SIMULTANEOUS MEASUREMENT OF DICHROISM AND BIREFRINGENCE ON
SUSPENSIONS OF ABSORBING PARTICLES

J. C. Ravey * and C. Houssier **

*Laboratoire de Biophysique, Centre 1er Cycle, Université
de Nancy I, C.O. No. 140, 54037 Nancy Cedex, France

**Laboratoire de Chimie Physique, Université de Liège
Sart-Tilman, B-4000 Liège, Belgium

The principle of a new method for the simultaneous measurement
of the dichroism and birefringence (including the determination
of their signs) of absorbing solutions subjected to electric
pulses, is described. It involves the measurement of the photo­
current signals as a function of the angle of the polarization
directions with respect to the electric field.
Observations on carbon-black suspensions using this procedure
are reported.

INTRODUCTION

In previous studies implying the measurement of the birefringence
in absorption regions showing dichroism effects, a preliminary deter­
mination of the dichroism was made using an optical arrangement with
one polarizer only (1,2). The photocurrent signal detected in the
presence of polarizer and analyser was then corrected for the
dichroism contribution in order to determine the birefringence or
birefringence dispersion curve. In the present study, a procedure
is described which does not require any modification of the optical
setting whilst allowing the birefringence and dichroism amplitudes
and signs to be evaluated. It is applied to the study of carbon­
black suspensions and its usefulness is compared to that of other
methods.

Carbon-black consists of rigid aggregates made of small isotropic
spheres (0.01 μ about), having a complex refractive index \( n \). Its
value is not perfectly known, but \( n = 1.96 - i 0.66 \) is the value
generally accepted (9). These aggregates are not spherical, and from a statistical point of view, they may be likened to spheroids of ellipticity about 2, and of volume compactness between 0.03 and 0.25 (7). Of course, such anisometric particles may be readily oriented in an electric or hydrodynamic field. The suspensions become at the same time dichroic and birefringent, due to the anisometric form of the particles. Their study necessitates the special experimental set up which will be described in the present paper.

The apparatus uses pulsed electric-fields contrary to the one recently described by Champion et al. (10).

OPTICAL RELATIONSHIPS

If \( \hat{n}_h \) and \( \hat{n}_\| \) are the two complex principal indices of the medium birefringent and dichroic, we define \( \delta \) and \( \delta' \) as follows:

\[
\delta - i \delta' = \frac{2\pi \ell}{\lambda_0} (\hat{n}_h - \hat{n}_\perp)
\]

where \( \ell \) is the pathlength and \( \lambda_0 \) the wavelength. \( \delta \) is then the optical retardation and \( \delta' \) the differential absorption related to the more conventionally used dichroism.

\[
\Delta A = A_\| - A_\perp \quad \text{with} \quad \delta' = 2.3 \Delta A/2.
\]

The expression for the calculation of the birefringence in regions of absorption where a dichroism contribution may be present, has been previously derived for optical arrangements not including (1,2) or including (3-5) a quarter-wave plate between the sample and the analyser. For the latter arrangement, which offers the highest sensitivity, the expression reads (when the slow axis of the quarter-wave plate is at 135° with respect to the field direction):

\[
\Delta I \over I_\infty = \frac{I_A - I_\infty}{I_\infty} = \exp \left( - \frac{\delta'/3}{\lambda_0} \right) \left\{ \cosh \delta' - \cos (\delta + 2\alpha) \right\} \left( 1 - \cos 2\alpha \right)^{-1}
\]

(1)

where \( \Delta I \) is the change of light intensity on the photomultiplier with respect to the light intensity "at rest" \( I_\infty \), for a rotation of the analyser through an angle \( \alpha \) from the crossed position towards the polarizer.

In the absence of dichroism, eq. 1 becomes:

\[
\Delta I \over I_\infty = \frac{\cos 2\alpha - \cos (\delta + 2\alpha)}{(1 - \cos 2\alpha)}
\]

(1b)

the well-known relationship used for birefringence determinations (2).