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"Comparative analysis of cheapest monochromatic wavelength filter for measurement of absorbance"

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ABSTRACT

The present research work is about absorbance measurement by using different mixtures of cheapest monochromatic wavelength solutions filters for colorimetric analysis. The study of the filters is important in colorimetry. The filters are generally used to get monochromatic radiation of a particular frequency band. The objectives of research work is to detect solution absorption filters. An absorption filter was built by using mixtures of ten different chemicals. The observations of various experiments regarding the individual transmittance spectra, expected transmittance spectra superimposed spectra and observed spectra of solution filters shows various spectral region at 0.01 M concentration. The solution filter would be suitable for absorbance measurement at monochromatic wavelength in various colorimetric analysis. Observations of values of expected wavelength of maximum absorption and observed wavelength of maximum absorption, expected percentage transmittance and observed percentage transmittance is maximum are recorded.

KEYWORDS Solutions, spectra, absorption, transmittance, Colorimetry, Filter.

Introduction

The study of the filters is essential in colorimetry. In colorimetric analysis the light of definite wavelength is necessary and it provides a simple means for determining minute quantities of the substances using proper filters. When monochromatic or homogeneous light falls upon a homogeneous medium, a portion of the incident light is reflected, a portion is absorbed, a portion is scattered within a medium and the remainder is transmitted. Beer Lambert's law states that when monochromatic light passes through a transparent medium the rate of decrease in intensity with thickness of the medium is proportional to the intensity of the light. This is equivalent to state that the intensity of the emitted light decreases exponentially as the thickness of the absorbing medium increases arithmetically. (Strong, 1952). According to Sill (1961) and Mortimer (2003) absorption filters are usually made from dyed glass, lacquered gelatin, or synthetic polymers to offer a wide range of applications. Two types of colour filters viz. solid colour filters and liquid colour filters. Solid colour filters are simple coloured glass or film of coloured gelatin. Liquid colour filters consist of a glass cuvette with flat parallel walls containing coloured solutions of different shades in fixed concentrations or variable concentrations [Fox (1951), Hargue and Calfee (1932) and Barnes *et. al.,* (1945)].

Objective of the present work:

As compared to solid filters, the solution filters are very easy to prepare. Such filters are more durable than the solid filters and cheapest than the solid filters. Therefore it is necessary to study the transmission characteristics of solution filters so as to get monochromatic radiation of a particular frequency band and hence the effective band width in the visible region. Keeping this objective we have studied different solution filters. Scientific Reports (1966) and Rand (1969) are concluded the efficiency of a COJ-500-D Griffin Colorimeter with the created filter was defining by equating the slope of calibration curve of aqueous KMnO4 solution with that obtained with the manufacturer filter of the colorimeter.

Materials and Methods:

A) Preparation of solutions:

The aqueous solutions of different metal ions are prepared in the concentration of 0.1 M. All the chemicals used were of analytical grade and the water used was twice distilled.

i. Nickel chloride ($NiCl_2$, $6H_2O$): 2.3765 g of nickel chloride was dissolved in little distilled water and finally diluted to 100 ml to get 0.1 M solutions of it.

ii. Cobalt sulphate ($CoSO_4$, $7H_2O$): In order to get 0.1 M solution of cobalt sulphate, 2.8099 g of it was dissolved in double distilled water and finally diluted to 100 ml.

iii. Copper nitrate ($Cu(NO_3)_2$, $3H_2O$) : 2.4152 g of solid copper nitrate was dissolved in double distilled water and finally diluted to 100 ml to get 0.1 M solution.

iv. Copper chloride ($CuCl_2$, $2H_2O$): 0.1 M solution of copper chloride was prepared by dissolving 1.7045 g of salt of it in distilled water and diluted to 100 ml.

v. Sodium dichromate ($Na_2Cr_2O_7$, $2H_2O$): 2.9790 g of sodium dichromate was dissolved in little distilled water and diluted to 100 ml. The resulting solution is of 0.1 M concentration.

vi. Potassium permanganate ($KMnO_4$): 0.0158 g of solid potassium permanganate was dissolved in double distilled water and finally diluted to 100 ml. The resultant solution was having concentration of 0. 1 M.

vii. Rhodamine-B: 04790 g of Rhodamine - B was dissolved in little distilled water and finally diluted to 100 ml to get 0.001 M solution.

viii. Chromic Chloride ($CrCl_3$, $6H_2O$): 2.6638g of chromic chloride was dissolved in distilled water and finally diluted to 100 ml. The resultant solutions was having concentration of 0.1 M.

ix. Copper-ammonium ion: 0.8060 g of copper sulphate was dissolved in 100 ml of ammonia to get copper - ammonia complex. The resultant solution is of 0.1 M copper ammonium ion.

x. Nickel - ammonium ion: 07574 g of nickel sulphate was dissolved in 100 ml of ammonia to get nickel - ammonia complex. The resultant solution is of 0.1 M nickel-ammonium ion.

The individual transmission spectra of each solution is taken in the visible region using spectrophotometer. In current study rectangular cell was used, which possess some particular characteristics. The percentage transmittance and absorbance are noted in the visible region i.e. 400 to 89 m. In similar way spectra of each solution under study is taken. The plots of the percentage transmittance versus wavelength in mg of each solution are plotted.

Transmittance spectra of two individual solutions were plotted on the same scale. The portion of the super imposed curves is selected in such way that it will give narrow spectral region. In the selected spectral region, maximum percentage transmittance of any two curves is subtracted from hundred percent transmittance and remainder is again subtracted from maximum percentage transmittance of other curve at the same wavelength. Similarly all the plots were plotted at different wavelengths in selected spectral region and that gives the expected transmittance spectrum for a mixture of two solutions.

The combinations of solutions which are expected by superimposition of the curves are made in the concentrations 0.1 M and then the transmission spectrum of each mixture of two solutions is taken. That is the observed transmittance spectrum in the expected region. The expected and observed transmittance spectra are plotted on the same scale and on the same graph paper. Then wavelength of maximum absorption ($_{max}$), maximum percentage transmittance, half band width and range of the solutions filters are determined.

RESULTS AND DISCUSSION:

The observations of various experiments regarding the individual transmittance spectra, expected transmittance spectra superimposed spectra and observed spectra of various solution filters are given in Table 01 to 09 Table and Fig.01 to Fig. 16 From these observations, results of expected wavelength of maximum absorption, observed wavelength of maximum absorption, expected percentage transmittance, observed percentage transmittance, expected half band width and observed half band width obtained are as given below:

Table 01: Percentage transmittance of 0.1M of different solutions at various wavelength

Sr. No.	Wavelength in (mμ)	Transmittance percentage									
		Chromic Chloride		Copper nitrate	Copper chloride	Potassium permanganate	Nickel chloride		Copper-tetra ammonium ion		Nickel - tetra ammonium ion
1	300	70	70	10	35	11	88	85	75	78	87
2	320	76	75	65	47	12	85	85	80	80	85
3	340	71	72	80	58	13	82	79	82	82	75
4	360	67	65	85	65	15	71	72	85	85	45
5	380	54	55	87	74	25	40	40	87	87	62
6	400	35	37	88	81	43	30	30	90	90	84
7	420	15	15	87	85	61	50	51	89	90	90
8	440	05	05	86	88	80	85	80	88	88	90
9	460	03	03	84	88	70	95	87	85	81	90
10	480	08	08	82	88	45	96	92	65	66	90
11	500	20	23	80	87	15	97	95	43	43	83
12	520	37	37	77	85	12	98	95	23	23	80
13	540	33	35	70	82	12	99	95	09	15	74
14	560	27	27	65	79	15	99	94	-	-	61
15	580	16	16	55	74	25	97	90	-	-	58
16	600	08	08	45	69	45	95	85	-	-	61
17	620	04	04	35	60	60	90	80	-	-	67
18	640	05	06	30	50	70	87	75	-	-	75
19	660	12	10	23	40	75	85	72	-	-	81
20	680	18	18	17	30	80	83	70	-	-	85
21	700	28	25	13	25	90	80	70	-	-	88
22	720	33	33	12	18	95	77	75	-	-	88
23	740	46	43	10	12	98	75	80	-	-	87
24	760	50	54	07	08	98	77	85	-	-	-

Table 03: Percentage transmittance of 0.1M of different solutions at various wavelength

Sr. No.	Wavelength in (mμ)	Transmittance percentage									
		Copper nitrate		Copper chloride			Potassium permanganate	Sodium dichromate		Rhodamine-B	
1	300	-	-	25	-	-	05	-	-	-	-
2	320	20	20	35	35	35	05	-	-	-	-
3	340	85	80	66	65	66	05	-	-	-	-
4	360	95	92	78	78	78	08	-	-	20	-
5	380	97	93	83	83	83	25	-	-	25	-
6	400	98	94	87	85	86	61	-	-	20	-
7	420	99	95	88	87	87	78	-	-	23	-
8	440	99	96	90	88	88	70	-	-	40	-
9	460	99	96	90	89	89	46	-	-	30	-
10	480	99	97	90	89	89	17	-	-	05	-
11	500	99	97	90	89	89	04	-	-	02	-
12	520	99	97	90	89	90	02	10	-	02	-
13	540	99	96	90	89	90	02	10	15	02	-
14	560	95	95	90	88	90	02	65	65	02	12
15	580	90	91	84	83	85	16	84	85	02	20
16	600	83	83	76	76	76	51	85	86	42	35
17	620	72	72	66	66	66	58	86	86	80	75
18	640	58	58	55	55	56	62	86	86	88	88
19	660	45	45	44	45	44	68	86	86	90	90
20	680	32	32	32	32	33	74	86	86	90	90

21	700	23	23	23	23	23	80	85	85	90	90
22	720	17	17	17	16	22	83	84	84	89	89
23	740	13	13	13	14	13	84	-	83	89	89
24	760	12	13	-	13	11	85	-	82	89	88
25	780	12	-	-	13	-	-	-	-	89	88

Table 04: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of nickel chloride and cobalt sulphate		Wave length in (mμ)	mixture of nickel chloride and copper nitrate		Wave Length in (mμ)	mixture of nickel chloride and copper chloride	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	400	25	27	300	20	15	300	27	32
2.	420	35	40	320	55	45	320	39	43
3.	440	55	58	340	68	60	340	51	55
4.	460	47	52	360	50	47	360	43	45
5.	480	37	42	380	35	35	380	31	33
6.	500	30	35	400	32	32	400	31	32
7.	520	25	30	-	-	-	-	-	-
8.	400	25	27	-	-	-	-	-	-

Table 05: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of nickel chloride and cobalt sulphate		Wave length in (mμ)	mixture of nickel chloride and copper nitrate		Wave Length in (mμ)	mixture of nickel chloride and copper chloride	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	520	35	32	520	38	44	360	10	10
2.	540	48	42	540	51	57	380	12	12
3.	560	65	55	560	75	75	400	15	15
4.	580	83	74	580	70	70	420	25	25
5.	600	77	68	600	63	63	440	50	45
6.	620	66	57	620	53	53	460	40	35
7.	640	55	48	640	41	41	480	20	20
8.	660	45	39	660	32	32	500	15	14
9.	680	35	31	680	26	26	520	12	12
10.	700	28	26	700	22	22	-	-	-

Table 06: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of nickel chloride and cobalt sulphate		Wave length in (mμ)	mixture of nickel chloride and copper nitrate		Wave Length in (mμ)	mixture of nickel chloride and copper chloride	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	300	10	10	300	15	15	360	10	10
2.	320	43	33	320	27	32	380	13	40
3.	340	58	50	340	40	47	400	20	60
4.	360	58	54	360	32	40	420	35	59
5.	380	47	38	380	23	29	440	70	41
6.	400	25	19	400	16	20	460	68	17
7.	420	12	08	420	10	12	480	50	-
8.	440	06	04	440	05	05	500	35	-
9	-	-	-	-	-	-	520	23	-
10	-	-	-	-	-	-	540	15	-

Table 07: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of nickel chloride and cobalt sulphate		Wave length in (mμ)	mixture of nickel chloride and copper nitrate		Wave Length in (mμ)	mixture of nickel chloride and copper chloride	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	360	30	14	580	02	02	560	-	12
2.	380	49	25	600	12	47	580	-	20
3.	400	72	58	620	47	60	600	30	35
4.	420	80	74	640	40	50	620	51	60
5.	440	83	69	660	33	40	640	52	55
6.	460	74	48	680	20	28	660	33	43
7.	480	58	20	700	13	20	680	22	32
8.	500	32	10	720	05	15	700	15	23
9.	520	10	-	740	-	11	720	-	17
10.	-	-	-	760	-	-	740	-	13

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Table 08: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of nickel chloride and cobalt sulphate		Wave length in (mμ)	mixture of nickel chloride and copper nitrate		Wave Length in (mμ)	mixture of nickel chloride and copper chloride	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	520	10	10	580	03	10	540	06	15
2.	540	10	10	600	26	35	560	54	60
3.	560	65	55	620	24	36	580	68	75
4.	580	76	68	640	18	33	600	62	70
5.	600	69	63	660	12	28	620	52	62
6.	620	58	55	680	06	22	640	41	53
7.	640	43	44	700	02	17	660	30	40
8.	660	30	33	720	-	13	680	18	30
9.	680	18	22	740	-	10	700	08	20
10.	700	12	15	-	-	-	720	02	14

Fig. 01: Individual, expected and observed percentage transmittance of nickel chloride and cobalt sulphate at various wavelength

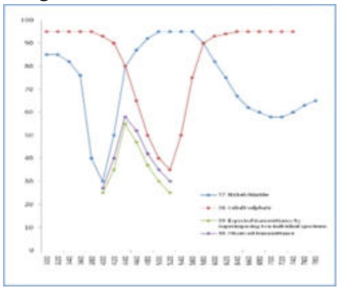

Fig. 02: Individual, expected and observed percentage transmittance of nickel chloride and copper nitrate at various wavelength

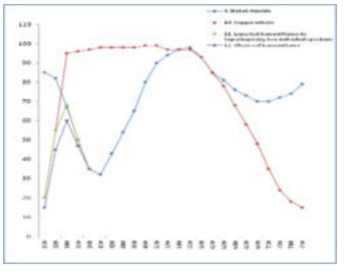

Fig. 03: Individual, expected and observed percentage transmittance of nickel chloride and copper chloride at various wavelength

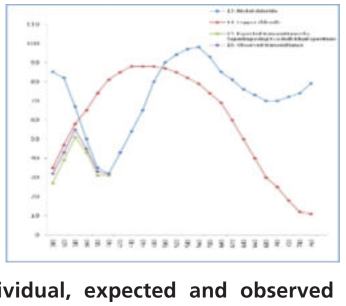

Fig. 04: Individual, expected and observed percentage transmittance of copper nitrate and cobalt sulphate at various wavelength

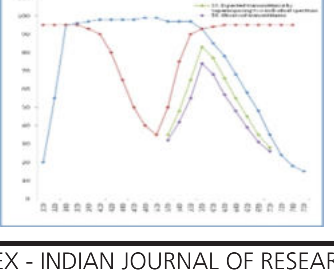

Fig. 05: Individual, expected and observed percentage transmittance of copper chloride and cobalt sulphate at various wavelength

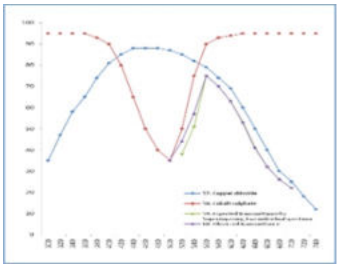

Fig. 6 : Individual, expected and observed percentage transmittance of chromic chloride and copper nitrate at various wavelength

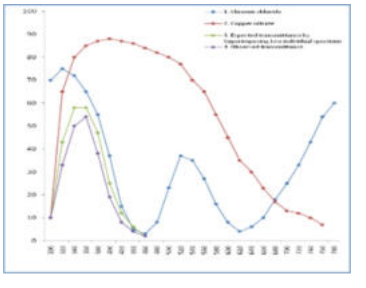

Fig. 7 : Individual, expected and observed percentage transmittance of chromic chloride and copper chloride at various wavelength

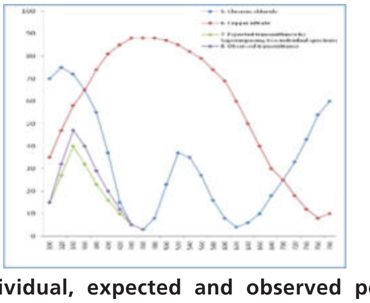

Fig. 8: Individual, expected and observed percentage transmittance of potassium permanganate and nickel chloride at various wavelength

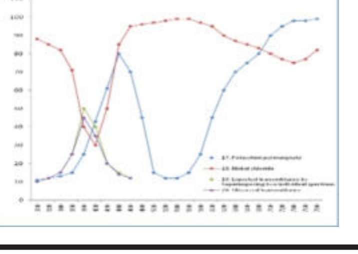

Fig. 9 : Individual, expected and observed percentage transmittance of nickel chloride and copper tetra-ammonium ion at various wavelength

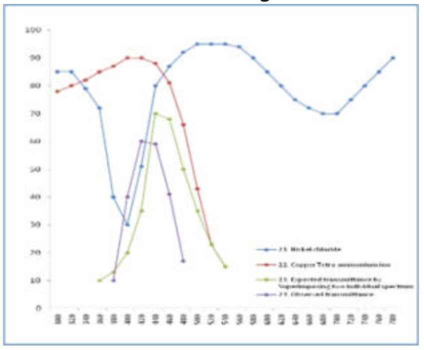

Fig10 : Individual, expected and observed percentage transmittance of nickel tetra - ammonium ion and copper tetra - ammonium ion at various wavelength

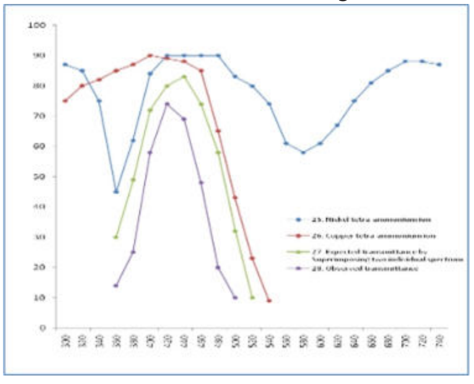

Fig. 11: Individual, expected and observed percentage transmittance of Copper chloride and Rhodamine-B at variou

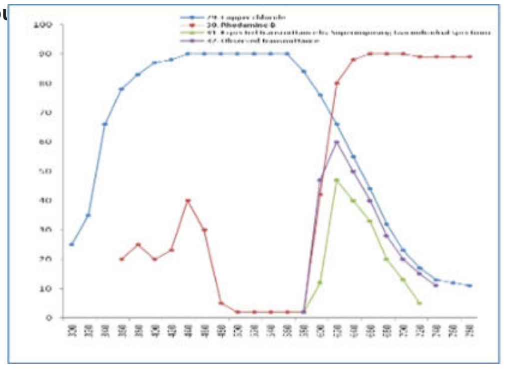

Fig. 12: Individual, expected and observed percentage transmittance of Copper nitrate and Rhodamine-B at various wavelength

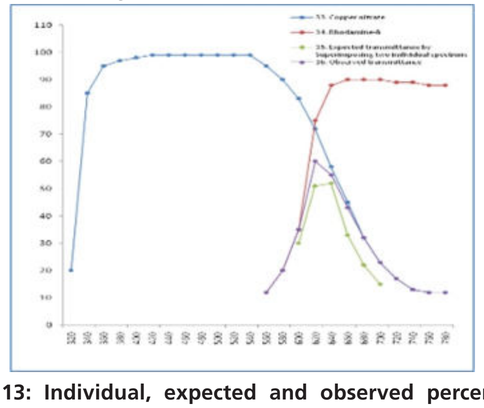

Fig. 13: Individual, expected and observed percentage transmittance of Copper nitrate and Sodium dichromate at various wavelength

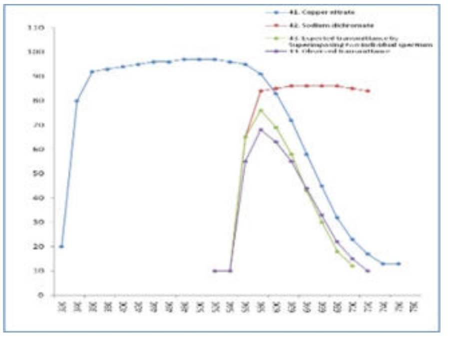

Fig.14: Individual, expected and observed percentage transmittance of Copper chloride and Potassium permanganate at various wavelength

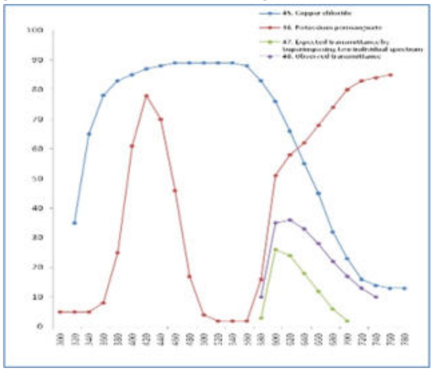

Fig.15: Individual, expected and observed percentage transmittance of Copper chloride and Sodium dichromate at various wavelength

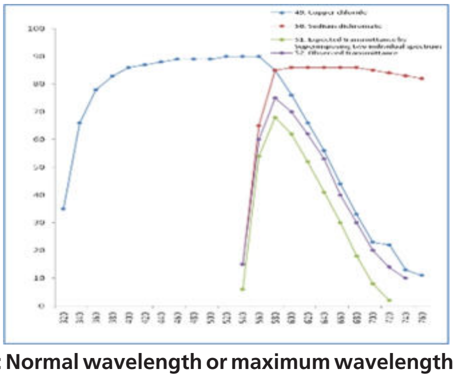

Fig. 16: Normal wavelength or maximum wavelength

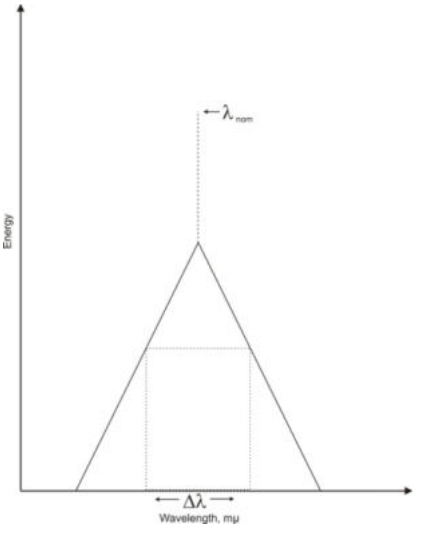

Table 9. Comparative analysis of mixture of different solution filters and its transmittance spectra, expected transmittance spectra superimposed spectra and observed spectra.

Sr. No.	Solution Mixture	λmax expected	λmax observed	%T expected	%T observed	$\Delta\lambda_{max}$ half band width (expected) mμ	$\Delta\lambda_{max}$ half band width (observed) mμ
1.	$CrCl_3 + Cu(NO_3)_2$	360	360	58	54	80	72
2.	$CrCl_3 + CuCl_2$	360	360	40	47	72	76
3.	$NiCl_2 + Cu(NO_3)_2$	340	340	68	60	68	80
4.	$NiCl_2 + CuCl_2$	340	340	51	55	92	104
5.	$KMnO_4 + NiCl_2$	440	440	50	45	52	56
6.	$NiCl_2 + Cu(NH_3)^{++}$	440	420	70	60	72	80
7.	$Ni(NH_3)_4^{++} + Cu(NH_3)^{++}$	440	420	83	74	124	80
8.	$CuCl_2$ + Rhodamine-B	620	620	47	60	52	80
9.	$Cu(NO_3)_2$ + Rhodamine-B	640	620	52	60	60	88
10.	$CuCl_2 + CoSO_4$	440	440	55	58	92	112
11.	$Cu(NO_3)_2 + Na_2Cr_2O_7$	580	580	76	68	100	108
12.	$CuCl_2 + KMnO_4$	600	620	26	36	72	108
13.	$CuCl_2 + Na_2Cr_2O_7$	580	580	68	75	96	112
14.	$Cu(NO_3)_2 + CoSO_4$	590	590	83	74	132	140
15.	$CuCl_2 + CoSO_4$	560	560	75	75	128	144

According to Robinson and Overston (1951) values of expected wavelength of maximum absorption, observed wavelength of maximum absorption, expected percentage transmittance, observed percentage transmittance, expected half band width and observed half band width obtained are mentioned in tabular format.

Adeeyinwo Adedeji (2007) absorption filter had constructed using 40% CuSO4.5H2O solution in 8M HCl (w/v) in glass support of 2mm internal diameter. A better solution filter is that which gives narrow spectral region and smallest half. Hence from the results, following solution alters are the narrow band solution filters.

A mixture of solution of chromic chloride (0.1 M) and copper nitrate (0.1M), chromic chloride (0.1M) and copper chloride (0.1M), nickel chloride (0.1M) and copper chloride (0.1M), nickel chloride (0.1M) and copper nitrate (0.1M), shows narrow spectral region of 370m to 400m. While a mixture of solution of potassium permanganate (0.01M) and nickel chloride (0.1M) shows a spectral region of 400 m to 520 m.

From the results comparatively narrow band solution filters are mixture of nickel chloride (0.1M) and-copper tetra-ammonium ion (0.1M), nickel tetra-ammonium ion and copper tetra- ammonium ion, copper chloride (0.1M) and rhodamine-B (0.1M), copper nitrate (0.1M) and rhodamine-B (0.01M) shows 350 m to 760 m, 580 m to 760 m and 580 m to 760 m spectral region respectively.

Further wide band solution filters are mixture of solution of copper nitrate (0.1M) and sodium dichromate (0.1M), copper chloride (0.1M) and sodium dichromate (0.1M) which shows spectral region of 520 m to 740 m. A mixture of solution of copper chloride (0.1M) and potassium permanganate (0.01M), mixture of solution of nickel chloride (0.1M) and cobalt sulphate (0.1M) are also wide band solution filters and shows spectral region of 560 m to 760 m and 380 m to 520 m respectively.

There are some solution filters which are not of much use because their half band widths are wider. Such solution filters are a mixture of solution of copper nitrate (0.1M) and cobalt sulphate (0.1M), copper chloride (0.1M) and cobalt sulphate (0.1M), which shows 520 m to 760 m of spectral region.

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