SHORT COMMUNICATION

A Novel Spectrophotometric Method for the Determination of Histamine Based on Its Complex Reaction with Ni(II) and Alizarin Red S

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ABSTRACT

The development of analytical method of histamine (His) using Ni (II) and alizarin red S (ARS) reagents by UV-Vis spectrophotometry has been done. The objective of this research is to determine the ability of Ni(II) and alizarin red S to form color complex compound with histamine and it will be used to detect the presence of histamine qualitatively and quantitatively as well. Absorbance was measured at a maximum wavelength of 604 nm. In this method, it has been carried out optimization of analytical parameters such as the concentration of Ni(II), the concentration of alizarin red S, pH, and response time. Analytical parameter optimization showed concentration of Ni(II) is 20 ppm, alizarin red S 75 ppm, pH 8, and a response time of 15 min. The method validation indicated that the coefficient of variation, detection limit, and the limit of quantitation are 0.245%; 9.49 ppm; and 31.62 ppm respectively with a sensitivity of 0.0063/ppm and linearity of 0.99. Accuracy to histamine with a concentration of 50, 75, and 125 ppm are 105.87%, 101.06%, and 97.21%, respectively.

Keywords: *histamine; Ni(II); alizarin red S; spectrophotometry*

ABSTRAK

Telah dilakukan penelitian tentang pengembangan metode analisis histamin (His) menggunakan pereaksi Ni(II) dan alizarin red S (ARS) secara spektrofotometri sinar UV tampak. Penelitian ini bertujuan untuk mengetahui kemampuan Ni(II) dan alizarin red S dalam penggunaannya sebagai reagen untuk menentukan histamin secara kualitatif dan kuantitatif. Absorbansi diukur pada panjang gelombang maksimum 604 nm. Dalam metode ini, telah dilakukan optimasi parameter analitik seperti konsentrasi Ni(II), konsentrasi alizarin red S, pH, dan waktu reaksi. Hasil optimasi parameter analitik dengan metode spektrofotometri diperoleh konsentrasi optimum Ni(II) adalah 20 ppm, alizarin red S 75 ppm, pH 8, dan waktu reaksi selama 15 menit. Hasil validasi metode menunjukkan koefisien variasi, limit deteksi, dan limit kuantitasi masing-masing 0,25%; 9,49 ppm; dan 31,62 ppm dengan sensitivitas 0,0063/ppm dan linieritas 0,99. Akurasi untuk histamin dengan konsentrasi 50, 75, dan 125 ppm adalah 105,87%, 101,06%, dan 97,21%.

Kata Kunci: *histamin; Ni(II); alizarin red S; spektrofotometri*

INTRODUCTION

Histamine is an important biogenic amine involved in regulating numerous physiological and pathophysiological processes in humans and animals [1]. Histamine in normal circumstances is naturally occurred and derived from histidine substances through enzymatic decarboxylation process [2]. Histamine is usually a mild illness with a variety of symptoms including rashes, nausea, vomiting, diarrhea, flushing, swelling of the face and tongue, sweating, headache, dizziness, palpitation, oral burning, metallic taste and hypotension [3]. The most well-known role of histamine is mediating part of the inflammatory responses to various allergic reactions [4-5]. Histamine (scombroid) poisoning is associated with the consumption of scombroid fish such as tuna, bonito and mackerel [6]. After fish, cheese is the food in which the highest concentrations -sometimes >1000 mg kg^{-1} e recorded [7]. The chemical structure of histamine is shown in Fig. 1.

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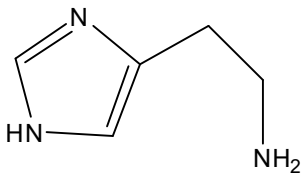

Fig 1. Chemical structure of histamine

Several analytical methods have been developed for the analysis and determination of histamine levels such as ultrasensitive flow injection electrochemical [8], lignin modified glassy carbon electrode [9], Thin Layer Chromatography (TLC) [10], High Performance Liquid Chromatography (HPLC) [11], ^{1}H-NMR [12], electrochemiluminescence [13], liquid-chromatography tandem mass spectrometry [1], PCR-DGGE [14] and spectrophotometry [15]. In this study, analytical procedure for the determination of histamine is based on the complexes reaction, which can form a color compound and then it is measured by a UV-Vis spectrophotometer UV-Vis. The analytical parameters including optimization of Ni(II) concentration, alizarin Red S concentration, pH and response time for formation of complex had been investigated as well. The analytical validations were performed including coefficient of variation, detection limit, limit of quantitation, sensitivity, linearity, and accuracy.

EXPERIMENTAL SECTION

Materials

Histamine reference standard was purchased from Sigma Aldrich, Singapore. $NiSO_4.6H_2O$ and alizarin red S was purchased from Merck, Germany. CH_3OH, CH_3COONa, $Na_2HPO_4.2H_2O$, $NaH_2PO_4.2H_2O$, CH_3COOH, NaOH, $NaHCO_3$ were pure analytical grade.

Instrumentation

The instrumentals used were UV-Vis spectrophotometer Shimadzu-1800 and pH meter Eutech. UV-Vis spectrophotometer was used to measure the wavelength and absorbance of complex compounds formed. While pH meter was used to measure the pH of the buffer solution preparation and standard solution for analytical optimization of pH.

Procedure

Preparation of reagent

Histamine (0.1000 g) was weighed quantitatively and dissolved in methanol. The solution was transferred to a 100 mL volumetric flask and made up with the same solvent to mark.

$NiSO_4.6H_2O$ (0.4785 g) was weighed quantitatively and dissolved in distilled water. The solution was transferred to a 100 mL volumetric flask and made up with distilled water to mark. The same procedure was done for alizarin red S but the mass was 0.1 g.

Preparation of alizarin red S-Ni(II) complex solution

A 0.25 mL alizarin red S solution was transferred quantitatively into a 10 mL volumetric flask and added 1.0 mL of Ni(II) solution and 1.0 mL buffer solution of pH 7. It was made up with methanol to mark and shake until homogeny and let it for 10 min. The wavelength of complex solution was measured with UV-Vis spectrophotometer at λ 300-800 nm.

Preparation of histamine-alizarin red S-Ni(II) complex solution

A 0.25 mL alizarin red S solution was transferred quantitatively into a 10 mL volumetric flask and added 1.0 mL of Ni(II) solution, 1.25 mL of histamine solution, 1 mL buffer solution of pH 7 at room temperature for 10 min. It was made up with methanol to mark. The wavelength of complex solution was measured with UV-Vis spectrophotometer at λ of 300-800 nm.

RESULT AND DISCUSSION

In this study, the spectrophotometric method for determination of histamine is based on the complex reaction between histamine, alizarin red S, and Ni(II) using an UV-Vis spectrophotometer with a concentration of histamine 125 ppm, alizarin red S 25 ppm, and Ni(II) 100 ppm. From Fig. 2, it can be seen that the complex compounds of alizarin red S and Ni(II) produces maximum wavelength at 560 nm. Alizarin complexation occurs at the *peri*-hydroxycarbonyl group and results in the formation of the C=O $\rightarrow$ M–O coordination bond and six-membered chelate cycle in compound [16]. This complex compound will then react with histamine forming a new pink complex compound with a maximum wavelength at 604 nm. These results indicate that a shift in the wavelength of maximum absorption into greater due to bathochromic effect. Ni(II) binds the existing amine group on histamine. This compound is predicted that it has an octahedral shaped molecular. In the molecular structure of the complex, histamine acts as a bidentate ligand by chelating the Ni(II) ion. The Ni(II) ion is in a square pyramidal geometry defined by two N atoms of aqua ligand at pyramid apex. In the crystal packing of $[Cu(His)(ARS)(H_2O)_2]$ complex, histamine along with neighboring oxalate ion participates in weak hydrogen bonds of N–H-O.

The wavelength of the histamine - alizarin red S - Ni(II) complex compound is used as the wavelength for the entire analytical parameter optimization. Optimization of Ni(II) and alizarin red S concentration is obtained from the increase in absorbance due to higher concentration. The optimum results of Ni(II) and alizarin red S concentration are 20 ppm and 70 ppm, as shown by Fig. 4 and Fig. 5. The optimum pH for complex formation were determined. In Fig. 6 it is obtained that pH optimum is at pH 8. The reaction of complex formation took place in alkaline conditions because in pH>8 histamine - alizarin red S - Ni(II) solution starts to be formed colloidal solution. It is caused by precipitation of $Ni(OH)_2$ because in this condition Ksp $Ni(OH)_2$ has been reached [17]. The response time optimization shows that the decreasing of absorbance is after 0-10 min, and it rose significantly in the 15th min and then decreased again in

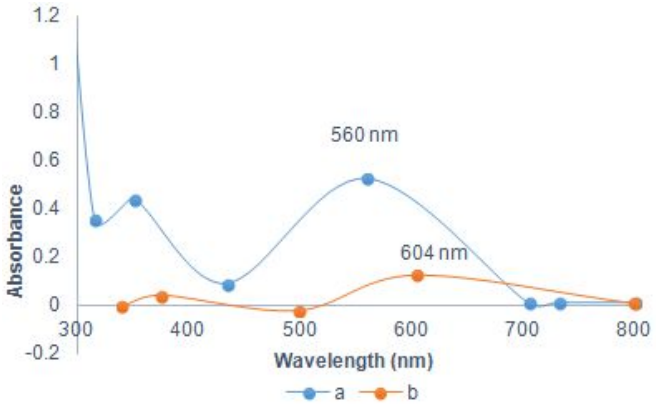

Fig 2. (a) UV-Vis spectra of alizarin red S-Ni(II) complex (b) UV-Vis spectra of alizarin red S-histamine-Ni(II) complex

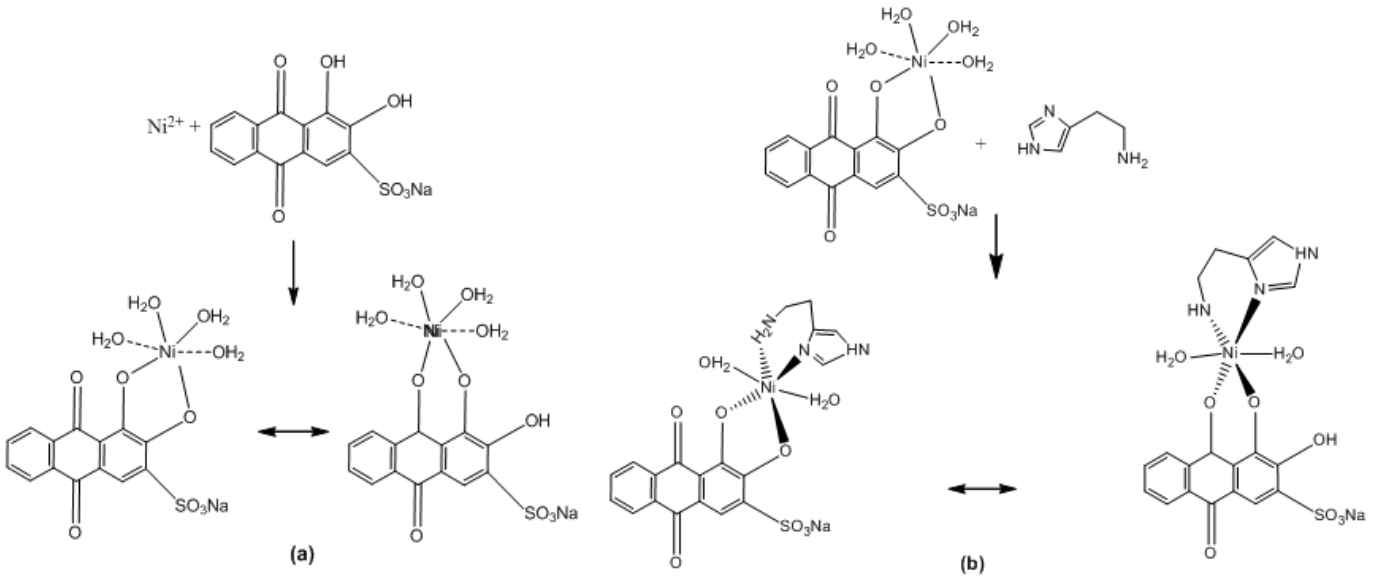

Fig 3. (a) The reaction of Ni(II) and alizarin red S [18] (b) The prediction reaction of Ni(II), histamine and alizarin red S

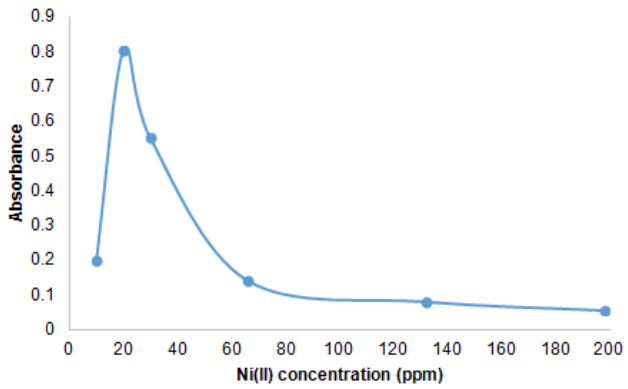

Fig 4. Optimization of Ni(II) concentration

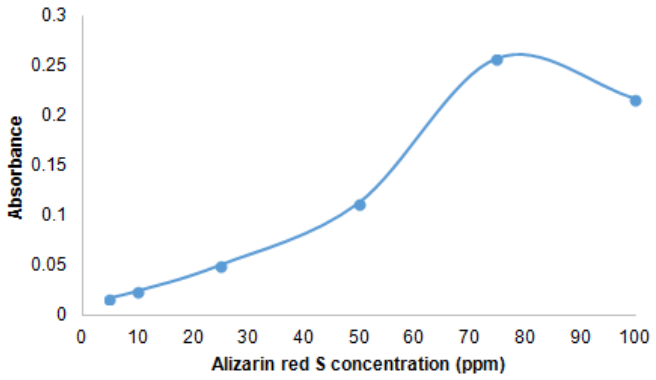

Fig 5. Optimization of alizarin red S concentration

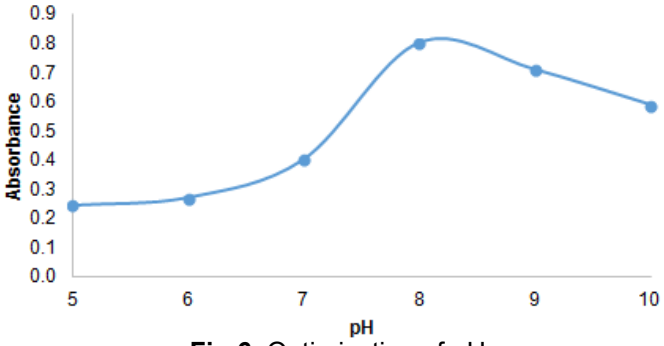

Fig 6. Optimization of pH

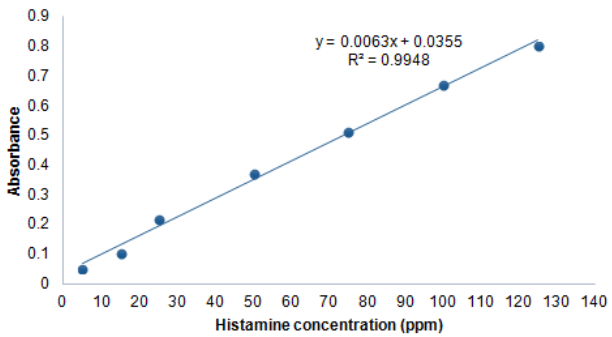

Fig 7. Calibration curve of histamine

Table 1. Validation parameters of method

Validation parameter	Result
Detection limit and quantity limit	9.49 ppm and 31.62 ppm
Linearity	0.99
Sensitivity	0.0063/ppm (slope)

Table 2. Accuracy of method

Real Concentration (ppm)	Found Concentration (ppm)	Recovery (%)
50	52.94	105.87
75	75.79	101.06
125	121.51	97.21
Mean		101.38

Table 3. Variation coefficient (precision) of histamine standard

Histamine (ppm)	Absorbance				Precision (%)
	x_1	x_2	x_3	$\bar{x}$	
50	0.368	0.371	0.369	0.369	0.19
75	0.510	0.509	0.515	0.511	0.27
125	0.825	0.826	0.829	0.826	0.27
Mean					0.24

the 20th min. So the optimum response time for the formation of the complex is considered to be for 10-15 min.

From the results of the optimization concentration of alizarin red S and Ni(II), pH and response time, linear calibration curves are obtained at the range of 50-125 ppm of histamine shown by Fig. 7. The linear regression is 0,0063x + y = 0.0355 and R^2 = 0.9948. Validation parameters are shown in Table 1. Based on linear regression and Table 1, linearity is closed to 1 so it is quite good. Two directions ANAVA shows $t_{table} < t_{calculation}$, so H_0 is rejected and there is a correlation between the concentration with absorbance. The accuracy of the method range of 101.38% is shown in the Table 2 so that is indicated that this method of approaching the actual state of histamine concentration. Variation coefficient of histamine by 0.245% is shown by Table 3 and a sensitivity of 0.0063 obtained from the slope of histamine standard curve.

CONCLUSION

We have successfully demonstrated the spectrophotometric method for the determination of histamine based on complex reaction using Ni(II) and alizarin red S as reagent at room temperature. From the present study it can be concluded that this method has simple methodology, easy work-up, short reaction times, low cost, and accurate.

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