ORIGINAL RESEARCH PAPER | Physics | Volume - 7 | Issue - 3 | March - 2017 | ISSN - 2249-555X | IF : 4.894 | IC Value : 79.96

"Absorbance measurement by monochromatic wavelength solution filters"

KEYWORDS: Wavelength, absorption, transmittance, nickel tetra - ammonium ion

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ABSTRACT The purpose present research work is to find out solution absorption filters for colorimetric explores. An absorption filter was so built by using mixtures of seven different chemicals. The filter have a monochromatic wavelength. 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 are similar in mixture solution of $CrCl_3$ + Cu $(NO_3)_2$, $CrCl_3$ + $CuCl_2$ and $KMnO_4$ + $NiCl_2$. Whereas expected percentage transmittance and observed percentage transmittance is maximum in mixture solution of nickel tetra - ammonium ion and copper tetra - ammonium ion.

INTRODUCTION:

Colorimetric procedures are involve in quantitative studies performed in the research laboratories. Working principle of colorimeter is based on the Beer Lambert's law. According to the law, when a monochromatic radiation transfer through a solution of absorbing medium, the absorbance is directly proportional to the concentration and width of the solution in the light track (Strong, 1952). Absorption filters are usually made from dyed glass, lacquered gelatin, or synthetic polymers to offer a wide range of applications (Sill, 1961 and Mortimer, 2003). According to Rogers 1986, Burtis and Ashwood, 1994) certain metal complexes or salts liquefied or suspended in glass yield colour equivalent to the predominant wavelength transmitted. Scientific Reports (1966) and Rand (1969) status that the efficiency of a COJ-500-D Griffin Colorimeter with the created filter was defining by equating the slope of calibration curve of aqueous $KMnO_4$ solution with that obtained with the manufacturer filter of the colorimeter. The capability of the photometric system to yield a linear relationship between the radiant power incident on its detector and the measurable quantity provided by the system was performed by plotting a calibration curve for standard aqueous solution of $KMnO_4$ Reule (1968).

A) Purpose of the filters:

They are used extensively to obtain approximately monochromatic radiation for photochemical or photo biological investigations. They are also used to reduce the effect of stray radiations or undesired spectral orders in dispersing systems. In general, the narrower the transmitted wavelength band and the closer its peak agrees with the absorption maximum of the substance being analyzed. The filter whose color should be as close as possible to the complementary color of the solution in the visible region. The filter should give narrower transmitted wavelength band so that its[3] effective band width is small.

B) Theory of colorimetry:

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. If the intensity of incident light is expressed by I_0 that of absorbed light by I_a, that of transmitted by I_t and that of the reflected by I_r and scattered light by I_s, than

$$I_0 = I_a + I_t + I_r + I_s$$

I_r is usually eliminated by the use of a control such as a comparison cell and I_s and can be reduced using clear solutions, hence.

$$I_0 = I_a + I_t$$

Lambertzs investigated the relation between I_0 and I_t while Beers extended the experiments to solutions. Spectrophotometry and colorimetry are based upon Lamberts and Beers laws.

C) Choice of absorption cell and Operations of the spectrophotometer:

There are different types of the absorption cells used in the ultra violet and visible regions. In current study work rectangular cell was used, which possess some particular characteristics. The rectangular cells are used for used for the liquids or solutions. The glass windows are sufficiently transparent for use in ultraviolet-and visible regions. Fused quartz is the window material for the cells. The cell window faces was parallel and flat to within a few wavelengths of radiation used. The dimensions of cell was perpendicular to the path of the radiation so that the radiation will not strike the walls and reflect from them.

Before taking the actual transmittance or absorption spectra, the instrument should be 'on' at least half on hour to stabilize electronic. The pilot light glows, indicating the electronics are on. When the power control switch is in the ideal or on, 100% transmittance is adjusted by REF front Panel taking reference solution in both rectangular cells. The solutions or liquid which is to be used in the cell should be transparent and clear. Similarly zero percent transmittance is adjusted using an opaque block in the reference position wavelength control: Rotating the wavelength control, rotates the wavelength cam, setting the angular position of the prism. This determines the control wavelength of the band of light; passing through the exit slit.

D) Measurement of transmittance and absorbance:

A cell is cleaned and coloured solution is taken in a cell and the kept in the sample position. The power switch is made on. The percentage transmittance and absorbance are noted in the visible region i.e. 400 to 89 m. (Ref. Table 1 to Table 03). 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 (Ref. Fig. 01 to Fig.05).

E) Superimposition of two curves:

Transmittance spectra of two individual solutions were planned 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.

The combinations of solutions which are expected by superimposition of the curves are made in the range of concentration 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,

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half band width and range of the solutions filters are determined.

EXPERIMENTAL

A) Preparation of solutions:

The solutions of selected metal ions are prepared in the concentration of 0.1 M. All the chemicals used were of analytical grade and double distilled water.

1) **Nickel chloride ($NiCl_2$, $6H_2O$):** 2.3765 g of nickel chloride was liquefied in little distilled water and diluted to 100 ml to get 0.1 M solutions.
2) **Copper nitrate ($Cu(NO_3)_2$, $3H_2O$) :** 2.4152 g of solid copper nitrate was liquefied in double distilled water and finally diluted to 100 ml to get 0.1 M solution.
3) **Copper chloride ($CuCl_2$, $2H_2O$):** Preparation of 0.1 M solution of copper chloride was obtain by dissolving 1.7045 g of salt of it in 100 ml distilled water.
4) **Potassium permanganate ($KMNO_4$):** 0.0158 g of solid potassium permanganate was dissolved in double distilled water and finally diluted to 100 ml.
5) **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.
6) **Copper-tetra 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.
7) **Nickel – tetra ammonium ion:** 0.7574 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.

Observation tables: 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	10	35	11	88	85	75	78	87
2	320	75	65	47	12	85	85	80	80	85
3	340	72	80	58	13	82	79	82	82	75
4	360	65	85	65	15	71	72	85	85	45
5	380	55	87	74	25	40	40	87	87	62
6	400	37	88	81	43	30	30	90	90	84
7	420	15	87	85	61	50	51	89	90	90
8	440	05	86	88	80	85	80	88	88	90
9	460	03	84	88	70	95	87	85	81	90
10	480	08	82	88	45	96	92	65	66	90
11	500	23	80	87	15	97	95	43	43	83
12	520	37	77	85	12	98	95	23	23	80
13	540	35	70	82	12	99	95	09	15	74
14	560	27	65	79	15	99	94			61
15	580	16	55	74	25	97	90			58
16	600	08	45	69	45	95	85			61
17	620	04	35	60	60	90	80			67
18	640	06	30	50	70	87	75			75
19	660	10	23	40	75	85	72			81
20	680	18	17	30	80	83	70			85
21	700	25	13	25	90	80	70			88
22	720	33	12	18	95	77	75			88
23	740	43	10	12	98	75	80			87
24	760	54	07	08	98	77	85			

Table 02: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave length in (mμ)	mixture of chromic chloride and copper nitrate		Wave length in (mμ)	mixture of chromic chloride and copper chloride	
		Expected	Observed		Expected	Observed
1.	300	10	10	300	15	15
2.	320	43	33	320	27	32
3.	340	58	50	340	40	47
4.	360	58	54	360	32	40
5.	380	47	38	380	23	29
6.	400	25	19	400	16	20
7.	420	12	08	420	10	12
8.	440	06	04	440	05	05

Table 03: Expected and Observed percentage transmittance of mixture at various wavelength

Sr. No.	Wave Length in (mμ)	mixture of potassium permanganate and nickel chloride		Wave length in (mμ)	mixture of nickel chloride and copper -tetra ammonium ion		Wave length in (mμ)	mixture of nickel - tetra ammonium ion and copper ammonium ion	
		Expected	Observed		Expected	Observed		Expected	Observed
1.	360	10	10	360	10	10	360	30	14
2.	380	12	12	380	13	40	380	49	25
3.	400	15	15	400	20	60	400	72	58

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4.	420	25	25	420	35	59	420	80	74
5.	440	50	45	440	70	41	440	83	69
6.	460	40	35	460	68	17	460	74	48
7.	480	20	20	480	50		480	58	20
8.	500	15	14	500	35		500	32	10
9.	520	12	12	520	23		520	10	
10.				540	15				

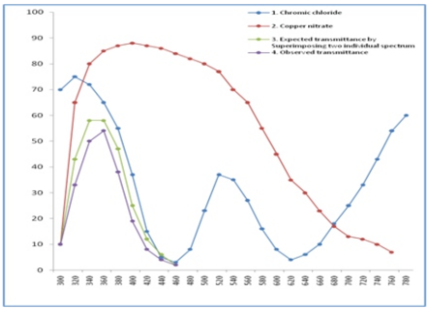

Fig. 1 : Individual, expected and observed percentage transmittance of chromic chloride and copper nitrate at various wavelength

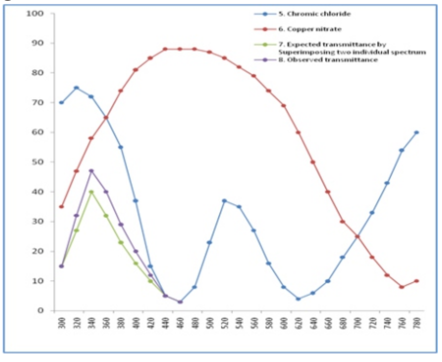

Fig. 2 : Individual, expected and observed percentage transmittance of chromic chloride and copper chloride at various wavelength

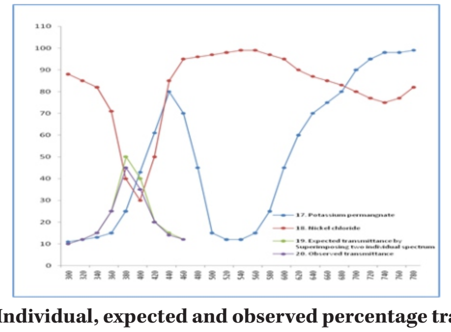

Fig. 3 : Individual, expected and observed percentage transmittance of potassium permanganate and nickel chloride at various wavelength

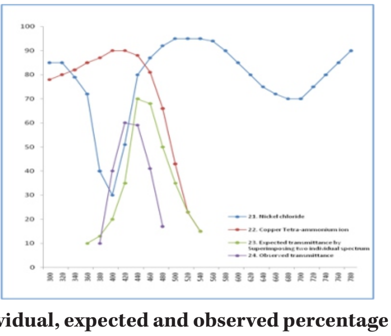

Fig. 4 : Individual, expected and observed percentage transmittance of nickel chloride and copper tetra-ammonium ion at various wavelength

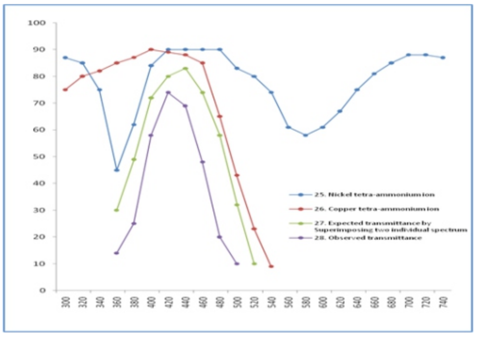

Fig. 5 : Individual, expected and observed percentage transmittance of nickel tetra - ammonium ion and copper tetra - ammonium ion at various wavelength

RESULTS AND DISCUSSION

The observations of several study concerning the individual transmittance spectra, expected transmittance spectra superimposed spectra and observed spectra of above mentioned solution filters are given in Table 01 to Table 03 and Fig. 01 to Fig. 05.

Sr. No	Solution Mixture	max expected	max observed	%T expected	%T observed	Δ_{max} half band width (expected) m	Δ_{max} half band width (observed) m
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.	$KMnO_4$ + $NiCl_2$	440	440	50	45	52	56
4.	$NiCl_2$ + $Cu(NH_3)^{++}$	440	420	70	60	72	80
5	$Ni(NH_3)_4^{++}$ + $Cu(NH_3)^{++}$	440	420	83	74	124	80

Robinson and Overston (1951) have detected a series of colour filters to give great selectivity. As of these observations, 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) concluded that an absorption filter was so constructed using 40% CuSO4.5H2O solution in 8M HCl (w/v) in glass support of 2mm internal diameter. The filter was found to have a nominal wavelength of 540±0.92nm, spectral bandwidth of 41±0.82nm and a peak transmittance of 36±0.40%. Observations indicate that the values of expected wavelength of maximum absorption and observed wavelength of maximum absorption are similar in mixture solution of CrCl3 + Cu (NO3)2, CrCl3 + CuCl2 and KMnO4 + NiCl2. Whereas expected percentage transmittance and observed percentage transmittance is maximum in mixture solution of nickel tetra - ammonium ion and copper tetra - ammonium ion. Wherein expected half band width and observed half band width obtained are minimum and maximum in KMnO4 + NiCl2 mixture and NiCl2 + $Cu(NH3)^{++}$ and $Ni(NH3)4^{++}$ + $Cu(NH3)^{++}$ mixture solution respectively.

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References:

1. Adeeyinwo C. E. and Adedeji A. L. (2007) : Construction of Absorption Filter for colorimetry and its performance characteristics, Biomedical Research; 18 (2): 93-96
2. Association of Clinical Biochemists, England (1966): Colorimeters - A critical assessment of five commercial instruments. Scientific Reports; No 2.
3. Burtis C. A. and Ashwood E. R. Photometry (1994): In Tietz Textbook of Clinical Chemistry, Philadephia. Saunders SW Company 2nd edition. pp. 104 - 131.
4. Mortimer A. (2003): Light filtration, Olympus Microscopy Resource Center, Olympus America, Inc Melville, New York, 11747.
5. Rand R. N.(1969): Practical spectrophotometric standards. Clin Chem 15: 839 - 863.
6. Reule A. (1968): Testing spectrophotometer linearity. Appl Opt 7: 1023 - 1025.
7. Robinson A.M. and Ovenston, T.C.J. (1951): A simple flame photometer for international standard operation and notes on some new lipid spectrum filters. Analyst, 76, 416-424.
8. Rogers A. (1986): Colour transmission in metal chemistry. J Chem Edu 23: 18 - 19.
9. Sill C. W. (1961): Transmittance spectral of colour filters. Anal Chem 33:1584-1587.
10. Strong F.C. (1952): Theoretical basis of the Bouguer Beer law of radiation absorption. Anal Chem 24: 338 – 341.