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Determination of Concentration of NaCl Solution within its Saturation Limit using Refractive Index Method

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Abstract: ***At room temperature NaCl solution of one to five molal concentration was prepared separately. Refractive index of each molal concentration of NaCl solution was obtained using Spectrometer and hollow glass prism. By using Shuster method and Sodium source as a monochromatic light source it was verified with that refractive index of solution was found to be increased with increase in molal concentration of solution. Graph of refractive index of medium against molal concentration showed linear relationship. Another unknown molal concentration of NaCl solution within saturation limit was prepared. Refractive index of that unknown concentration of NaCl solution was 1.3642. The obtained value of refractive index of medium was used to determine concentration of the solution by help of graph and was founded to be approximately 4 molal concentration.***

Keywords: Refractive index, Molal Concentration, NaCl

1. Introduction

Refractive index of one to five molal concentration of NaCl solution was obtained using monochromatic Sodium light source, hollow glass prism and Spectrometer. Principle of Shuster's method was used to find angle of minimum deviation [3]. With increase in molality of solution density of the solution increases [4] which in turn reduces velocity of light in medium [5]. Thus with increase in molality refractive index of solution should increase and was confirmed experimentally [1]. Linear increase in refractive index with increase in molal concentration was observed graphically [2]. Refractive index of unknown NaCl solution gave the value of concentration of solution with help of graph.

2. Experiment

At room temperature one molal to five molal concentration of NaCl solution was prepared separately. Telescope, Collimator and prism table were horizontally aligned using spirit level. Cross wire of telescope was adjusted on fine slit. Prism filled with one molal concentration NaCl solution was kept on prism table with its base parallel to telescope and collimator. Shuster's method was used to obtain angle of minimum deviation [3]. This procedure was repeated five times for one molal NaCl solution to obtain mean of angle of minimum deviation. As angle of Prism A=60° the prism formula

$$\mu = \frac{\sin\{[A+\angle m]/2\}\ [6]}{\sin[A/2]}$$

Reduces to $\mu = 2*\sin[(60+\angle m)/2]$…….. (1)

Equation (1) was used to calculate refractive index of one molal NaCl solution. Similarly refractive index of two, three, four and five molal NaCl solution was obtained. Graph of Refractive index against molal concentration was plotted. Another unknown NaCl solution was prepared. Refractive index of that unknown solution was 1.3642. By knowing it corresponding concentration of unknown NaCl solution was approximately 4 molal concentration. Observation table are given below.

Table 1: One molal NaCl solution:

Sr	∠m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∠m
1	162°33'	342°16'	138°17'	317°59'	24°16'	24°17'	24°16'
2	148°59'	328°36'	125°	304°42'	23°59'	23°54'	23°56'
3	135°27'	315°05'	111°28'	291°09'	23°59'	33°56'	23°57'
4	122°48'	302°34'	98°45'	278°30'	24°03'	24°04'	24°03'
5	110°04'	289°57'	85°21'	265°06'	24°43'	24°51'	24°47'

Thus ∠m= 24°11'
$\mu = 2*\sin[(60+\angle m)/2] = 1.3406$
Hence refractive index of 1 molal NaCl solution at room temperature was 1.3406.

Table 2: Two molal NaCl solution:

Sr	∠m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∠m
1	94°57'	274°44'	69°55'	249°45'	25°02'	24°49'	24°55'
2	81°30'	261°22'	56°40'	236°05'	24°50'	25°17'	25°03'
3	66°50'	246°40'	41°47'	221°44'	25°03'	24°56'	24°59'
4	51°08'	231°13'	26°35'	206°37'	24°33'	24°36'	24°34'30''
5	38°39'	218°43'	14°02'	194°12'	24°37'	24°31'	24°34'

Thus ∠m= 24°49'06"
$\mu = 2*\sin[(60+\angle m)/2]$
$\mu = 1.3488$
Hence refractive index of 2 molal NaCl solution at room temperature was 1.3488.

Table 3: Three molal NaCl solution

Sr	∠m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∠m
1	25°341'	205°46'	0°5'	180°18'	25°36'	25°28'	25°32'
2	11°30'	191°39'	345°53'	166°09'	25°37'	25°30'	25°33'
3	357°30'	177°42'	331°59'	152°11'	25°31'	25°31'	25°31'
4	344°05'	164°27'	318°30'	139°	25°35'	25°27'	25°31'
5	326°12'	146°33'	300°36'	121°	25°36'	25°33'	25°34'

Thus ∠m= 25°32'
$\mu = 2*\sin[(60+\angle m)/2] = 1.3580$

Hence refractive index of 3 molal NaCl solution at room temperature was 1.3580

Table 4: Four Molal NaCl solution

Sr	∫m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∫m
1	310°28'	130°46'	284°36'	104°59'	25°52'	25°47'	25°49'
2	297°20'	117°36'	271°38'	91°49'	25°42'	25°47'	25°44'
3	282°23'	102°38'	256°15'	76°24'	26°08'	26°14'	26°11'
4	268°26'	88°33'	62°28'	242°18'	26°08'	26°05'	26°06'
5	254°53'	75°	228°43'	48°48'	26°10'	26°12'	26°11'

∫m = 26°0'
μ = 2*Sin [(A+∫m)/2]
μ = 1.3640
Hence refractive index of 4 molal NaCl solution at room temperature was 1.3640

Table 5: Five molal NaCl solution

Sr	∫m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∫m
1	154°44'	334°28'	128°30'	308°06'	26°14'	26°22'	26°17'
2	140°48'	320°30'	113°48'	293°35'	27°	26°55'	26°57'30''
3	124°52'	304°37'	98°41'	277°58'	26°11'	26°39'	26°25'
4	110°52'	290°05'	83°39'	263°23'	27°13'	26°42'	26°57'30''
5	96°06'	275°56'	69°50'	249°41'	26°16'	26°15'	26°15'30''

∫m = 26°34'
μ = 2*Sin[(A+∫m)/2]= 1.3712
Hence refractive index of 5 molal NaCl solution at room temperature was 1.3712

Table 6: Unknown Concentration of NaCl Solution:

Sr	∫m position		Direct reading		difference		mean
	A'	B'	A	B	A'-A	B'-B	∫m
1	310°28'	130°46'	285°16'	105°49'	25°12'	25°57'	25°34'
2	297°20'	117°36'	270°28'	90°39'	26°52'	26°47'	26°49'
3	282°23'	102°38'	256°15'	76°24'	26°08'	26°14'	26°11'
4	268°26'	88°33'	62°28'	242°18'	26°08'	26°05'	26°06'
5	254°53'	75°	228°43'	48°49'	26°10'	26°12'	26°10'

∫m = 26°02'
μ = 2*Sin[(A+∫m)/2]
μ = 1.3642
Hence refractive index of unknown NaCl solution at room temperature is 1.3642

3. Result and Discussion

Increase in refractive index of medium with increase in molal concentration below saturation limit of NaCl solution was verified [1]. Refractive index of unknown solution was 1.3642. The corresponding value of concentration with help of graph was approximately 4 molal concentration.Graph of refractive index against molal concentration is shown in figure (1).

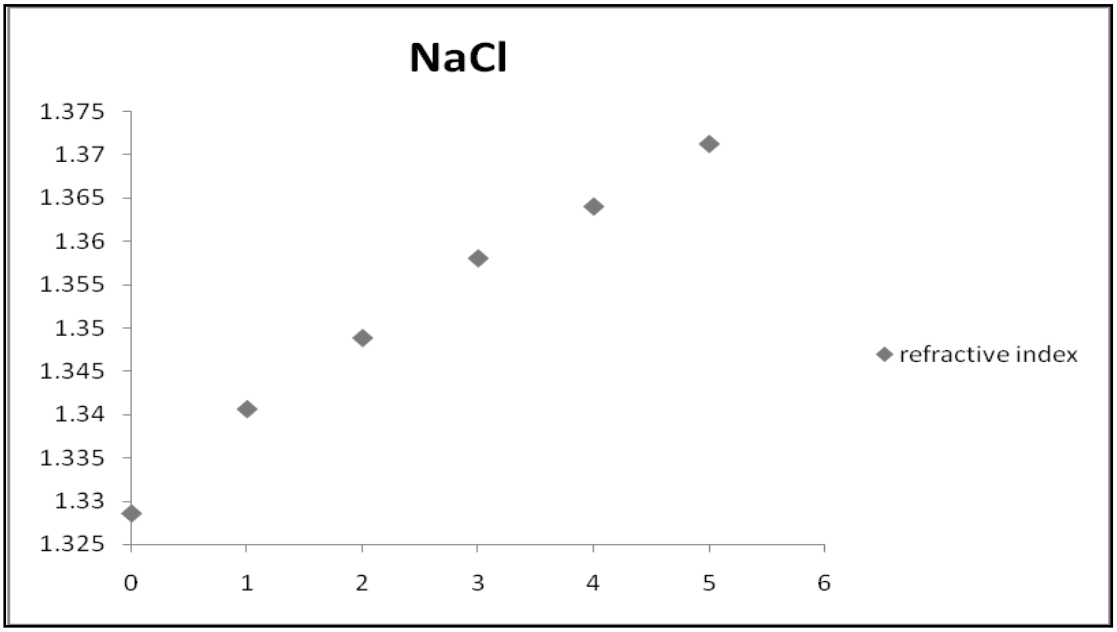

Figure 1: Graph of refractive index of NaCl solution against molal concentration

4. Conclusion

By help of graph of refractive index of medium against molal concentration we can determine concentration of unknown NaCl solution if we know refractive index of that particular solution.

5. Future Scope

Instead of using titration method to find concentration of unknown solution [7] this alternative method of refractive index would save wastage of solution to determine its concentration.

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Pratik Rajendra Patankar did MSc Physics. His Achievements:
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