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Measurement of the Optical Rotation Angle Using a Rotating-Wave-Plate Stokes Polarimeter

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1 Abstract

A polarimeter based on Stokes-Mueller formalism and rotating-wave-plate Stokes polarimeter is successfully developed to measure the optical rotation angle in a chiral medium. The average relative error in the measured rotation angles of glucose solutions with concentrations ranging from 0 to 1.2g/dl is determined to be 3.78%. The correlation coefficient between the measured rotation angle and the glucose concentration is found to be 0.9995, while the standard deviation is just 0.00376 degrees. From the sol-gel materials containing $C_{17}H_{17}ClO_6$ with concentrations ranging from 0 to 0.0665g/ml, the average relative error in the measured rotation angles is determined to be 3.63%. Consequently, the developed system is evaluated with a precision of 5.4% approximately in rotation angle measurement.

2 Introductions

In 1997, Cameron and Cóte [1] designed a glucose sensing digital closed-loop processing system, which is based on the heterodyne interference technique and a lock-in amplifier is used to obtain the rotation angle of the glucose. In 2004, Lin et al. [2] proposed a heterodyne Mach-Zehnder interferometer to enhance the measurement resolution about $6\times10^{-5^\circ}$. However, Lin's optical configuration is complicated. In 2006, Lo and Yu [3] adopted a liquid-crystal modulator to modulate the azimuth of the linearly polarized light in a sinusoidal signal and developed a new signal-processing for measuring the glucose concentration. In the proposed optical scheme, a linearly polarized input light of 45° is incident on two kinds of chiral medium. The Stokes parameters of the output light are detected by a rotating-wave-plate Stokes polarimeter and the algorithm for obtaining rotation angle is derived successfully.

3 Method

According to the Stokes-Mueller formalism, the Stokes vector $\hat{S}$ models the polarization state of incident light and the Mueller matrix for a chiral medium is expressed as M_{CB}, hence, the Stokes vector S_{CB} of output light is calculated by

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$$S_{CB} = \begin{bmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{bmatrix}_{CB} = M_{CB}\hat{S} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(2\gamma) & \sin(2\gamma) & 0 \\ 0 & -\sin(2\gamma) & \cos(2\gamma) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{S}_0 \\ \hat{S}_1 \\ \hat{S}_2 \\ \hat{S}_3 \end{bmatrix}. \quad (1)$$

For input polarization condition is chosen a linear polarization light at 45° direction, and by applying Cramer's rule, and the optical rotation angle can be determined as

$$\gamma = \tan^{-1}(S_1 / S_2) / 2. \quad (2)$$

4 Experimental results

In this study, samples containing glucose solutions and sol-gel materials containing griseofulvin ($C_{17}H_{17}ClO_6$) are prepared. The procedure for fabricating the chiral samples is carefully executed and the calibration of polarimeter is done. The experimental results are shown as below:

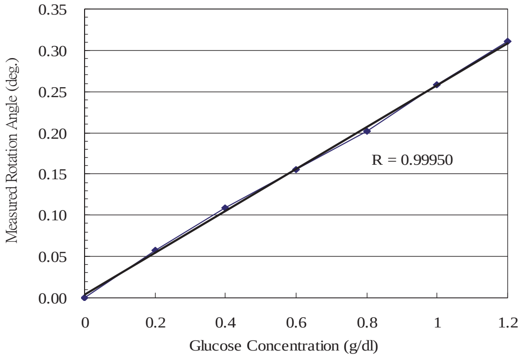

Fig. 1. Variations of rotation angle with glucose concentration (sample: glucose solution).

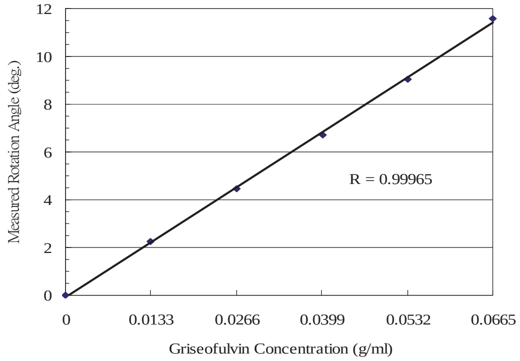

Fig. 2. Variations of rotation angle with chiral griseofulvin concentration (sample: griseofulvin sol-gel).

References

1. BD Cameron, GL Cóte, IEEE Trans. Biomed. Eng. **44**, 1221 (1997)
2. JY Lin, KH Chen, DC Su, Opt. Communi. **238**, 113 (2004)
3. YL Lo, TC Yu, Opt. Communi. **259**, 40 (2006)