Characterisation of Bi-refringentcoatings and substrates using the Aquila nkd Spectrophotometer, Optical Coating Measurement System.

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This application note Illustrates the use of the nkd- series optical coating measurement system for characterisingtransparentbi-refringentfilmsorsubstrateswithease.

Bi-refringent or optically anisotropic materials have optical properties which are not the same inalldirections within a given sample.Some naturalcrystal materials exhibitbirefringence and othermaterialssuchaspolymerscanhave birefringence induced intentionally or not by the manufacturing process. Stretched polymer films can have different refractive indices for different orientations ofthesample.Thedifferenceinrefractiveindexfors-andp-polarised incident light, is used as a measure of the bi-refringence ofthematerial.

Measuring transparent bi-refringent films and substrates poses an impossible task old fashioned spectrophotometers and a difficult one for ellipsometers. For the old-type spectrophotometers, the difficulty arises from the fact that the incident light polarisation is unknown and undefined. Without defining the incident polarisation, no sensible analysis of the resulting T and R spectrum can be performed. The Aquila nkd spectrophotometer overcomes this because the incident light polarisation is well known and can be selected for each measurement.

In ellipsometry the incident polarisation is known but other problems arise from the fact that the samples are transparent. Ellipsometric analysis cannot account for the multitude of front and back surface reflections generated by transparent substrates. To overcome this the sampleneeds toberoughened on one side making this a destructive measurement technique. Even withthisrougheningorblackingouttreatment,itisneveran ideal measurement and the valuable transmission data is lost. With the nkd spectrophotometer, transparent substrates are an advantage at the additional spectroscopic information provided by the transmissiondataallows for accurate determination ofthe sample absorption. No sample preparation is required and the user simply places the film or substrate on the sample platform. The incident polarisation can be selected using the Pro-Optix™ software, which handles all aspects of the measurement and analysis process.

Requirement for measuring these ansiotropic materials in increasing withtheprocessing of thin glasses and polymer films for displayapplications.LCDimagequalityforexamplecansuffer if there is spatial variation in light polarization over the screen, producing dark streaks on the viewing area. The birefringent effect can also be very beneficial. Liquid crystals are a twisted birefringentmaterialused in many laptop displays.The example here examines one type of polymer film which has been processedintentionallytoinducebi-refringence.

InFigure1.asampleofPolycarbonatestretchedinonedirection has been measured on the nkd-7000. Transmittance (T) and reflectance(R) measurements for s- polarised incident light are shown. A note of the orientation of the sample for this measurement was made and is indicated as 0° sample orientation in the results. Analysis of this spectra using the powerfulPro-Optix™ yieldedthedispersion shown in Figure 2. A Cauchy model, just one of the dispersion algorithms availablein the software, was used to describe the Polycarbonate. The excellent fit of the calculated model to the measured spectra, achieved by the analysis software can be seen overlaid on the measured data. The model used was saved in the software database for use in analysis of subsequent measurements on thissample.

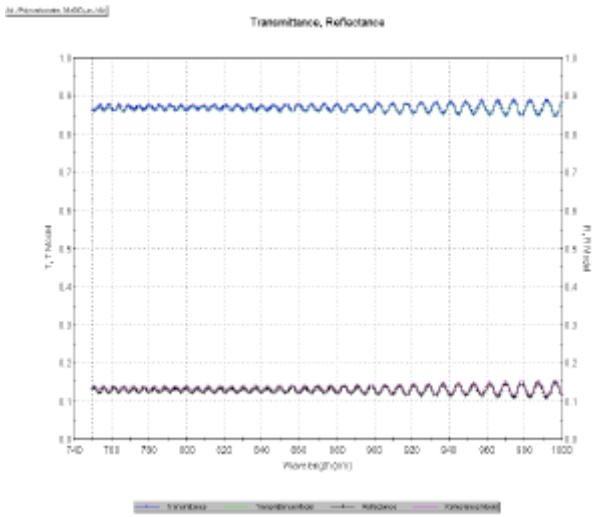

Figure1.Tand R for sample1-Polycarbonate.Orientation0°,s-polarisation.

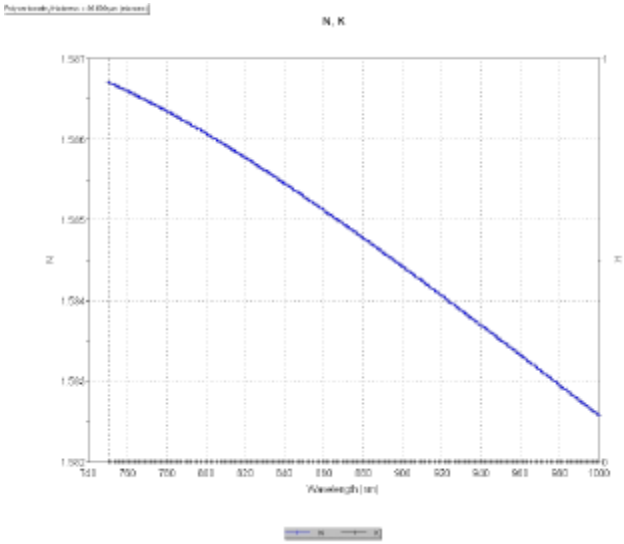

Figure2.n&kfor sample1-Polycarbonate.Orientation0,s-polarisation.

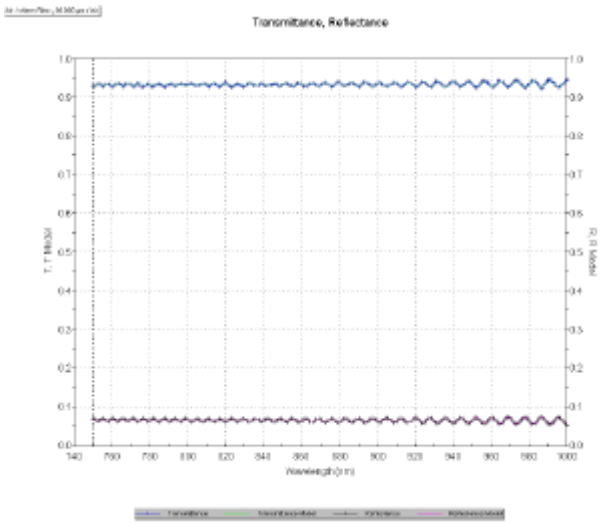

Figure3.Tand R for sample1-Polycarbonate.Orientation0°,p-polarisation.

Withoutrotatingthesample,thesamemeasurementsweremade butthis timetheincident lightwasselectedat p- polarisation.The resultingspectrum(Fig.3)andcomplexrefractiveindices(Fig.4) are presented. A slight difference inrefractiveindex betweenthe p-ands-polarisation canbeseenbutitisnotsignificant.

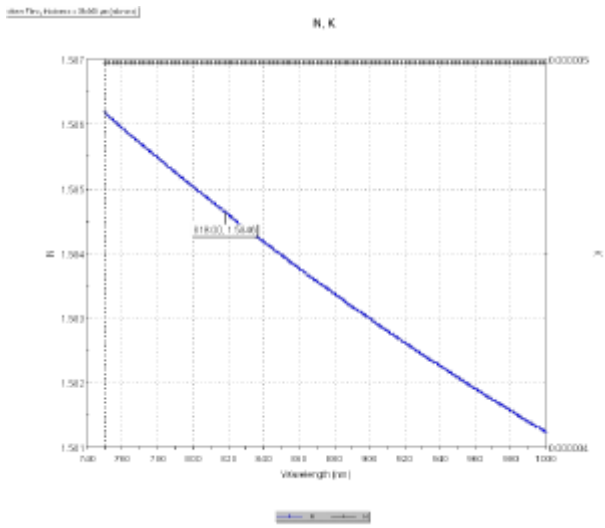

Figure4.n&kfor sample1-Polycarbonate.Orientation0°,p-polarisation.

The sample was then rotated by 90° and the measurements repeated. T andRforp-polarisedincidenceisshowninFigure5. below. Analysis using the stored database model provided the refractive indices shown in Figure 6. Some difference is seen between this andthep-0°sample orientation but again it is not significant.

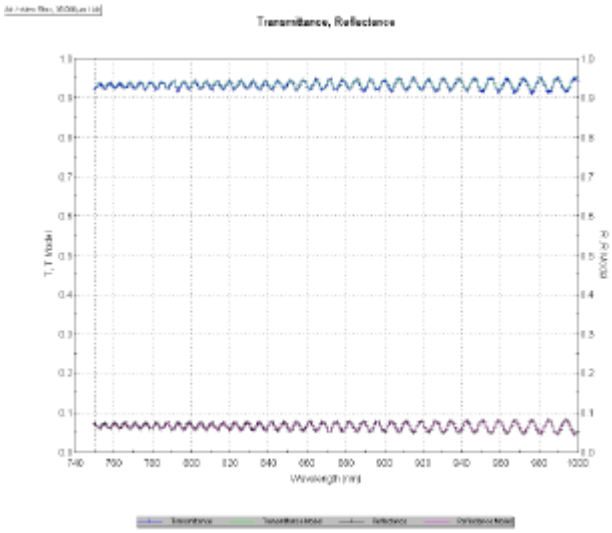

Figure5.Tand R for sample1-Polycarbonate.Orientation90°,p-polarisation.

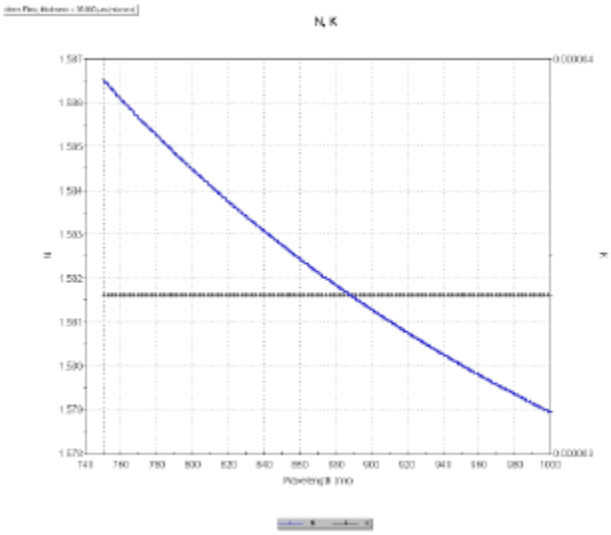

Figure6.n&kfor sample1-Polycarbonate.Orientation90°,p-polarisation.

The real changes areseenfor thes-polarisation measurements at 90°, see Figure 7. Analysis of the spectrum, Figure 8, revealed a muchhigher refractive index than for all the other measurements. The degree of bi-refringence was calculated and is shown in Figure9.

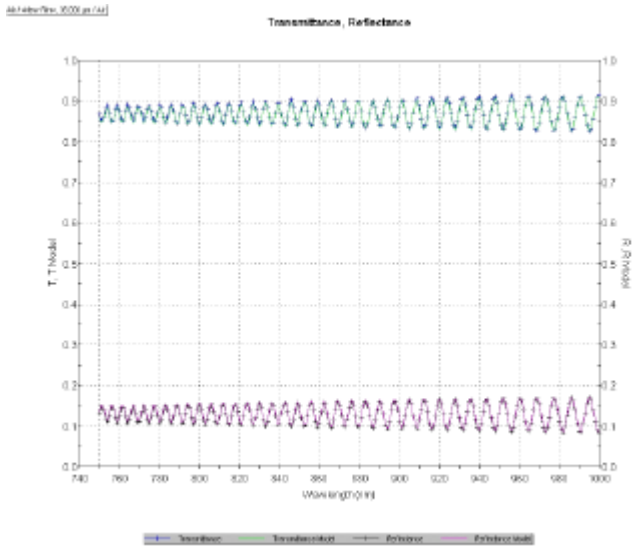

Figure7.Tand R for sample1-Polycarbonate.Orientation90°,s-polarisation.

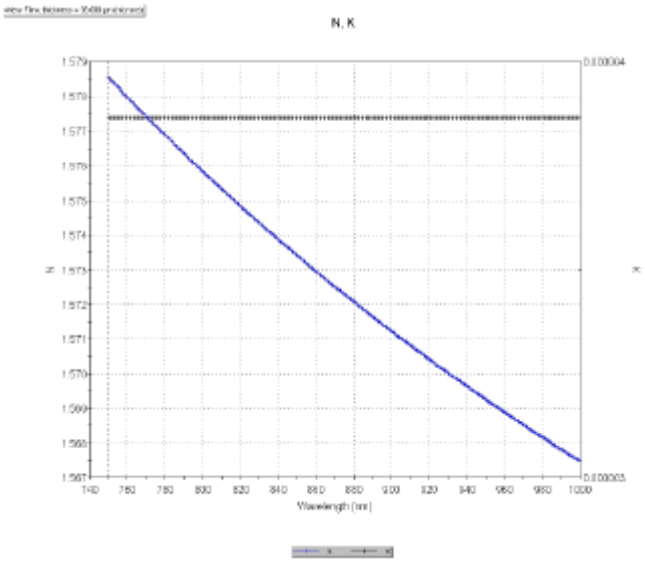

Figure8.n&kfor sample1-Polycarbonate.Orientation90°,s-polarisation.

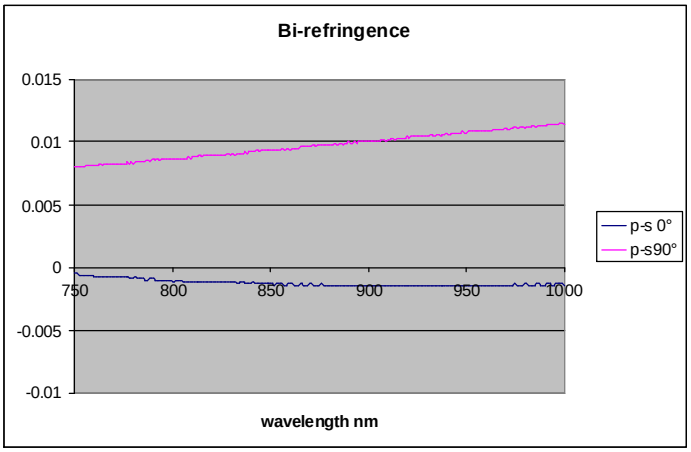

Figure8.Differencebetweenp- ands-polarisation measurements for thetwo measuredorientations ofthesamples.

It is clear then that the nkd provides an ideal solution for measuringtransparentandbi-refringentpolymerfilms.Inaddition to providing precise transmittance and reflectance data the nkd canalsobeusedtodeterminetherefractiveindex,absorptionand amountofbi-refringenceinthematerial, quickly andaccurately.