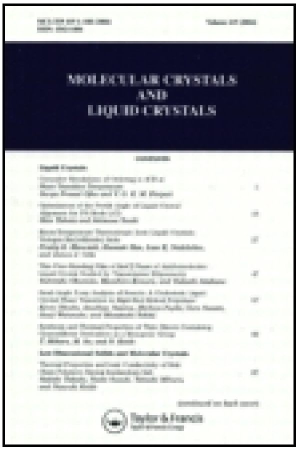

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E. Wolarz [a] & T. Martyński [a]
[a] Institute of Phys., Technical Univ., Poznań, Poland
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CORRECTIONS FOR THE FLUORESCENCE INTENSITY OF PLEOCHROIC DYES ORIENTED BY NEMATIC LIQUID CRYSTAL MATRICES IN "SANDWICH" CELLS

E. WOLARZ, T. MARTYŃSKI
Institute of Phys., Technical Univ., Poznań, Poland

Abstract. The optical corrections for the polarized fluorescence intensities of the dyes oriented homogeneously by the nematic liquid crystals in "sandwich" cells are theoretically calculated. The improvements are found to be of a great importance for accurate measurements of the fluorescence intensities and may be useful in the liquid crystal display technology.

INTRODUCTION

The "sandwich" cells, widely applicable in the liquid crystal display technology, are very useful and comfortable for the polarized fluorescence intensity experiments[1,2] and the polarized Raman scattering studies[3,4,5,6]. Usually two different geometries of experiments are considered: the parallel one - the direction of the exciting light beam is parallel to the direction of observation of the fluorescence, the perpendicular one - the directions described previously are perpendicular **each other**.In these two cases the light beams reflected at the dielectric boundaries are all perpendicular to the glass plates of the cell. This fact simplifies the interpretation of the experimental results. The situation is more complicated for an oblique geometry, i.e. when the excitation beam and the direction of observation are not perpendicularto each other. In a special case, for the liquid crystal layer having uniaxial symmetry and composed of rodlike molecules, there is a posibility to extract the "pure" components I_{zz} and I_{zy} (defined as averages over a product of squared projections of the absorption and emission moments on appropriate axes in the laboratory frame) from the "observed" one, I^{obs}_{zz} and I^{obs}_{zy}, which are measured outside the cell. In the following part the way to obtain a formula joining the ratio of the "pure" intensities and the ratio of the "observed" one will be described.

CALCULATIONS

The geometry of experiment is presented in Figure 1. The "sandwich" cell is parallel to the YZ-plane of the laboratory frame. It contains liquid crystal - dye layer with the director oriented along the Z axis. The exciting light beam and the direction of observation of the emitted light form a plane parallel to the X and Y axes. The polarized fluorescence intensities observed

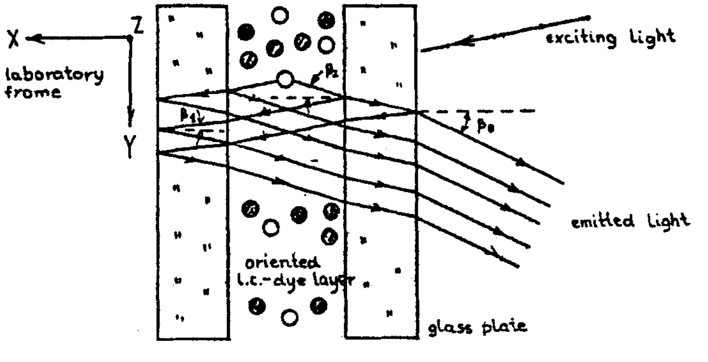

FIGURE 1 Geometry of the experiment.

outside the "sandwich" cell are not the pure one, because of the optical uniaxiality of the nematic layer and the multiple reflections and deflections in the cell. Moreover, different reflection and deflection optical coefficients for different polarizations of the observed light have to be incorporated.

There is only considered a situation when the exciting light beam is polarized parallelly to the director. In this case the "pure" perpendicular and parallel components of fluorescence intensity do not depend on the direction in the XY-plane[1]. Therefore these intensities can be easily calculated from the "observed" I_{zz}^{obs} and I_{zy}^{obs} one. The situation is not the same if the exciting light is polarized perpendicularly to the Z axis. The "pure" component I_{yy} depends then on the direction in the XY-plane and it is not posible to extract it from the "observed" I_{yy}^{obs} one.

In the following part of the paper a factor C joining the ratio of the "pure" and the "observed" intensities will be calculated

$$I_{zy}/I_{zz}=C(n_g,n_o,n_e,\beta_0)\circ I_{zy}^{obs}/I_{zz}^{obs}, \qquad (1)$$

where C depends on β_0 – the angle of observation (Fig.1) and the optical refractive indices: n_g (glass), n_o, n_e (the ordinary and the extraordinary one of the liquid crystal).

The direction of the exciting light is considered to be fixed but calculations can easily be done in the situation when the angle of incidence is a variable. The amount of the reflected and the deflected beams, which contribute to the observed intensity of light, is restricted to five components (Fig.1)

$$I_{zy}^{obs}=I_{zy}^{obs1}+I_{zy}^{obs2}+I_{zy}^{obs3}+I_{zy}^{obs4}+I_{zy}^{obs5} \qquad (2)$$

Calculations based on the theory of reflection and deflection of light lead to the following results:

$$I_{zy}^{obs1}=I_{zy}\circ(t_{21}^{o}\circ t_{10}^{o})^{2} \stackrel{def}{=} I_{zy}\circ m_{2}^{o},$$
$$I_{zy}^{obs2}=I_{zy}\circ[(t_{21}^{o})^{3}\circ(t_{12}^{o})^{2}\circ t_{10}^{o}\circ r_{01}^{o}]^{2} \stackrel{def}{=} I_{zy}\circ m_{2}^{o},$$
$$I_{zy}^{obs3}=I_{zy}\circ[(t_{21}^{o})^{2}\circ t_{12}^{o}\circ t_{10}^{o}\circ r_{01}^{o}\circ r_{12}^{o}]^{2} \stackrel{def}{=} I_{zy}\circ m_{3}^{o}, \quad (3)$$
$$I_{zy}^{obs4}=I_{zy}\circ[(t_{21}^{o})^{2}\circ t_{12}^{o}\circ t_{10}^{o}\circ r_{01}^{o}]^{2} \stackrel{def}{=} I_{zy}\circ m_{4}^{o},$$
$$I_{zy}^{obs5}=I_{zy}\circ(t_{21}^{o}\circ t_{10}^{o}\circ r_{12}^{o})^{2} \stackrel{def}{=} I_{zy}\circ m_{5}^{o} ,$$

where the transition and the reflection coefficients are:

$$r_{ik}^{o}=tg(\beta_k-\beta_i)/tg(\beta_i+\beta_k),$$
$$t_{ik}^{o}=2\cos\beta_i\circ\sin\beta_k/\sin(\beta_i+\beta_k)\circ\cos(\beta_i-\beta_k) , \quad (4)$$
$$i,k=0,1,2.$$

The equations (2) and (3) are also true for the I_{zz}^{obs} intensity component but in this case the coefficients (4) are:

$$r_{ik}^{e}=\sin(\beta_i-\beta_k)/\sin(\beta_i+\beta_k),$$
$$t_{ik}^{e}=2\cos\beta_i\circ\sin\beta_k/\sin(\beta_i+\beta_k), \quad (5)$$
$$i,k=0,1,2.$$

The "pure" components I_{zy} and I_{zz} can be obtained from combination of equalities (2), (3), (4) and (5). The C factor is calculated from comparision of the ratio I_{zy}/I_{zz} with the formula (1):

$$C(n_g,n_o,n_e,\beta_0)=m^{e}/m^{o} , \quad (6)$$

where

$$m^{e}=m_1^{e}+m_2^{e}+m_3^{e}+m_4^{e}+m_5^{e} , \quad (7)$$
$$m^{o}=m_1^{o}+m_2^{o}+m_3^{o}+m_4^{o}+m_5^{o} . \quad (8)$$

RESULTS

Figures 2a, 2b, 2c presents the plots C vs. β_0 for liquid crystals with the different optical anisotropies

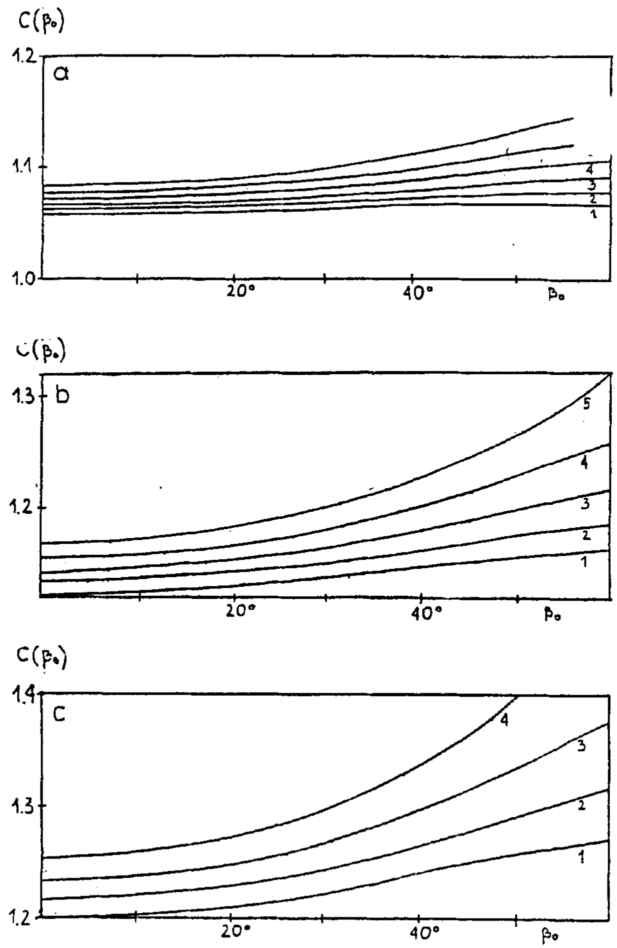

FIGURE 2 The plot of the factor C vs. β_0 for: a-Δn=0.1, b-Δn=0.2, c-Δn=0.3. The numbers describe the curves with n_e equal: 1-1.8, 2-1.7, 3-1.6, 4-1.5, 5-1.4, 6-1.3.

$\Delta n = n_e - n_o$. As it is seen, the C factor increases when the optical anisotropy decreases and for small angles β_0 is about 1.08 for $\Delta n=0.1$, 1.15 for $\Delta n=0.2$, and 1.25 for $\Delta n=0.3$. As an example one can take the 5CB liquid crystal at temperature T=300K with the optical anisotropy $\Delta n=0.18$ ($n_e=1.54$).[7] Then the difference between the ratio of the "pure" and the "observed" components is about 15%.

The C factor derived above may be improved by incorporation of the next light reflection contributions to the amount (2). This would be necessary for the large observation angles β_0.

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