the pharmaceutical industry: Drugs without chromophores (light-absorbing groups) require oxidizing and reducing agents. These agents enable precise concentration analysis of these medications by altering their oxidation state. Since oxidation produces a large number of breakdown products, these reagents are particularly helpful for stability testing**.**

Examples of oxidizing agents

1. Potassium permanganate ($KMnO_4$)
2. Hydrogen peroxide (H_2O_2)
3. Chromic acid (H_2CrO_4) or potassium dichromate ($K_2Cr_20_7$)
4. Nitric acid (HNO_3)
5. Fluorine (F_2), Chlorine (Cl_2) , Bromine (Br_2)
6. Ozone (O_3)
7. Ferric ion (Fe^{+3})

Examples of Reducing agents: (Electron donors)

1. Sodium Borohydride ($NaBH_4$)
2. Lithium Aluminum Hydride ($LiAlH_4$)
3. Hydrogen gas (H_2) with metal catalysts (eg: PD, pt, Ni)
4. Carbon monoxide (CO)
5. Sodium (Na) or Lithium (Li) metals
6. Iron sulfate ($FeSO_{4)}$
7. Ascorbic acid (Vitamin -C)

PH Indicators

Principle: Compounds that alter color in response to a solution's pH are known as pH indicators. The indicator molecule's dissociation causes a change in color that makes it visible by spectrophotometry by changing its light-absorbing characteristics.[13-16]

Significance in the pharamaceutical industry: When analyzing medication acid-base equilibria, pH indicators are frequently employed, especially when titrating basic or acidic pharmaceuticals. They are essential for making sure formulations have the proper pH, which might impact the stability, solubility, and bioavailability of drugs.

Examples

1. Litmus
2. Bromothymol blue
3. Bromo cresol Green
4. Phenolphthalein
5. Methyl Orange
6. Universal Indicators

- Red for strong acids
- Green for neutral solutions
- Purple for strong bases

Diazotization reagents

a) Principle: Pharmaceutical companies utilize diazotization reagents, usually sodium nitrite and hydrochloric acid, to change primary amines into diazonium salts. Following their coupling with another reagent, these diazonium compounds can create an azo compound, which is typically strongly colored and detectable by spectrophotometry.[17-19]

Significance in the pharmaceutical industry: The analysis of medications containing primary aromatic amines, which are prevalent functional groups in many pharmaceuticals, benefits greatly from diazotization processes. This technique offers a very sensitive way to measure these medications in dose and bulk forms. Additionally, it is widely used in quality control and impurity profiling to make sure that pharmaceutical formulations don't contain hazardous byproducts like aniline derivatives.

Examples

1. Sulfonamide antibiotics

2. N-(1-naphthyl) ethylenediamine
3. Sodium nitrite ($NaNO_2$) + Acid (HCl, H_2SO_4, etc.)
4. Nitrosyl chloride (NOCl)
5. Nitrosyl sulfuric acid ($NOHSO_4$)
6. Amyl nitrite ($C_5H_{11}ONO$)
7. Isoamyl nitrite ($C_5H_{11}ONO$)
8. Tert-Butyl nitrite (t-BuONO)

Table 2: Application of NQS as a chromogenic reagent used in the determination of pharmaceutical drugs by spectroscopy.

S.No	Drug	Category	Solvent to prepare std drug soluton	Wavelength (nm)	Reagent	Reaction condition	Linearity Range(ug/ml)	Co efficient constant	Molar absorptivity	LOD & LOQ	Applications	References
1	Rivaglitazone	Antibiotic Antidiabetic	Distilled water	459	0.01M of NQS was prepared by dissolving 0.26 g of NQS in 100 ml of distilled water	Add 1ml of 10ppm standard drug solution+(0.1-3.5)ml of 0.01M NQS reagent and the absorbance was measured	0.3 -25	0.9974	1.94103L.mole^{-1}cm^{-1}	0.34 &1.138	Tablets	[20]
2.	Sulfasalazine	Antibiotic	Water	456	0.05g of NQS in distilled water in 200ml volumetric flask & solution was made up to the mark	0.08g of std drug dissolved in distilled water in 200 ml volumetric flask +3 drops of NaOH and the solution was made up to the mark than absorbance was measured	(1-25) ×10^{-5} M	0.9893	1.438×104L/mol^{-1} cm^{-1}	0.0911 &0.0273	Tablets	[21]
3.	Finasteride	Anticancer	Equal volumes	447	0.3% (w/v) of NQS	20mg of finasteride	2-14ug/ml	0.999	-	0.03& 0.09	Tablets	[22]

			of methanol and distilled water		was prepared by dissolving 0.3 g of NQS in distilled water in 100ml volumetric flask made up to mark with distilled water	standard drug was dissolved in a mixture of equal volumes of methanol and distilled water + 1.0ml of 0.3% NQS + 1.0 ml of (Ph 13.0) Na_3 HPO_4 buffer solution make the volume with distilled water in 50ml volumetric Flask than absorbance was measured						
4	Atomoxetine HCL	Norepinephrine reuptake inhibitor	Distilled Water	474nm	An accurately weighed NQS 0.30 g was transferred into a 100 mL volumetric flask and dissolved in an appropriate	Standard drug solution of Atomoxetine HCL (100ug/ml) + 1% w/v potassium hydroxide (2 mL)+0.3% w/v 1,2naphthoquinone-4-sulfonic acid	10-50ug/ml	0.999	-	0.20& 0.606	Tablets	[23]

					volume of distilled water	sodium salt (2 mL) make the volume with water then absorbance was measured						
5.	Gancyclovir	Antiviral	Distilled water	495	An accurate weight of 50 mg of NQS was transferred to 10mL amber-colored volumetric flask and dissolved in 10 mL distilled water after vigorous stiring 0.5% w/v of NQS reagent solution was obtained	1 mL of a solution of Gancyclovir +1 mLof Na_2CO_3 buffer solution (pH 9.2) + 1 mL of a 0.5% of NQS reagent (1,2-naphthoquinone-4-sulfonate) solution to the flask maintain 25 C for 10 minutes than make the volume with methanol absorbance was measured	0.5-350	0.99965	0.22×10^4 x L $mole^{-1}cm^{-1}$	0.545 &1.818	Capsules	[24]

6.	Trimethoprim	Antibiotic	Methyl alcohol	478	(2%)w/v NQS was prepared by dissolving 2g of reagents in 30ml of methyl alcohol.Make the volume 100ml with distilled water	O.5000g of standard drug solution+10ml of ethyl alcohol. Make the volume 100ml with distilled water than absorbance was measured	5-16ug/ml		6.21×10^{7}X L X $Mole^{-1}cm^{-1}$	0.0436 &0.135	Tablets	[25]

7	Irbesartan	Angiotensin receptor 2 antagonist	Methanol	465	0.3 gm. of NQS was accurately weighed transferred into a 100 ml calibrated flask, dissolved in 20 ml distilled water, and make up the volume up to the mark with Bidistilled water to obtain a solution of0.3 % (w/v).	1-6ug/ml standard Irbesartan drug solution+1.2ml of 0.09M NaoH+1.4ml of NQS reagent The reaction solutions were allowed to proceed at room temperature for 10 minutes the volume was made up to bidistilled water than absorbance was measured	1-6	0.9998	87521.1.L/mol.cm	0.248 & 0.829	Tablets	[26]
8	Losartan	Angiotensin receptor -2 antagonist	Methanol	465	0.3 gm. of NQS was accurately weighed transferred into a 100 ml calibrated flask,	0.2-1ug/ml of standard losartan drug solution +1.2ml of 0.09M NaoH+1ml of NQS reagent The reaction	0.2-1	0.9998	231176.7 L/mol.cm	0.059 & 0.199	Tablets	[26]

					dissolved in 20 ml distilled water, and make up the volume up to the mark with Bidistilled water to obtain a solution of0.3 % (w/v).	solutions were allowed to proceed at room temperature for 10 minutes finally the volume was made up to bidistilled water than absorbance was measured						
9.	Hydrochlorothiazide	Thiazide Diuretic	Methanol	465	0.3 gm. of NQS was accurately weighed transferred into a 100 ml calibrated flask, dissolved in 20 ml distilled water, and make up the volume up to the mark with Bidistilled	0.25-1.25ug/ml standard drug solution+1ml of 0.09M NaoH+1ml of NQS reagent The reaction solutions were allowed to proceed at room temperature for 5 minutes finally the volume was made up to bidistilled	0.25-1.25	0.9998	230475.1 L/mol.cm	0.063 &0.212	Tablets	[26]

					water to obtain a solution of0.3 % (w/v).	water than absorbance was measured						
10.	Lamivudine	Nucleoside Reverse Transcriptase Inhibitors	Distilled water	453	0.7 g of NQS dissolved in 100 ml of distilled water.	10 ml of standard drug solution + 2ml of 1N NaOH + 1ml of NQS reagent (0.7%) allow to stand for 20 minutes .made up to 100 ml with distilled water.Than absorbance was measured.	10-60	0.99		6.93& 21	Tablets and capsules	[27]

11	Chlorthalidone	Phthalimidine diuretic	Methanol	440	50mg of NQS in 10 ml amber coloured VF + 5 ml of water+ 10 min of sonification than make the volume with water	1ml of std drug solution in 10 ml VF + 1ml of sodium carbonate buffer solution + 1ml of 0.5% NQS place in Water bath at 60 c for 20 minutes make the volume with methanol than absorbance was measured	2-12	0.994	-	0.58& 1.72	Tablets	[28]
12	Acyclovir	Antiviral	Bidistilled water	495	0.5 g of NQS in bidistilled water in 100 ml volumetric flask and make the volume 100 ml with distilled water	0.1-3.0 µg/mL concentration of standard ACV working solution (100 µg/mL) + NQS (1.0 mL, 0.5%, w/v) solution in a glass centrifuge tube. With bidistilled water, the amount was brought to 10	0.1-3.0	0.9995	2.5324×104 L/mol.cm	0.03& 0.01	Tablets	[29]

						mL than absorbance was measured						
13	Valacyclovir HCL	Antiviral	Alkaline solution of Sodium hydrogen carbonate.	505	0.5% w/v of NQS was prepared by dissolving 0.5g in bidistilled water and make up to the volume 100ml with bidistilled water	Standard Valacyclovir drug solution(0.06-2.0)+1.0ml of 0.5% w/v NQS reagent and make up to the volume 10 ml with bidistilled water then 1000ml of mixture of ethanol and chloroform was injected. after centrifugation absorbance was measured.	0.06-2.0	0.9995	7.9493 L/mol.cm	0.02 & 0.06	Tablets	[30]
14	Orlistat	Lipase Inhibitor or anti obesity	Ethanol	469	0.07g of NQS in 10ml of deionized water and make the volume 10 ml with	1.5 ml of standard Orlistat drug solution + 1ml of NQS reagent + 1ml of NaOH + make up to the	20-400	0.9992	1735.06 L/Mol cm	1.1228 & 3.8171	Capsules	[31]

					distilled water	volume 10 ml with deionized water then absorbance was measured						
15	Chloramphenicol	Antibiotic	Methanol	489	0.26 g of NQS in 20 ml of distilled water make the volume 100 ml with distilled water	0.01g of standard drug + 5 ml of methanol + +0.3 g of zinc powder + 0.5 ml of conc.HCL then kept aside for 5 min in waterbath at 50^{o}C for complete reduction wait 15 min for cooling then diluted to 100ml with distilled water Then absorbance was measured	1-9	0.9983	1.86×104 L/Mol cm	0.068 & 0.207	Capsules	[32]

16	Desloratadine	Antihistamine	Methanol	485	0.2% w/v of NQS was prepared by dissolving NQS in distilled water	2.5 to 37.50ug/ml of std drug solution in 10ml VF + 1.25 ml of 0.2% NQS solution +%0.2ml of borax solution make the volume with water then absorbance was measured after 15 minutes.	2.50-37.50	0.996	0.59×104L/ Mol cm	0.039 & 0.16	Tablets	[33]

17	Ertapenam	Antibiotic or anti infective	Distilled water	444	NQS was Prepared by dissolving 500 mg of 1,2 Naphthaquinone sulphonate in 100 mL of distilled water	(0.5-3) ml of standard drug solution + 2 ml of NaOH (20%) +1.5 ml of NQS reagent (0.5%) in 25 ml Volumetric Flask make the volume with distilled water then kept aside for 5 min then absorbance was measured	0.5-3.0	0.9998	57×105L/Mol cm	0.0063 & 0.019	Injections	[34]
18	Dabigatran etexilate Mesylate	Anticoagulant	Methanol	454	Precisely weighed NQS (0.5 g) was disintegrated in sufficient distilled water. The volume was made to 100 mL using the same.	Dabigatran (10 µg/mL) was produced by taking 1 mL of drug solution from standard solution,1 mL of 0.5% NQS solution, 1 mL of 2% KOH and final volume was made using distilled water	1-10	0.999	0.00074L/mol cm	0.048 & 0.147	Capsules	[35]

						then resulting solution was scanned b/w 400-800 nm						
19	Daru navir	Anti retroviral	Milli pore distilled water	444	0.5% w/v of NQS was prepared by dissolving 0.5g in bidistilled water and make up to the volume 100ml with bidistilled water	Standard solution of Darunavir + 1ml of NQS + 1ml of NaOH in 10 ml volumetric flask then kept aside for 2 min at lab temperature then solution was made up to the mark with distilled water. Then absorbance was measured.	10-60	00.9988	1.3874x105 L/mol cm	2.057	Tablets	[36]

20	Methoxamine HCL	Selective alpha -1 adrenoreceptor agonist or sympathomimetic	Millipore distilled water	445	NQS solution(0.5%, 1.93 x 10^{-2} M)	MHC standard drug solution+1ml of NQS + 1.0 ml of NaOH solutions were added to each tube and kept aside for 2 min. at lab temperature. The solutions were made up to the mark with distilled water. The absorbance was measured at λmax 445nm	5-30	0.9997	1.9652 x 105 L/mol cm	0.5191	Injection powder	[37]
21	Glucosamine	Amino monosaccharide	Distilled water	451	NQS solution was freshly prepared in water at concentration of 0.01M and protected from sunlight.	40-700ug/ml of standard drug solution + 0.5 ml of 0.1 M NaOH + 2ml of 0.01M NQS reagent were added. The solutions were shaken and placed in a thermostatic	4-70	0.9999	-	2.70×10-2 & 8.99×10-2	Capsules	[38]

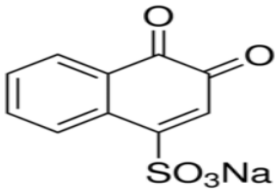
						oven at 60°C for 20 min. The reaction was discontinued by putting the test tubes in a bath of cold-water. The volume was then topped up with water.then absorbance was measured						
22	Enlapril maleate	Angiotensin converting enzyme Inhibitor	Alkaline solution(0.1M)NaOH	518	A solution of 0.5% (w/v) NQS was prepared by dissolving 0.5 g in distilled water, transferred into a 100 mL volumetric flask and diluted to the mark with	1 mL of (250) µg/ml Enalapril was transferred into 10 mL volumetric flask +1 mL of 0.5% (w/v) NQS was added + 1 ml from buffer solution of pH =12 (NaOH / Na_3HPO_4). The reaction was completed to volume by	5-47.5	0.9988	0.8815×104 L/mol cm	0.3351 & 1.1173	Tablets	[39]

					Deionized water and mixed well.	deionized water, and the resulting solution was measured at 518 nm						
23	Fluoxetine	Antipsychotic	Distilled water	490	0.5 g of NQS dissolved in 100 ml of distilled water.	Standard drug solution + 50uL of buffer solution of PH- + 50uL of NQS solution (0.5% w/v) The reaction solution was allowed to proceed for 10 min at room temperature(25± 5◦C). The absorbance of the solution in each well was measured by the microplate reader	2-40	0.9997	4.8×104 L/mol cm	1.5 & 4.5	Tablets and capsules	[40]
24	Fluvoxamine	Antipsychotic	Distilled water	470	0.5 g of NQS dissolved in 100 ml of distilled water.	Standard drug solution + 50uL of buffer solution of PH- + 50uL of NQS solution	5-80	0.9996	6.1×104 L/mol cm	4.2 &2.7	Tablets and capsules	[40]

						(0.5% w/v) The reaction solution was allowed to proceed for 10 min at room temperature(25± 5◦C). The absorbance of the solution in each well was measured by the microplate reader						

25	Paroxetine	Antipsychotic	Distilled water	490	0.5 g of NQS dissolved in 100 ml of distilled water.	Standard drug solution + 50uL of buffer solution of PH- + 50uL of NQS solution (0.5% w/v) The reaction solution was allowed to proceed for 10 min at room temperature(25± 5◦C). The absorbance of the solution in each well was measured by the microplate reader	2-40	0.9992	5.9×104 L/mol cm	1.8 & 5.5	Tablets and capsules	[40]

NQS Reagent



1, 2 Napthaquinone 4-sulphonate sodium.

NQS Profile

It is chemically called 1,2 Napthaquinone 4-sulphonate sodium. It is a chromogenic reagent used in the estimation of primary aromatic amines and it is a derivative of quinine. It will produce a bright red colour in alkaline solution and is also fluorescent.[41-43]

IUPAC Name	**Sodium 3,4 dioxo 3,4 dihydro naphthalene 1,4 sulphonate**
Molecular Formula	C_{10} H_5 NaO_5S
Molecular Weight	260.2g
Melting Point	289 ^oC
Synonyms	Beta napthaquinone 4-Sulphonate

Introduction of NQS Reagent

1,2-Naphthoquinone-4-sulfonate (NQS) is a reagent increasingly employed for the analytical determinations of amines and amino acids by using ultraviolet-visible (UV-Vis) spectrophotometric detection. NQS is able to react in basic medium and moderate temperatures with both primary and secondary amino groups to produce spectrophotometrically detectable derivatives. Many researchers have used NQS extensively to determine amines, and reddish dyes were extracted into chloroform.[44-46] Folin.[43] first described a method for determining amino acids that relies on the combination of the amino groups with NQS in an alkaline solution to form highly colored compounds. NQS was first introduced as a reagent for the calorimetric determination of amino acids in 1922. NQS was used by Hashimoto et al.[46] to qualitatively analyze derivatives of phenethylamines. Thin-layer chromatography was used to extract the reaction products, and a variety of methods, including elemental analysis, nuclear magnetic resonance (NMR), infrared (IR), and mass spectrometry, were used for analysis. NQS has been widely used as a chromogenic reagent for the spectrophotometric measurement of numerous pharmaceutical amines throughout the past 20 years. No review has been done on the use of NQS for derivatization of amine groups found in pharmaceuticals. Applications of NQS as a chromogenic reagent in

spectrophotometry will be examined in this review. We shall present the detecting systems and derivatization conditions.[47]

Principle and Mechanism of NQS

The mechanism of action of NQS reagent involves when the NQS treated with any amine containing compound that will release hydroxyl group and sodium sulfonate group is replaced with aromatic amine group.[41-43]

Applications of NQS Reagent

1. NQS used to determine drugs which contain amine group
2. Determination of aromatic amines in waste water
3. It is used in the determination of amphetamine and meta-amphetamine in urine by RP HPLC
4. By using visible spectrophotometric method fluorometric method and HPLC method pharmaceuticals can be estimated in reactions with NQS.

Advantages of spectrophotometric methods

Spectrophotometric methods offer several advantages in pharmaceutical analysis, particularly due to their simplicity and cost-effectiveness. These methods are easy to implement and require relatively inexpensive equipment compared to more complex techniques like HPLC or LC-MS.[48-53]

Simplicity and Cost-Effectiveness: Compared to sophisticated analytical techniques like HPLC or LCMS, spectrophotometric approaches are much less expensive and easier to implement. This enables them to be regularly used in quality control labs, where prompt and precise analysis is crucial.

Non-Destructive: Spectrophotometry's frequent non-destructive nature is one of its main benefits. This makes it possible to analyze samples without consuming or changing them, which is particularly useful when examining costly or scarce medicinal compounds.

Broad Applicability: Spectrophotometry is a versatile technique that can be utilized for a number of pharmaceutical applications, such as impurity identification and drug formulation analysis, because it can be used to examine a wide range of molecules, including both organic and inorganic substances.

High Sensitivity: Spectrophotometric techniques can detect and quantify drugs at very low concentrations when combined with the right reagents, making them an efficient way to analyze trace levels of substances, which is essential for stability testing and impurity profiling.

Applications of Spectrophotometric Methods in Pharmaceuticals

Because of their adaptability and efficiency in examining a wide range of therapeutic component as and formulations, spectrophotometric techniques are frequently used in pharmaceutical applications.[54-58]

Drug assay in bulk and formulations

Application: Spectrophotometric methods are extensively used for the assay of Active Pharmaceutical Ingredients (APIs) in both bulk and formulated dosage forms like tablets, capsules, and injections.

For instance, UV-visible spectrophotometry is frequently used to assess the concentration of medications such as aspirin, ibuprofen, and paracetamol and guarantee that formulations contain the proper dosage.

Application of Dissolution Studies

Spectrophotometry is used to track how quickly medications dissolve in solid dose forms like tablets. It aids in determining how rapidly and effectively the medication is released from the formulation. For instance, spectrophotometric measurements of the drug's release over time during dissolution tests offer important information about the active ingredient's release kinetics, which are essential for bioavailability research.

Application of Stability Testing

Stability studies use spectrophotometric techniques to track drug degradation under a variety of stressors (such as heat, light, and humidity). Changes in absorbance can show the emergence of degradation products. For instance, drugs undergoing accelerated stability testing may show distinct absorbance patterns, which enable analysts to monitor the stability and shelf life of the drug over time.

Quantification of impurities Application

Impurities such as residual solvents, degradation products, or excipients in pharmaceuticals can be quantified using spectrophotometry. Example: Impurity profiling of drug substances is

performed by detecting trace impurities, which may influence the quality, safety, and efficacy of the pharmaceutical product.

Analysis of biological samples Application

Spectrophotometric methods are employed in bioanalysis to measure drug concentrations in biological samples like plasma, urine, or blood. Example: Techniques like diazotization are used to measure drugs containing amino groups in biological fluids, aiding in pharmacokinetic studies and therapeutic drug monitoring.

Kinetic research Application

Spectrophotometry can be used to track the rate of chemical processes, such as drug degradation or interactions with excipients. This aids in figuring out the reaction's kinetics and activation energy. Spectrophotometric kinetic studies, for instance, offer details on the stability of medications over time as well as the rate at which they degrade or interact with other formulation ingredients.

CONCLUSION

The spectrophotometric study of drugs using 1, 2-naphthoquinone-4-sulfonate (NQS) reagent demonstrates a simple, sensitive, and cost-effective method for drug analysis. The reaction between NQS and the studied drug results in the formation of a stable colored complex, which can be quantitatively measured at a specific wavelength using a UV-Vis spectrophotometer. The method shows high selectivity and sensitivity, making it suitable for the determination of drugs in both bulk and pharmaceutical formulations. The developed technique exhibits good linearity, accuracy, and precision, with minimal interference from common excipients. Additionally, the proposed method is eco-friendly due to the reduced need for hazardous reagents and solvents. In conclusion, the NQS-based spectrophotometric method is a valuable analytical tool for quality control and routine drug analysis in pharmaceutical industries and research laboratories.

Funding

No funding received for this research work.

Availability of data and material

All data and materials are available on request.

Declarations

Ethics approval & consent to participate

Not applicable.

Consent of publication

Not applicable as our study does not include patients.

ACKNOWLEDGEMENT

The authors are grateful to Prof. Giriraj T Kulkarni, Principal, Gokaraju Rangaraju College of Pharmacy for providing necessary laboratory facilities. The authors are thankful to Gokaraju Rangaraju Educational Society for providing the adequate infrastructure facilities.

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