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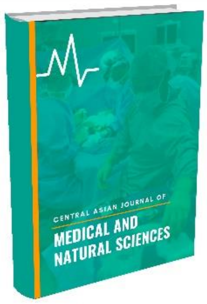

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SYNTHESIS OF QUERSETIN COMPLEX COMPOUNDS WITH IRON (II) IONS ASSESSMENT OF ITS STABILITY

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ABSTRACT: Complexes of quercetin with iron (II) ions were synthesized, its IR spectra were studied, and it was proven that if Fe-O bond was formed in the 627 cm^{-1} region of the oscillation, a complex of shifts in several bonds would occur, in addition, the results of the analysis of UV-spectra showed that bathochromic shifts of about 7 nm and 64 nm were detected, and the stability constant of the synthesized complex compound was calculated, according to which the stability constant of the complex formed from the cation Fe (II) and quercetin was found to be $\beta_K' = 5{,}5 \cdot 10^{-3}$ at 273 nm and $\beta_K' = 4{,}6 \cdot 10^{-3}$ at 340 nm.

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KEYWORDS: Flavonoid, quercetin, Quercetin-iron (II) complex, IR-spectrum, stability constant, molar absorption coefficient.

INTRODUCTION

It is known that flavonoids belong to the group of natural compounds found in plants and tend to form supramolecular systems according to their structure [1]. Flavonoids are involved in oxidation-reduction processes in the plant body and act as attractants, information-carrying molecules and antistress agents [1]. A number of flavonoids are involved in the formation of the bright color of flowers and fruits of plants and attract birds and insects involved in the pollination, reproduction and spread of plants [1].
Flavonoids as polyfunctional compounds form complexes with some d-metals [1]. Therefore, it is important to study the ability of flavonoids to form complexes with some d-metal ions and to obtain nanoparticles from them. In addition, flavonoids improve the pharmacological and biological properties of chelate formation [2-4].

Quercetin (3,3 ',4', 5,7-pentahydroxyflavone), one of the representatives of flavonoids, is attracting the attention of many researchers due to its antioxidant, antibacterial and anti-cancer active biological and pharmaceutical activity. Its Tb (III), Mg (II), Cu (II), Fe (II), Cr (III), Co (II), Sn (II), VO (IV), Zn (II), Mn (II), Pb (II) and Ni (II) as the formation of chelates with metal ions such has been studied by many researchers [5 - 15]. According to its structure, quercetin consists of three phenol rings. It has three available sites for metal chelation including 3-hydroxy-4-keto group, 5-hydroxy-4-keto group, and ortho-dihydroxyl (catechol) groups of the ring, that is, the hydroxy and keto groups in quercetin have the ability to form metal complexes [16,17,18]. Therefore, the synthesis of internal complex compounds of quercetin with various d-metal ions and the assessment of their stability is one of the current problems.

THE PURPOSE OF THE WORK

Synthesis of complex compounds of quercetin with iron (II) ions to assess its stability.

Inspection facilities and measurements

Reagents: Quercetin (chemically pure), KBr (Clean for analysis), $FeSO_4 \cdot 7H_2O$ (Clean for analysis), methanol, distilled water.

Measurements: IR spectra (operating in the range of 4000-400 cm^{-1} spectrum) on WQF-510A (named RAY-LEIGHT) spectrometer, UV spectra obtained on a spectrophotometer, samples were measured in mass analytical balance (model AUY120) (model AUY120), reactions: in the water bath (model D 2000) was carried out.

Synthesis of Complex

0.120 g of quercetin ($C_{15}H_{10}O_7$) dissolved in 25 ml of methanol and 0.055 g of $FeSO_4 \cdot 7H_2O$ dissolved in 10 ml of methanol were mixed at room temperature. The mixture was stirred continuously in a water bath equipped with a 60 ° C refrigerant for 2 hours, then the mixture was cooled to room temperature. The resulting dark brown precipitate was washed three times with water and three times with methanol, purified from unreacted $FeSO_4 \cdot 7H_2O$ and quercetin, and dried. A dry sample was used to obtain IR spectra, and solutions were used to obtain UV and field of view spectra.

The results obtained and their discussion

The reaction of quercetin with iron ions is based on the following equation [19]:

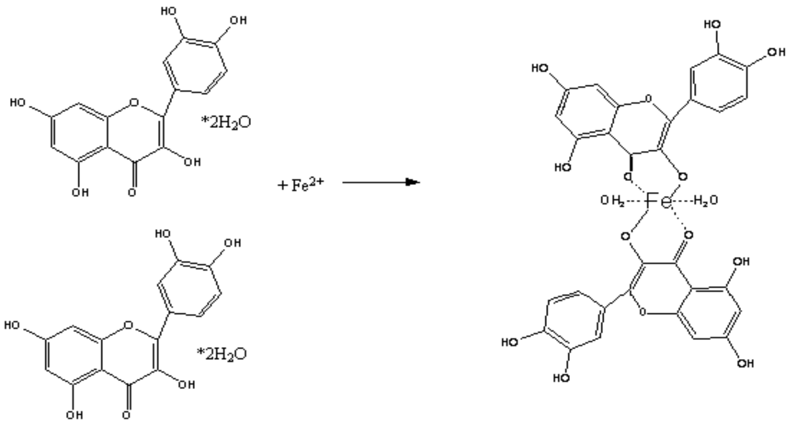

Figure 1. Formation of quercetin Fe (II) complex

Quercetin reacts with iron (II) ions to form a blackish brown compound that is solid at room temperature. This complex is soluble in methanol-water (volume ratio 1: 1), ethanol, DMSO (dimethyl sulfoxide) and tris-HCl-DMSO (but insoluble in water and carbon tetrachloride) were prepared and used to obtain UV spectra.

IR study of the Complex.

IR spectrometry was used to check the binding properties and coordination sites of the quercetin. The main peaks of the quercetin and the complex are given in Table 1.

Table 1

IR spectra of quercetin and quercetin complex (band position in cm^{-1})

	v(C = O)	v(C = C)	v(O-H)	v(C-O-H)	v(C-O-C)	v(Fe-O)
Quercetin	1664	1612	3402-3319	1319	1263	-
Complex	1641	1604	3205	1356	1269	627

The IR spectra of the reagents and the obtained complex are shown in Figures 2,3,4,5.

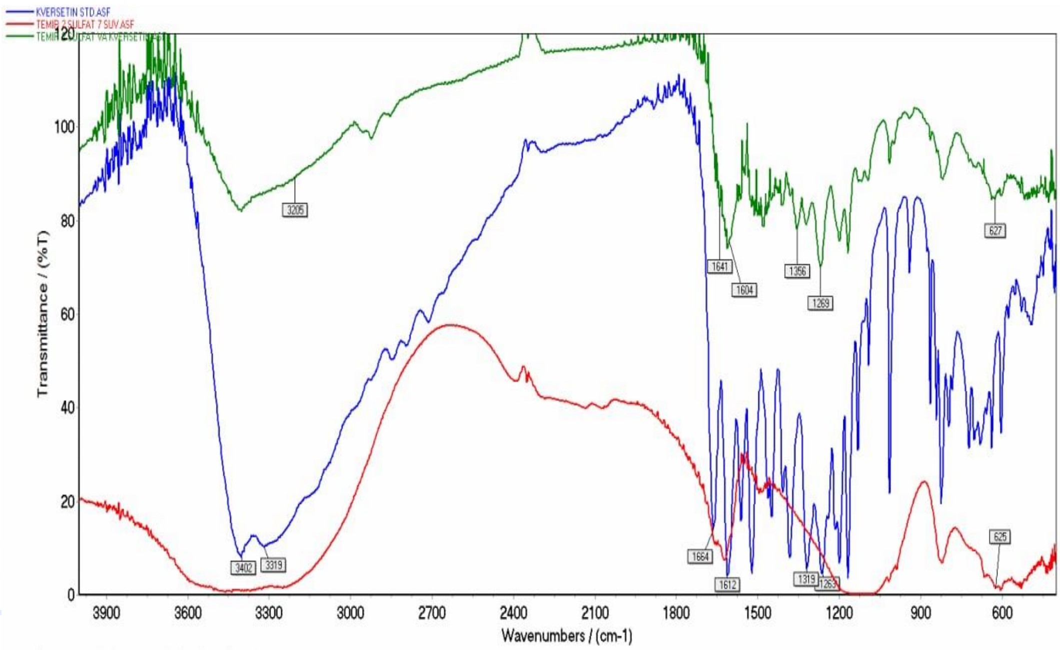

Figure 2. IR spectra of samples in the range of 4000-400 cm^{-1} spectrum

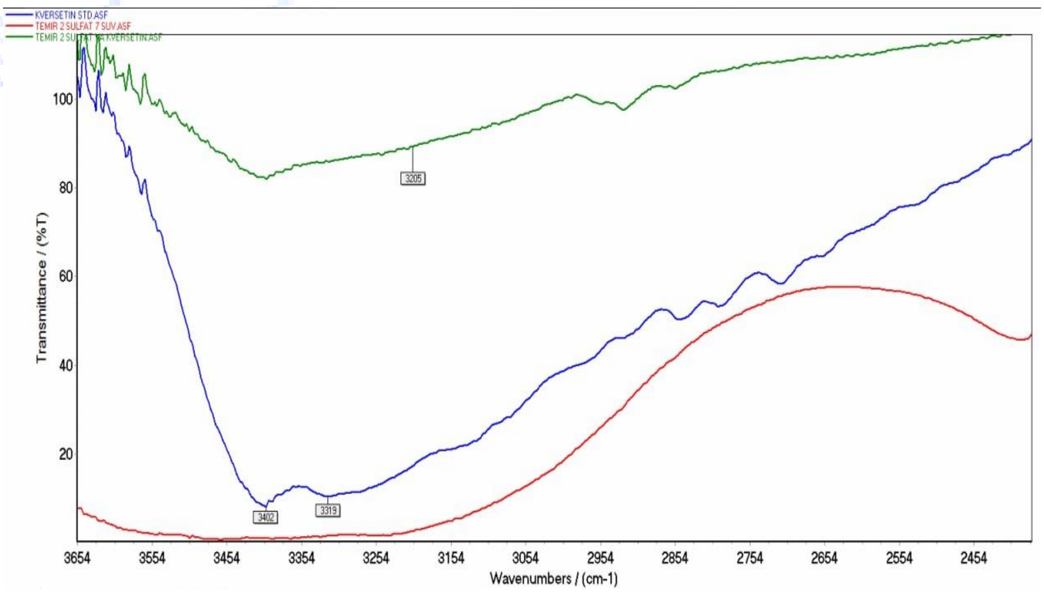

Figure 3. IR spectra of samples in the range 3654-2354 cm^{-1} spectrum

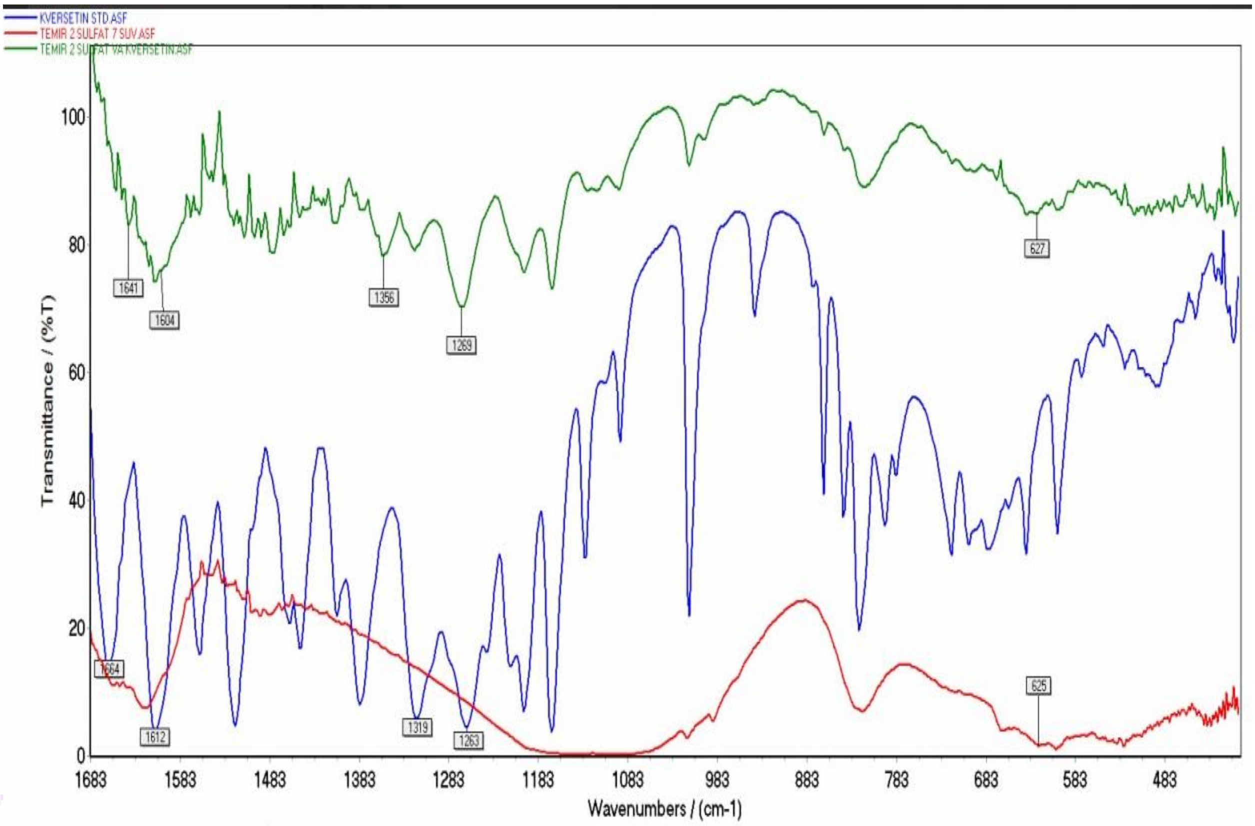

Figure 4. IR spectra of samples in the range 1683-400 sm^{-1} spectrum

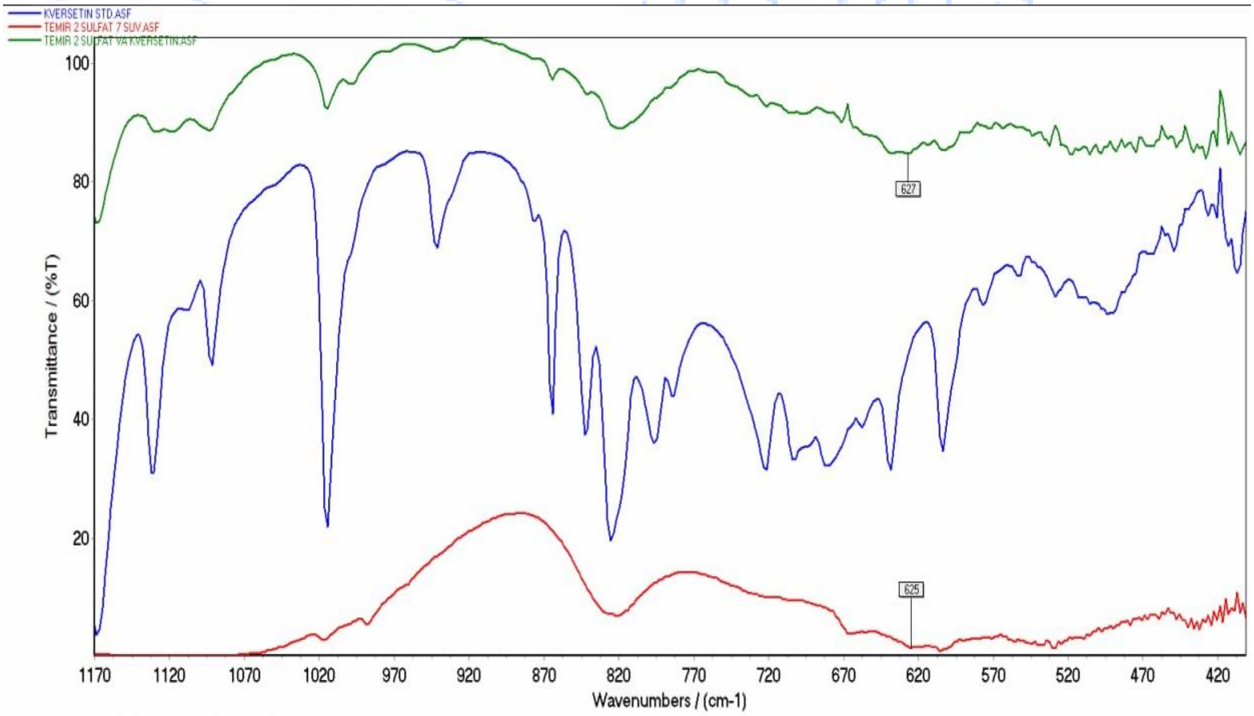

Figure 5. IR spectra of samples in the range 1170-400 sm^{-1} spectrum

From the information in the figures, it can be seen that the C = O elongation regime of the free quercetin occurred at 1664 cm^{-1}, which was converted to 1641 cm^{-1} with the formation of the complex. This shift confirmed the compatibility of carbonyl oxygen with the metal ion. The bands found at 1612 cm^{-1} and 1263 cm^{-1} are related to the frequencies v (C = C) and v (C-O-C), which are slightly changed in the metal complex to 1604 cm^{-1} and 1269 cm^{-1}, respectively. This result indicates that metal coordination has taken place. In addition, the Fe-O oscillation range at 627 cm^{-1} indicates the formation of a metal complex, while the free quercetin does not indicate such a bond. Due to the presence of the water molecule, there are a wide range of frequencies for quercetin (3402-3319 cm^{-1}) and complex (3205 cm^{-1}) (OH).

Complex study by UV spectroscopic method. The UB-spectrum of the complex in a mixture of methanol and water (1: 1) is shown in Figure 6.

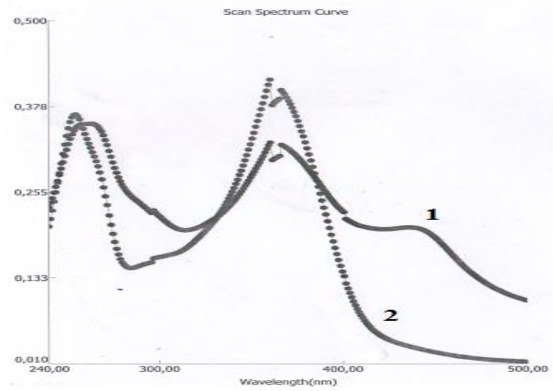

Figure 6. Absorption spectra of complex (1) and pure quercetin (2)

From the data in Figure 6, it can be seen that the quercetin shows two main absorption bands in the UV region. B-ring assimilation is associated with the absorption of A at 372 nm (group I) (cinnamoyl system) and at 256 nm (band II) (benzene system). When the absorption of the complex by ultraviolet light was observed, a bathochromic shift of the absorbance of both bands was felt. The solution of the complex in methanol and water (1: 1) resulted in a significant change in the spectrum of quercetin as a result of the formation of new peaks at 263 nm (range IV) and 436 nm (range III). This indicates that bathochromic shifts of approximately 7 nm and 64 nm occur, respectively. The spectral changes can be easily observed in Figure 6. This confirms the formation of a complex between quercetin and iron. The transition of point II to group IV is relatively insignificant. Thus, the formation of a complex of iron 3-OH and 4-C = O quercetin supports the idea that a new emerging peak may appear in the 436 nm Quercetin complex. It can also be explained by the bathochromic shift of absorption of both ranges and the acidic nature of the 3-hydroxy group proton, so the 3-OH and 4-keto groups are the first sites involved in this process. in the process of complex formation, the 5-OH group is not included due to the low proton acidity and the steric barrier produced by the first complex.

Evaluation of the stability of quercetin complex with Fe (II) ion. To study the composition and stability of complex compounds formed in solution under the influence of complexing metals (M) and ligands (R), a series of isomolar solutions with different ratios of initial concentrations of reagents are usually prepared, followed by the optical density (λ) of these solutions at certain wavelengths (l) measured on an ultraviolet (UV) spectrophotometer. The stability constant (β) of complex compounds formed in solution using the isomolar series method is calculated. Typically, the molar absorption coefficients of these complexes are found along with the stability constants. Classical computational algorithms [18-19] are not always used, in particular, the stability constants of very strong complexes are incorrectly determined. In our opinion, the accuracy of the assessment of stability constants should depend not only on the strength of the formed complexes, but also on the ratio of the initial concentration of metal (M) and ligand (R) in the model solutions. Incorrectly selected content can lead to large errors or does not allow to calculate the values of the stability constant ($\beta_K^{'}$) and the absorption coefficient (ε) in general. There are other similar statements in textbooks [20-25].

PURPOSE OF WORK

Stability constant of the composition of compounds in the formation of a single complex with specific absorption of light ($\beta_K^{'}$) and a study of the estimation of the absorption coefficient (ε) by the isomolar series method.

EXPERIMENTAL PART

Solutions of the reagents were prepared using chemically pure or clean for analysis and precisely weighed portions of reagents for analysis.

This is shown in Table 2, where the optical densities were measured simultaneously at different molar ratios (0.11 to 1.00) with a spectrophotometer with a quartz cuvette thickness l = 1 cm.

Table 2. Isomolar series

Mixture №	$C \cdot 10^3$, mol/l		C_{Fe}/C_R	A 273 nm	A 340 nm
	C_{Fe}	C_R			
1	0,1	0,9	0,11	0,026	0,058
2	0,2	0,8	0,25	0,025	0,154
3	0,3	0,7	0,43	0,067	0,260
4	0,4	0,6	0,67	0,078	0,373
5	0,5	0,5	1,00	0,087	0,454

Algorithm for calculating the molar coefficient and stability constant. Suppose that the conditional stability constant of the FeR complex is unknown and it is calculated in the traditional way, as shown in the manual [1]: first two series of the isomolar are selected, and then the molar coefficient is calculated. The molar coefficient of the complex is calculated according to the following formula (1):

$$\varepsilon_{ij} = \sqrt{\frac{A_i \cdot (A_j)^2 - A_j \cdot (A_i)^2}{A_j \cdot C_{Mi} \cdot C_{Ri} - A_i \cdot C_{Mj} \cdot C_{Rj}}}, \quad (1)$$

Where ε_{ij} is the molar absorption coefficient of the complex; C_{Mi}, C_{Mj}, C_{Ri}, C_{Rj} are the initial concentrations of metal (M) ions and ligands (R) in solutions i and j, respectively; A_i and A_j 273nm and 340nm are different optical densities of the same solution. Similar calculations are then performed for other pairs of solutions. The ε_{ij} values obtained for different pairs of solutions differ slightly due to random errors in solution preparation and photometry. Based on the average value of the molar absorption coefficient, the conditional stability constant of the complex under study ($\beta_K^{'}$) calculated formula (2):

$$\beta_K^{'} = \frac{A/\varepsilon_K}{\left(C_R - \frac{A}{\varepsilon_K}\right) \cdot \left(C_M - \frac{A}{\varepsilon_K}\right)}, \quad (2)$$

then, according to the algorithm, the stability constant of the same complex is found. The average calculated ε_{ij} value corresponds to the literature data. Thus, the choice of isomolar series used to evaluate the stability of complex compounds by the isomolar sequence method affects the accuracy of this assessment. To obtain sufficiently accurate results, the data obtained for solutions belonging to the same series should be used together (both mixtures should have an excess of metal or reagent).Thus, at 273 nm the stability constant of the complex is (β_K') 5,5·10^-3^, and at 340 nm the stability constant of the complex is (β_K') 4,6·10^-3^ it turns out that the two values are almost close.

CONCLUSIONS

1. The structure of the complex formed by quercetin with iron (II) ions was studied by IR spectroscopic method. As a result, the coordination of metals was shown to occur, i.e., the Fe-O oscillation range at 627 cm^{-1} indicates the formation of a metal complex.
2. The structure of the complex formed by quercetin with iron (II) ions was studied on UV spectroscopy. This indicates that bathochromic shifts of approximately 7 nm and 64 nm occurred, respectively.
3. The stability constant of the complex formed by quercetin with iron (II) ions was determined. According to it, at 273 nm the stability constant of the complex is (β_K') $5{,}5\cdot10^{-3}$ and at 340 nm the stability constant of the complex is (β_K') $4{,}6\cdot10^{-3}$.

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