THE NEOTIA UNIVERSITY
WORK INSTRUCTION

1.0 EXPERIMENT NO: BO/05

2.0 NAME OF EXPERIMENT: Polarimeter

3.0 0BJECTIVE: To determine the specific rotation of a cane sugar solution.

Figure 1: Left-panel : Polarimeter instrument and its set-up. Right-panel : Place of the solution tube in the instrument.

5.0 Apparatus:

1. Polarimeter (See Fig. 1a)
2. Solution tube filled with the given solution (see Fig. 1b)

6.0 Procedure

1. Switch on the power of the polarimeter instrument.
2. Illuminate the sodium lamp (yellow light) at maximum emmission. The light will pass through the solution tube.
3. Make an experiment with the distilled water. It will be filled in the tube.
4. Rotate the polarimeter using the rotating nob (see it at the bottom of the circular scale in Fig. 1 left-panel). It also rotates the circular scale.
5. First keep the eyepiece focused on the maximum intense yellow strip, and after rotation of the polarizer check the appearance of the intense black-strip at the same place. You will not note the corressponding scales of these two positions. This is just to examine the focus of the eyepience for the incoming polarized light.
6. Now again keep the eyepiece focused on the position where yellow or black strip was seen with maximum contrast, and then slightly rotate the analyzer. Once the yellow or black strip disappears, i.e., fades against the background and less intense and almost uniform field-of-view appears, note the reading of circular scale as well as vernier scale.
7. The polarizer plate consists of equal brightness of two component of polarized light at this point, so the field-of-view appears almost uniform. By slightly rotating it either in clock-wise

7.0 TABULATION:

Reading on Analyzer for Equal Illumination in Degrees													Rotation in Degrees	
With distilled water							With sugar solution							
First position			Second position (180° apart)			Strength of the solution per 100 c.c.	First position			Second position (180° apart)			Angle (θ_1)	Angle (θ_2)
Main Scale	Vernier	Total	Main Scale	Vernier	Total		Main Scale	Vernier	Total	Main Scale	Vernier	Total		

Figure 2: Table of Observations

or anto-clockwise direction, the deviation from this condition will be observed (see the theory in Appendix).

8. Fill the solution tube now with a given concentration of sugar (10 %; 5 %; 2.5 %) and perform the above experiment again and note down the corressponding readings of the circular scale.

9. The Vernier scale has markings from 0 to 10, however, it has 20 divisions. It resembles with the 20 divisions of the circular scale (in degree). Therefore, the least count of the Vernier scale is 0.05^o. It should be noted that the circular scale ranges from 0^o to 180^o.

10. The circular scale reading is that how many its divisions already passed from the zeroth of the Vernier scale. Note that reading in the table. While, for the reading of Vernier scale we see the division of this scale which matches exactly with the division of circular scale. We multiply that division of Vernier scale with its least-count and add in the reading of the main circular scale.

11. θ_1 is the difference between the reading of the first position on the circular scale for the sugar solution to the same for the distilled water. Similarly, θ_2 is the difference between the reading of the second position on the circular scale for the sugar solution to the same for the distilled water.

12. Mean θ is estimated as $\theta_1 + \theta_2/2$, which is the angle of the rotation of the plane of polarization of the light, when it passes through the solution.

8.0 Observations

1. Room temperature = ... ^{o}C.

2. Length of the solution tube = ... dm.

3. Mass of the sugar dissolved = ...gm.

4. Volume of the solution = ...in c.c.

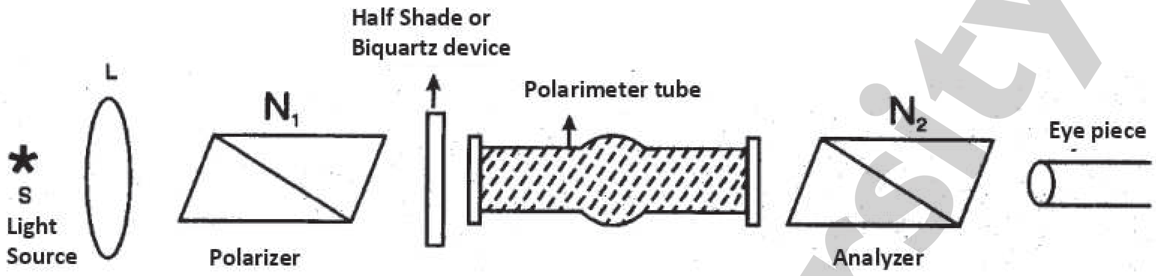

Figure 3: Schematic of the Experiment

5. Least count of the circular scale = ...^{o}

6. Least count of the vernier scale = ... ^{o} = ... $'$

9.0 Results

1. The formula to calculate the specific rotation (α) is given by :

$$\alpha = \frac{\theta}{l} \times \frac{V}{x}, \tag{1}$$

   where α = Specific rotation; l = Length of the solution tube in dm; V = Volume of the solution in c.c.; x = weight of the dissolved sugar in gm; θ = Rotation in degrees.

2. The specific rotation (α) of the cane sugar (for a given concentration per decimeter) solution at .....^{o}C is ....^{o}.

3. Estimate the same parameter α for the different concentrations of cane sugar.

4. Error estimation as per the general instruction.

5. Draw a graph between rotation vs concentration of the soutions.

10.0 Precautions

1. There should be no air-bubble in the tube while filling it with solution or distilled water.

2. While taking one set of the observations, the polarizer should not be disturbed.

3. The cap of the tube should not be tightened beyond a limit as it may strain the glass. Strained glass may produce elliptically polarized light which might interfere with the setting.

4. Two positions at $\pm 90^o$ may appear where the equal illumination remains for a long range. These readings should not be taken.

5. Switch off the lamp after completing the experiment.

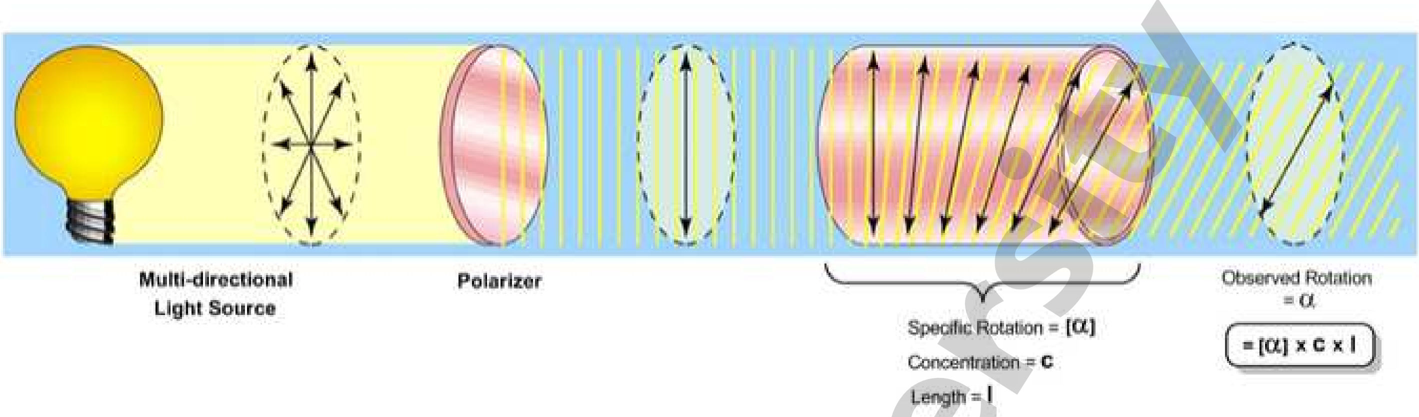

Figure 4: Specific Rotation of Plane Polarized Light from Optically Active Compound.

4.0 Theory

A polarimeter consists of two Nicols termed as polariser and analyser. These can be rotated about a common axis and the substance for which the rotation is to be determined, is placed in a tube in between these two. The half shade plate is placed between the polariser and the solution tube (cf., Fig. 3). This polarizer consists of a circular plate, one half of which is made of quartz plate cut parallel to the optic axis. It is of such a thickness that it produces a retardation of half-a-wave-length of sodium light between the ordinary and extraordinary rays. The other half of the plate is made-up of the glass and of such a thickness that the transmitted light is of the same intensity as that coming out from the quartz. Therefore, there will be two plane polarized light beams. One will be passing out of the glass portion and other pass out of the quartz. If these two beams of the polarized light of the same intensity are inclined on the principle section of the analyser then the two halves of the field-of-view (as observed through the eyepiece) will appear equally bright.

However, in between the polarizer and analyzer, we fill the sugar solution tube which causes the rotation of the plane of the polarization of incident lights. We estimate this property of the optically active compound by measuring the specific rotation ($[\alpha]$) which is a property of a chiral chemical compound. It is defined as the change in orientation of monochromatic plane-polarized light, per unit distanceconcentration product, as the light passes through a sample of a compound in the solution. Compounds which rotate light clockwise are said to be dextrorotary, and correspond with positive specific rotation. On contrary, the compounds which rotate light counterclockwise are said to be levorotary, and correspond with negative values of specific rotation. The specific rotation can be estimated as

$$\alpha = \frac{\theta}{l \times c}, \tag{2}$$

where l is the tube length, and c is the concentration. c is defined as the dissolved mass (gm) of the compound per unit volume (c.c).

A slight rotation in the plane of polarization in the clockwise or anticlockwise direction causes one component greater than the other. Therefore, either the quartz portion appears brighter than the glass or vice-versa. Thus, the analyzer can be set accurately so that the two halves of the field become equally bright.