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A Review on the measurement of optical activity: Polarimetry and Spectropolarimetry

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ABSTRACT: The plane polarized light passing through the solutions of some organic and inorganic compounds caused polarized light to rotate. This property is known as optical activity. The amount and direction of rotation can be determined with a Polarimeter and Spectropolarimeter. The present work gives the earlier, current developmental status and design considerations of existing optical activity measurements, instruments, analysis and techniques for automation. The above said areas are covered in the review. The intention of the present work is to develop the future research work in the field of polarimetry.

KEYWORDS: optical activity, polarimetry, spectropolarimetry.

I.INTRODUCTION

Polari meters can be used to find the specific rotation of the solution or if the specific rotation is known, they can be used to find its concentration at single wave length (the Na 589 nm D line). When they are calibrated to read directly the % of cane sugar in solution, they are named as saccharimeters.
In olden days Polarimeters used light sources of single wave length. Due to advances of modern technology light sources of multi wavelength are being used now; this system is called Spectro Polarimeter. In Spectropolarimeter the samples are studied over a wide range of wave length where by the dependence of the rotation on the selected wave length range is measured and is termed as Optical Rotatory Dispersion. The Spectropolarimeter is similar to a Polarimeter only inasmuch as they utilize radiation in the same wavelength range [1]. It finds extensive application in the analysis of sugar and other optically active drugs for the measurement optical rotation and direction [2]. The direction and extent of rotation (the optical rotatory power) is useful for both qualitative as well as quantitative analysis. It is great importance in the elucidation of chemical of chemical structural information of optically active components [3].

The main aim of this paper is

- to deliver an outline of the Polarimetry and Spectropolarimetry
- Design and development of the experimental setup for measurement of optical activity

Benjamin Carroll and Ira Blei [4] have reviewed history of various Polarimeters and application of Polarimeter. They also classified Automatic Recording Polarimeter in to two types: namely instruments in which the null-point method, other one is instruments in which a ratio method is used. Explained schematic diagram of Rudolph, Cary, Bendix-Ericsson, Gillham-King Spectro Polarimeter detailed in this paper.

Chiragadze and Venyaminov [5] presented the construction of a highly sensitive automatic recording Spectropolarimeter for the range from 0.5 to 2.3 um which was created based on ORD-UV-5 instrument of the Jasco firm. The maximum sensitivity of the Spectropolarimeter is 2*10^-4°.

Reinbold and pearson [6] described the modifications made to a Perkin-Elmer 141 polarimeter which enabled the acquisition of continuous optical rotatory dispersion data over the spectral region of 650-240nm. The modifications

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basically consisted of replacing the existing light source of the Model 141 polarimeter with a double grating monochromator and a high intensity xenon light source.

Troitskii and Generalov [7] designed the photoelectric Spectropolarimeter for the operation under conditions that radically reduces the light incident on the photomultiplier. The instrument can be used for operation with strongly colored likewise in performing measurements in the far UV range of the spectrum.

Simon and Pearson [8] described a completely modified Perkin and Elmar model 141 Polarimeter. The Bosch and Lomb monochromator contain a double grating modified CZERMU-TURNER mounting provides twice the dispersion of a single grating monochromator and increased spreading of the spectrum permits the use of wider slits for a given band pass than those used in a single grating monochromator . The extremely low stray light of the double grating B and L monochromator allows entire spectrum to be obtained without the necessity of additional operations on the optical system and subsequent changes in sensitivity. The high intensity xenon lamp source can be used over the entire wavelength range (650 to 240nm) thus eliminating the necessity of changing lamps to cover the spectral region.

Grivoryey and Karasik [9] presented a Spectropolarimeter of simpler design than available commercial instruments and suitable for study of the Faraday Effect in magnetic fields with an intensity as high as 8*10^4 A/M in addition to studies of natural optical activity. The instrument in a slave system with automatic tracing of the optical rotation curve. Its spectral range is 250 to 700nm and its error is ± 0.004°.

Victor C. Zadnik et al [10] described the modification made to a Perkin-Elmer model 241 Polarimeter to both interface it to an on-line microcomputer data system, and convert it to a microcomputer automated scanning optical rotatory dispersion Spectropolarimeter with a range of 650-240 nm. The modifications described in this paper have resulted in a unique computer automated scanning optical rotatory dispersion Spectropolarimeter which has a range of 650-240nm and a number of attractive features. The Bausch & Lamb monochromator, containing a double grating modified Cherny-Turner mounting with its low stray light characteristics and excellent dispersion, allow the entire spectrum to be obtained without the need of additional operations on the optical system and subsequent changes in sensitivity. The high intensity xenon lamp source can be used over the entire wavelength range of 650-240 nm, therefore eliminating the need to change lamps to cover the spectral region. The modifications installed to allow for control of the scanning and data acquisition by the microcomputer result in the rapid and easy acquisition and analysis of optical rotatory dispersion data. The advantage of having a spectrum run by the computer, and having the data digitized and stored for future recall on a disk in a computer readable format, is that time and effort is saved. Calculations and data retrieval can be performed immediately at the completion of a scan, or at any time in the future, without a great deal of effort. With a computer to both perform the scan and analyze the data, an extremely powerful, yet easy to use, scanning Spectropolarimeter system was obtained, which is excluding the cost of the existing microcomputer and monochromator systems, required less than $400 to construct.

Reinbold and Pearson [11] presented the modifications to a Perkin-Elmer model 141 Polarimeter to obtain continuous optical rotatory dispersion data over the entire spectral region which can be obtained with the original calcite polarizing and analyzing prisms and the IP 28 photomultiplier detection systems. The modifications are not extremely difficult and require only a minimum of technical services. The modification consisted essentially of adding an optical bench which contain high intensity light source.

Abramov and Gassakovaskii [12] designed a Spectropolarimeter for measuring optical activity with no modulator. He explains that when modulation is used in spectropolarimetric measurements only the plane polarized component of the total light flux that passes through the Polarimeter polarizer is modulated. Its informative part can then be analyzed by isolating the variable component of the total photomultiplier current. Modulation is normally carried out either mechanically for example by oscillating the polarizer at a specified frequency or by using magneto optical or electro optical modulators. The first method requires a high precision mechanical system capable of maintaining a specified modulation amplitude and frequency. The use of magneto or electro optical modulators demands a signal generator capable of providing relatively high frequencies. The use of mains current at 50 HZ always causes difficulties because of noise having the same frequency. Thus the use of a modulator as part of a reasonably high sensitivity

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Spectropolarimeter has certain difficulties. The method that he suggested for measuring the angle of rotation of plane polarized light by the optically active substance is based on the same principle of detecting only the plane polarized component of the light flux, but does not require modulation.

Leksikov A.A et al [13] designed an automatic Spectropolarimeter with electromechanical compensation of the rotation of the polarization plane of the light is based o n a KSP-4 recording potentiometer. Because of the application of stabilizing feedback introduced from the rotation sensor, a sensitivity of 0.005° has been achieved.

Ramamurthy and Jeevankumar [14] designed a low cost instrumentation based on the principle of new dispersion relation for the study of ORD is developed. The success of the present method is tested in case of a few bimolecular and the use of refractometry as a two in one instrumentation is set modestly.

Alekseev S.A et al [15] presented a Polarimeter which is intended for measuring in laboratory conditions of polarization characteristics of solids and liquid objects and also for analysis of properties and determination of concentration of optically active components of biomedical solutions. This instrument is based on the photometric scheme with a rotating analyzer and digital Fourier detection of photo receiver output signals, control of a spectral source measurements and data processing are carried out by means of the IBM PC.

K.Muralidhara Reddy and C.Nagaraja [16] has designed [16] A PC based Polarimeter based on Malus' law comprising of a polarizer (P) and an analyzer (A1), arranged on a common axis so that their transmission axes are parallel. Linear polarized light passes through the analyzer (A1). The transmission axis of the analyzer (A1) is parallel to this wave. When an optically active substance (ST) is placed between the polarizer (P) and analyzer (A1), the polarization plane of said linear polarized beam has an angle relative to the transmission axis of analyzer (A1). The linear polarized monochromatic light is divided into two equal parts by a beam splitter (BS1) after passing through said optically active substance (ST). One part of the light passes straightly through the analyzer (A1), which is parallel to the polarizer (P). Since the analyzer (A1) is always kept fixed, the optical rotation can be evaluated. The second part of the light reflected from the beam splitter (BS) at 90 deg is passed through a second analyzer (A2) positioned at 45 deg with respect to the polarizer (P) and the intensity is measured and analyzed.

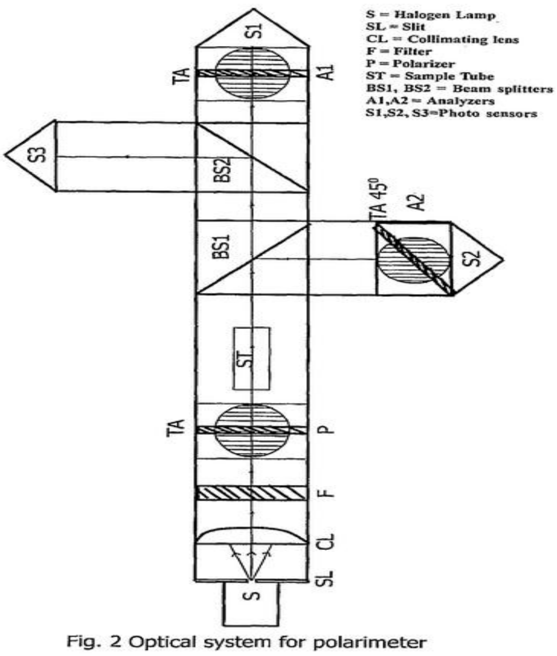

Fig. 2 Optical system for polarimeter

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The LUMO (liquid monitoring using novel optical sensors) presented [17] a paper on "optical rotary dispersion of sugars". In which describes the background information and theory of optical activity. Explained method, rotation of the polarization is clockwise for + and counter clockwise for -, and temperature effect on the optically active compounds. Discussed on Cotton effect of ORD Spectrum can be. Experimental setup is developed, block diagram explained with parts and specifications. The procedure developed for calculating the Optical rotation from malus law. Identified multiple sugars and measure their concentrations in sugar-water mixtures, ORD spectra for sucrose, glucose and fructose were measured in the visible wavelength region 500-700 nm. ORD spectra were measured for solutions containing two different sugar types at varying concentrations.

II.CONCLUSION

The present work can provide good research knowledge on Polarimeters and Spectropolarimeter theoretical methods and experimental method. The hardware and software implementation provides to develop new dimensions in the felid of polarimetry. Therefore, this paper provides an overview for a researcher interested in the field of polarimetry.

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D. Hanumesh Kumar completed M.Sc (Electronics and Instrumentation) from Sri Krishnadevaraya University in 2010. He is doing Ph.D in Instrumentation. His areas of interest are in Microcontroller based instrumentation, Virtual Instrumentation, Analytical Instrumentation, control systems and automation. He has published nearly 7 papers in national and international journals in Instrumentation.

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