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A LOW - COST PRECISION POLARIMETER

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Fabrication of a low-cost precision polarimeter, using locally available components, is described. The polarimeter utilizes a polarizing filter in conjunction with a typical monochromatic sodium line radiation source. The point of maximum cancellation of optical density is ascertainable both manually and electronically, with a scale readability of 0.1°. The specific rotation data determined for eight dextro-and levo-rotatory compounds are compared against those obtained by using standard, imported polarimeters, the percent error being within 0.21 - 2.0%.

Key words: Polarimeter fabrication, Low-cost polarimeter, Polarimetry.

Introduction

In veiw of continuing interst in experiments based on the rotation of plane-polarized light by chiral compounds, several attempts have appeared in literature bringing forth the fabrication of student polarimeters [1-3]. These polarimeters are, however, intended either for demonstrations using overhead projectors or individual experimentation by students [4 - 6]. Most of the versions use white light source, and hence the visual interpretation of the light transmitted through the polarimeter tube is no longer distinct. Also, accurate results are obtained only when relatively large rotations are involved. As precise measurement of optical activity is highly desirable even in many routine laboratory experiments, an attempt has been made in the present work to fabricate a precision polarimeter for more serious optical measurements. The polarimeter described here utilizes two polarizing filters, one acting as a polarizer and the other as an analyzer. An automobile lamp, powered by 12 V AC, drawn from a 220 V AC stepdown transformer, is used to produce monochromatic light in conjunction with a sodium filter. A conventional polarimeter tube (lenght 2 dm) is used in the polarimeter. The point of maximum cancellation may be monitored either manually or electronically as per details that follow.

Material and Methods

Construction and working. The schematic of the polarimeter is given in Fig. 1. The radiation source used is a 50 watt automobile headlight lamp operatable on 12 V AC/DC. It has a vertical filament at the focus of a built in metallic reflecter that increases the intensity of radiation in the direction of propagation. A 220 V AC to 12 V AC. 10 A step-down transformer is used to power the lamp. The condensing lens (f=20cm) projects a bright beam of light through the sodium filter (3x3 cm) to produce monochromatic light. The filter is the conventional sodium filter commonly used with most flame photometers. In order to protect the filter and the polarizer assembly from the lamp heat, a dual 10x12 cm (4 mm width) aluminium screen having a 1x1 cm slit in line with the optical axis of the system is fixed in front of and over the lamp as shown in the figure.

The polarizer is a Cannon polarizing filter (49 mm) com-

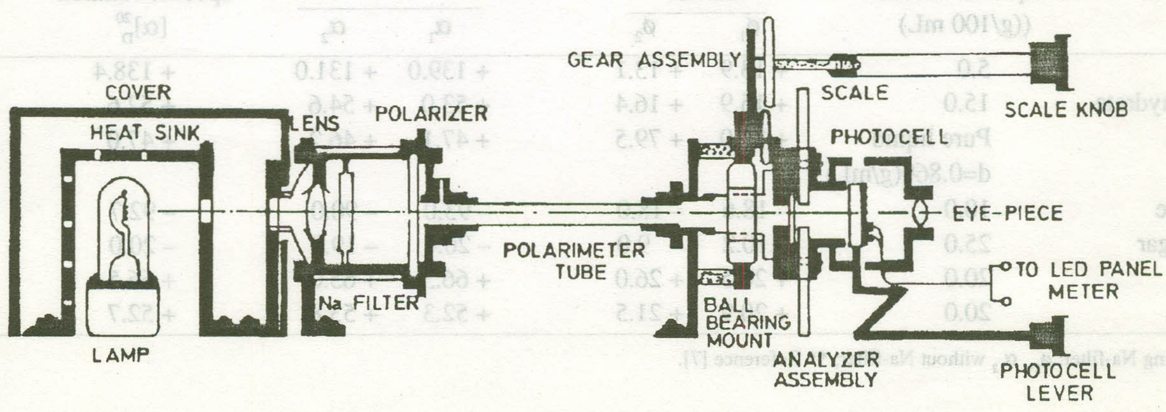

Fig. 1. The schematic of the polarimeter.

monly used with 35 mm cameras. It is screwed on a cylindrical black plastic mount cut from a hollow pipe. The rim of the filter can be freely rotated clockwise or anti-chockwise for zero adjustment. An indentical filter, the analyzer, is mounted on to a black perspex (6x6 cm) sheet, about 4 mm thick, with a 2 cm diameter hole at the centre. The rim of this filte is attached to a circular paper scale, marked 0 through 360˚ and glued at the back of a transparent circular plastic cover (Fig. 2). The scale runs agtainst a vernier scale mounted at the housing of the instrument.

With a given solution in the polarimete tube, the main scale (Fig. 3) can be manually rotated with the help of knob to locate the point of maximum cancellation. The angle of rotation, correct upto 0.1˚, can be directly read off. Table 1 presents list of parts and specifications. A digital panel meter (EEP, ICL 7107) is used in the polarimeter set up as an

TABLE 1. LIST AND SPECIFICATION OF COMPONENTS.

Part	Specification/make
Lamp	Reflector type, filment bulb, 12V, 60W locally made.
Transformer	Genral purpose, 220V AC, 50Hz input, 12V, 10A output, locally made.
Lens	Convex, 20 cmf, Cannon, Japan
Sodium filter	Flamephotometer filter, 3x3 cm, Bosch.
Polarizer/Analyzer	Polarization camera filters, 49 mm, Cannon, Japan.
Polarimeter tube	2 dm, Baird.
Ball-bearing	4.5 cm OD, 2.0 ID, SKF, Japan.
Gear wheel	5.0 cm, 1.5 cm and 2.0 cm diameter, plastic, locally made.
Scale	Plastic mounted, paper scale, 10.5 cm diameter, inscribed 0-360˚, locally made.
Eye-peice	10 cmf, Toyo, Japan.
Photo-cell	Selenium, 250 mV DC output, Electrodyczna, Poland.
LED panel meter	250 mV, high impedance, Energy Electronic Products, Kit, ICL, 7101, single chip, Manchester Avenue, Lod Angeles, CA 90045, USA.

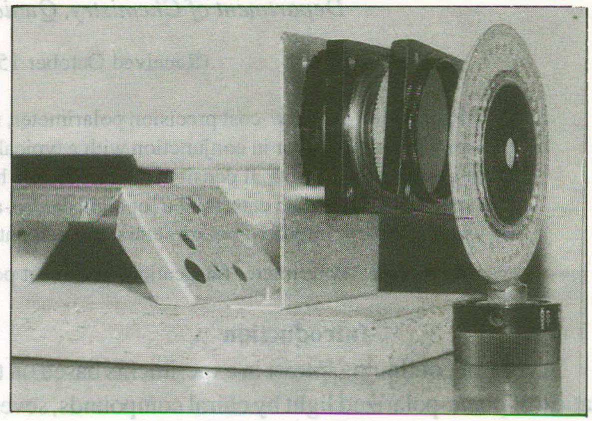

Fig. 2. The gear, analyzer and main scale assembly mounted on ball bearing.

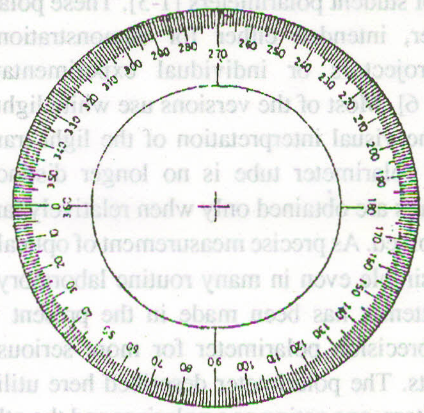

Fig. 3. The main scale.

TABLE 2. MEASURED ROTATIONS AT 20˚C FOR SOME OPTICALLY ACTIVE COMPOUNDS.

Compound	Concentration in aqueous solution ((g/100 mL)	Observed* rotation		Specific rotation*		Literature** specific rotation	Percent error
		ϕ_1	ϕ_2	α_1	α_2	$[\alpha]_D^{20}$	
Maltose	5.0	+ 13.9	+ 13.1	+ 139.0	+ 131.0	+ 138.4	0.43
Lactose hydrate	15.0	+ 15.9	+ 16.4	+ 53.0	+ 54.6	+ 52.6	0.76
α-Pinene	Pure liquid d=0.860(g/mL)	+ 81.0	+ 79.5	+ 47.1	+ 46.2	+ 47.0	0.21
Laevulose	10.0	– 18.6	– 18.0	– 93.0	– 90.0	– 92.7	0.32
Invert sugar	25.0	– 10.2	– 9.0	– 20.4	– 19.0	– 20.0	2.0
Sucrose	20.0	+ 26.5	+ 26.0	+ 66.3	+ 65.0	+ 66.5	0.30
Dextrose	20.0	+ 20.9	+ 21.5	+ 52.3	+ 53.8	+ 52.7	0.75

* ϕ_1, α_1 using Na-filter; ϕ_2, α_2 without Na-filter; ** Reference [7].

additional aid to electronically locate the point of maximum cancellation. To put the meter in operation, a lever is used to bring the selenium phot-cell in the path of mergent radiation thus activating the digital circuitry. The LED display reads 000 at the point of maximum cancellation. Thus any visual uncertainly in noting the angle of rotation is automatically taken care of. The photo-cell is properly shielded against any stray light, as shown in Fig. 1. The EEP kit includes basic components, printed board and fabrication details, and is easily available from local electronic shops in Pakistan. However, in case of non- availability, a 200-250 mV high impedance meter can be used instead.

Conclusion

The polarimeter described here is found to be suitable for precise experimentation involving measurement of optical activity. We have used the instrument for conducting kinetic and mutarotation based optical experiments in addition to routine work on identification of sugars. Table 2 summarizes some specific rotation data on eight chiral compounds. The average error ranges between 0.21- 2.0%, when the Na-filter is incorporated for producing the monochromatic light. the fin ished product costs US $60 only. All components used are available locally.

References

1. J.E. Fernandez, J. Chem. Educ., **53**, 508 (1976).
2. W.K. Dean, J. Chem. Educ., **54**, 494 (1977).
3. J.B. Kinney and J.F. Skinner, J. Chem. Educ., **54**, 494 (1977).
4. M.A. Gibas, J. Chem. Educ., **53**, 462 (1976).
5. R. Shavitz, J. Chem. Educ., **55**, 682 (1978).
6. H.C. Dorn, H. Bell and T. Birkett, J. Chem. Educ., **61**, 1107 (1984).
7. C. Robert (ed.), *Handbook of Chemistry and Physics* (Chemical Rubber Co., 1980).