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Study on the Colour Reaction of Ternary Complex of Yttrium-Rutin-Cetyltrimethylammonium Bromide

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In the presence of CTMAB, the photometric properties of rutin ternary complex are studied and a new method is found for the determination of yttrium. The experimental results show that yttrium reacts with rutin and CTMAB to form an orange complex. The maximum absorption wavelength is 450 nm and the amount of NaOH buffer solution is 2 mL. The added amount of CTMAB is 5 mL and the time developing colour is 0.5 h. The apparent molar absorption coefficient of the complex is 2.680 L $mmol^{-1}$ cm^{-1}. Lambert Beer's law is obeyed in the range of 0-0.2 mmol/L for yttrium.

Key Words: Yttrium, Rutin, CTMAB, Spectrophotometry.

INTRODUCTION

Rutin, also known as rutoside, is a kind of flaconoids containing four hydroxyl groups. Rutin whose source is very wide is present in many plants, such as rue leaves, tobacco, orange peel, tomato *etc*. The content of rutin is particularly rich in Sophora japonica rice and buckwheat flowers and China's medicinal rutin is extracted from the former[1,2]. Rutin belongs to polyphenol and vitamin whose important role is to expand blood capillary. It can allow the body to maintain normal capillary resistance and prevent atherosclerosis. Studies have shown that rutin can aid in healing cardiovascular diseases and be used as a nutrient tonic[3-5]. Rutin is a chelating agent useful for spectrophotometry, polarography, fluorescence and chemiluminescence analysis, which can react with many salts to get the complex[6,7]. According to coordination chemistry theory of traditional Chinese medicine, the active ingredient of Chinese traditional medicine is not simply the organic component or trace element, but the coordination compound of both. For instance, there is no cancer-killing ability of rutin but with $CuSO_4$ solution showed to the cancer cells only a minor role. However, after rutin and Cu(II) complexes generate, the greater killing effect on cancer cells occurs[8-13]. In view of the important role of rutin and metal complexes, the nature of yttrium-rutin-CTMAB ternary complex is studied by spectrophotometry, including the absorption curve, time of colouration, coordination number *etc*. These results can provide references for the development of the study on metal complexes in herbs and pharmacological effects of Chinese medicine.

EXPERIMENTAL

752 Spectrophotometer (Shanghai Spectrum Instruments Co., Ltd.); AL204 Analytical balance (Mettler-Toledo International Inc.); pHS pH meter (Shanghai Precision Instrument Co., Ltd.).

Yttrium standard solution: Weigh 0.0575 g of Y_2O_3(AR) and transfer it to a dry and clean beaker, add a small amount of 1 mol/L hydrochloric acid solution and then heat to dissolve it. Until the solution is cooled, adjust pH to near neutral with a concentration of 1 mol/L NaOH solution. Transfer it to the 250 mL volumetric flask, add deionized water to the mark line, to prepare standard solution of yttrium.

Rutin solution: Weigh about 1 g glycosides rutin (biochemical reagent, purity > 95 %), dissolve it with 100 mL of anhydrous ethanol, then filter to remove insoluble material and transfer it to the evaporating dish. Add hot filtrate to about 1/3, place it in a fume hood, wait until the achieved crystallization of high purity rutin by evaporation. Accurately weigh 0.1664 g rutin obtained by preparing in the dry clean beaker, add 130 mL of anhydrous ethanol, then slightly heat to dissolve. Transfer it to the flask after cooling, adjust the solution volume to the mark and then obtain the rutin solution of concentration 1.002 mol/L.

Surfactant solution: Weigh cetyltrimethylammonium bromide, dissolve it in deionized water, then fix volume to the scale line and get the solution of 0.02 g/L. By the same method, prepare solution of cetylpyridinium bromide and dodecyl trimethyl ammonium chloride of 0.02 g/L.

NaOH solution: Weigh 0.1 g of NaOH solid, transfer it to a clean beaker, add an appropriate amount of deionized water to dissolve, then transfer it to a 250 mL volumetric flask, add deionized water to the mark and finally get a NaOH solution with the concentration of 0.01 mol/L.

Methods: Transfer a certain volume of standard solution of yttrium to a 25 mL colourimetric tube and add rutin solution, CTMAB solution and NaOH buffer solution. After addition of all the solutions shake colourimetric tube thoroughly and place it at room temperature for 0.5 h. The final mixture solution is determined in a 1 cm colourimetric cylinder with reference of blank solution. First, scan the absorption curve in the spectrophotometer to get the maximum absorption wavelength and then measure the absorbance at the maximum absorption wavelength. Based on the experimental data, yttrium-rutin-CTMAB ternary complex is analyzed.

RESULTS AND DISCUSSION

Absorption curve: The yttrium-rutin-CTMAB ternary complex solution is prepared by the above method. With the reagent blank as reference, the absorption curve is scanned (Fig. 1). Fig. 1 showed that the maximum absorption wavelength of yttrium-rutin binary complex is 450 nm. After adding the surfactant, the ternary complex is generated with the same maximum absorption wavelength. But the absorbance of ternary complex is significantly increased, indicating that surfactants increase the absorption effect, which shows that the surfactant has a role in increasing absorption.

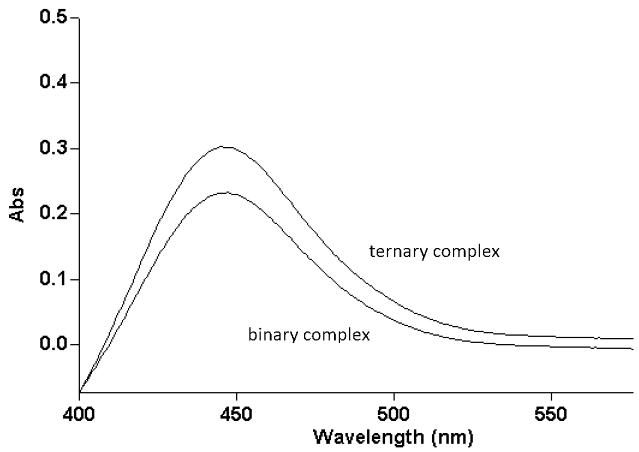

Fig. 1. Absorption curve of the rutin complexes

Choice of buffer solution and the effect of addition amount: Three different buffer systems, that is, CH_3COOH-CH_3COONa well buffer solution, mixed phosphate solution and NaOH solution are chosen to experiment. The results showed that when adding NaOH buffer solution the absorbance is the maximum, thus the NaOH solution is the best selection. The next step is to perform experiments on the effect of addition amount. Select 8 clean 25 mL colourimetric tubes, in each of which add some accurate reagents in proper order: 1 mL yttrium standard solution, 2.5 mL rutin solution, 5 mL CTMAB solution. Then into different colourimetric tube respectively add 0, 0.5, 1, 2, 3, 4, 6, 7 mL of NaOH solution. Dilute them with deionized water to the mark and place for 0.5 h after shaking. The absorbance of each colourimetric tube is determined with respective reagent blank at the maximum absorption wavelength 450 nm. Fig. 2 showed that when the amount of NaOH solution is in 1-4 mL range, the absorbance is maximum with little changes. According to this characteristic, the amount of NaOH buffer solution is chosen to be 2 mL.

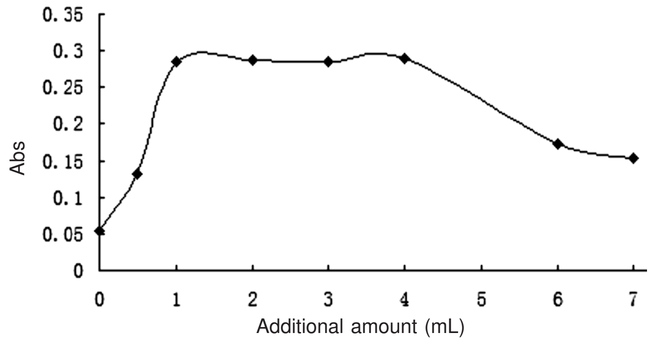

Fig. 2. Effect of additional amount of buffer solution

Choice of surfactant and the effect of addition amount: After three different surfactants are added, the absorbance is measured to find the best one. The absorption is the most obvious when cetyltrimethylammonium bromide (CTMAB) is used, so it is chosen as the surfactant. 1 mL yttrium standard solution and 2.5 mL rutin solution and 2 mL NaOH buffer solution are accurately added in eight 25 mL colourimetric tubes with pipette. Then in each colourimetric tube add 1, 2, 3, 4, 5, 6, 7, 8 mL CTMAB solution and shake up. After placing for 0.5 h, the solution's absorbance is measured at the wavelength of 450 nm with reagent blank as reference. Fig. 3 shows that the absorbance value is the maximum and stable in 3-6 mL range of CTMAB amount. Therefore, the addition amount of CTMAB is 5 mL in this experiment.

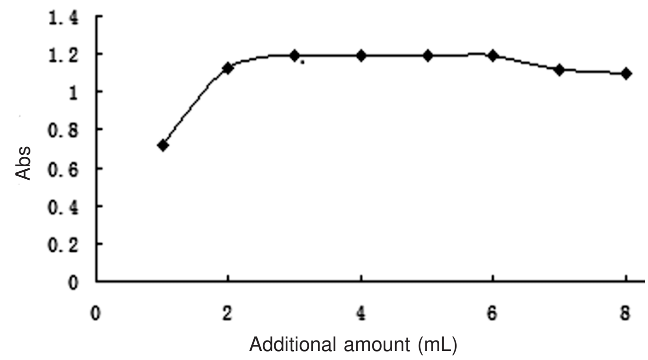

Fig. 3. Effect of additional amount of surfactant

Colouration time and stability: Yttrium-rutin-CTMAB solution is prepared by above experimental methods. The absorbance is measured every 5 min from the beginning of the solution colouration. Fig. 4 showed that when the colouration time is more than 0.5 h, the absorbance changes negligible. This shows that the colour reaction has been completed and the system become stable, so the best choice is to measure the absorbance after 0.5 h of colouration.

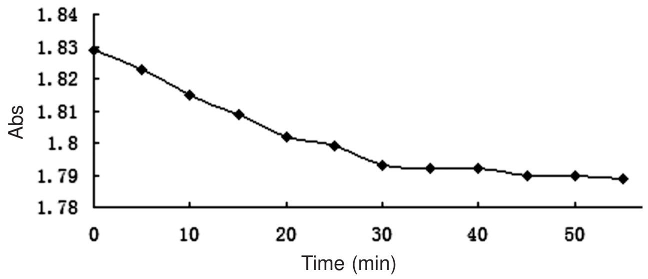

Fig. 4. Effect of colouration time

Composition of the complex: The coordination number of the rutin complex is determined by the molar ratio method. The basic principle is to add a fixed amount of standard solution of yttrium and varied volume of rutin solution in proper order. The absorbance is measured to draw a figure from which the coordination number is gained. Take 7 dry clean colourimetric tubes, add 1 mL standard solution of yttrium, 5 mL of CTMAB solution and 2 mL of NaOH buffer solution into each tube. Then add 1, 1.5, 2, 2.5, 3, 3.5 and 4 mL of solution of rutin. Finally, add deionized water to the mark, shake for 0.5 h, then measure the absorbance of the solutions. As shown in Fig. 5, the turning point is about 1 at the abscissa. According to the molar ratio method, the coordination number of the rutin complex is 1.

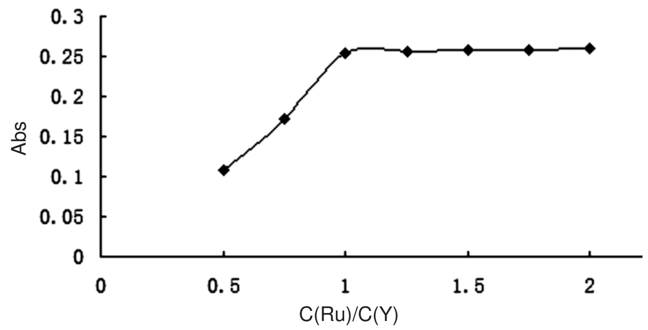

Fig. 5. Figure drawn by molar ratio method

Standard curve: Lambert Beer's law requires a good linear relationship between absorbance and concentration. Take 6 clean colourimetric tubes, into which add separately 0.5, 0.8, 1.0, 1.5, 2.0 and 2.5 mL standard solution of yttrium and then in proper sequence put in 2.5 mL rutin solution, 5.0 mL CTMAB solution and 2.0 mL NaOH buffer solution. In the end, deionized water is added to the mark of flask. Measure the absorbance and draw the figure by the similar method. As can be seen from the results, there is a good linear relationship between the absorbance and the yttrium concentration in 0-0.2 mmol/L and the apparent molar absorption coefficient is 2.680 L mmol^{-1} cm^{-1}.

Effect of interference ions: The best conditions are gained through the above experiments. Under these conditions, add 1 mL standard solution of yttrium and respectively add 1 mL interference solution of other common ions. The absorbance is measured with the reference of reagent blank and the experimental data are listed in Table-1. Table-1 shows that in addition to potassium ions, the rest have little influence on the yttrium complex.

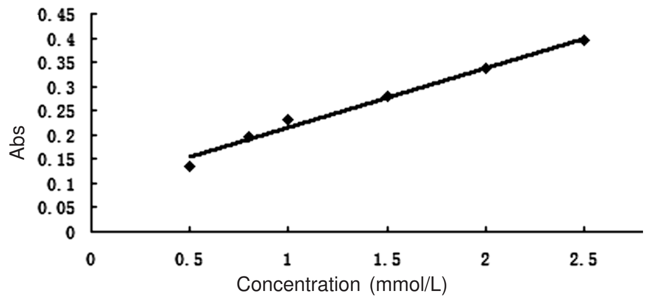

Fig. 6. Standard curve of yttrium

TABLE-1
EFFECT OF INTERFERENCE IONS

Concentration (mmol/L)		500	1000	1500
Relative error (%)	Na^+	0.6	0.6	0.6
	K^+	61.9	63.3	62.5
	I^-	-3.3	-2.5	-2.0

Conclusion

This experiment proves that yttrium, rutin and CTMAB can generate orange ternary complex. The best conditions are determined by the experiments of the buffer solution addition amount and the surfactant and the colouration time *etc*. Under the proper conditions, the coordination number of rutin complexes is 1. The study of the ternary complex, may not only help us to establish a new method for determination of trace yttrium, but also play a reference role in the complex study in medicine, environment and other related fields.

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