B6, 2000

1 Appearance of quartz wedge in white light

The wedge under cross-polars in white light appears with a repeated series of colored bands perpendicular to the length of the wedge.

The optical path difference (o.p.d.) between slow and fast rays increases up the wedge. When the o.p.d. is equal to $n\lambda$ where n is an integer, the monochromatic light of wavelength λ is unaffected by the wedge and blocked by the analyser. In white light, the attenuation of shorter λ's followed by longer λ's lead to a series of complementary colors which repeat over several order.

2 Determination of slow/fast directions of polymer strip

The method is illustrated in figure 1. When slow directions are superimposed,

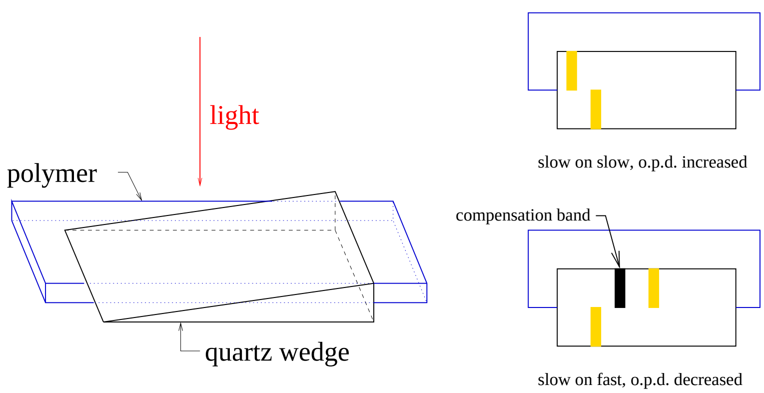

Figure 1: Determination of the slow and fast directions for a polymer strip. The polymer and quartz wedge are at 45° between cross-polarisers.

the o.p.d. for a given position along the wedge (*i.e* a given thickness) is increased:

$$\lambda_1 = t'\Delta n + K \quad \text{for polymer + quartz} \tag{1}$$
$$\lambda_1 = t\Delta n \quad \text{for quartz} \tag{2}$$

A band of given color, corresponding to the attenuation of the wavelength λ_1, is obtained for a smaller thickness t' if K, the o.p.d added by the polymer, is positive.

3 Stresses in a bending rig

The case is illustrated in figure 2. Near the upper part, the dark band

Figure 2: 4 points bending rig between crossed polarisers.

corresponds to a retardation of 3λ. This also corresponds to $t\Delta n$, so that:

$$\Delta n = \frac{3\lambda}{t} = \frac{3 \times 558^{-9}}{1.5 \times 10^{-3}} = 1.12 \times 10^{-3} \tag{3}$$

The birefringence of the material is the result of a difference between the principal stresses:

$$\Delta n = C(\sigma_{||} - \sigma_{\perp}) \tag{4}$$

It is important to note that the dark band for 3λ is very close to the surface. Near the surface, the component $\sigma_{\perp}$ is zero (no applied force). Therefore we have:

$$C\sigma_{||} = 1.12 \times 10^{-3} \tag{5}$$

Given that C, the stress-optical coefficient for polycarbonate is 7.8×10^{-11} Pa^{-1}, the longitudinal stress near the surfaces is **14.3MPa**. This is positive for the region in tension and negative for the one in compression.

4 Bending rig in white light

The situation is similar to that of quartz described above: the o.p.d. increases on both sides (here as a result of the stress rather than thickness change in quartz) of the neutral axis and complementary are observed.

When superimposing a slice of quartz, a retardation $\Delta n_{\text{quartz}} t_{\text{quartz}}$ is added or substracted to the o.p.d. resulting from travel through the PC beam.

Quartz is optically positive, meaning that $n_{\text{quartz}\,//(c)} > n_{\text{quartz}\,\perp(c)}$. The retardation due to the quartz slice will be:

$$\delta = \Delta n_{\text{quartz}} t_q = 0.009 \times 62 \times 10^{-6} = 5.58 \times 10^{-7} \tag{6}$$

Denoting y the distance from the neutral axis, positive in the tensile region, negative otherwise ($y \in [-5 \times 10^{-3}, 5 \times 10{-}3]$), the retardation due to the PC beam at y is

$$\frac{y}{0.005}\, 3\lambda \tag{7}$$

The o.p.d.'s cancel out if

$$y = \frac{0.005}{3\lambda} \times 62 \times 10^{-6} \times 0.009 = 1.66 \times 10^{-3} \tag{8}$$

If the c-axis of quartz is parallel to the strip, the dark band will be 1.66 mm into the tensile region, if it is perpendicular, the same distance into the compression region.