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Four-angle polarisation-resolved transmission FTIR mapping for materials orientation analysis

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Molecular orientation in polymeric and composite materials can play a significant role in overall mechanical performance. Infrared absorption by specific functional groups occurs preferentially when the electric vector of the probing beam is aligned with the dipole oscillation corresponding to the absorbing frequency, and can therefore be used to gain information on the molecular orientation of selected molecules. The team at the Tokyo Institute of Technology has developed a method whereby the dipole orientation angle, for each pixel of a hyper-spectral image can be determined from equation 1, where A_1, A_2, A_3, A_4 are absorbances at the four polarisation azimuths separated by $\pi/4$. The dipole orientation angle and strength are then plotted as “vectors” over each pixel within the spectral map, enabling the visualisation of molecular orientation. We have applied this method in the analysis of molecular re-orientation in silk fibres and in the study of the effects of additives to poly-lactic acid (PLA) composite materials. Figure 1 shows an example of the orientation vector map of spherulites formed in a PLA solvent cast film, showing the absorption strength (colour) and dipole orientation (vector line) for the C=O absorption at 1759 cm^{-1} (map = $150 \times 150\text{ }\mu\text{m}$).

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