

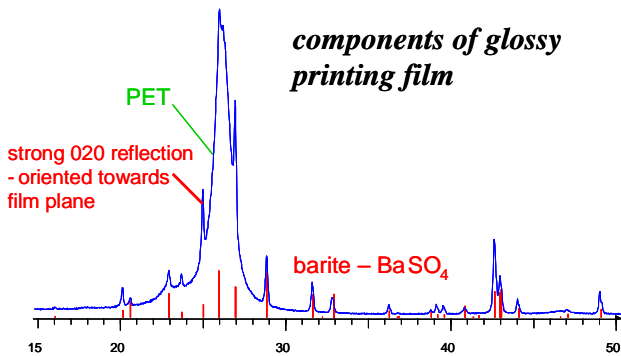
X-Ray Diffraction for Polymers & Composites

Introduction

X-ray diffraction is a key tool for understanding the properties of polymers and composites in relation to their solid-state structures. Crystalline materials give rise to the most obvious applications, but there is also important information to be obtained from semi-crystalline and even amorphous components.

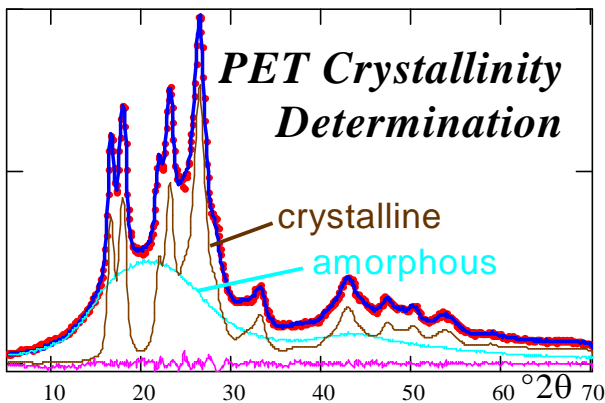
Phases

The most traditional use of XRD is still one of the most important – to identify the crystalline forms, or the phases that are present. This may concern the polymer type, its specific crystalline form, or the filler in a composite. Even a simple diffraction pattern can contain other information, e.g. about the orientation of the polymer and/or filler. The individual phases can often be characterised separately.



Crystallinity

The degree of crystallinity is a primary characteristic of polymers and XRD is the most adaptable means of measuring it. Our preferred methodology uses pattern-fitting techniques, as illustrated below.

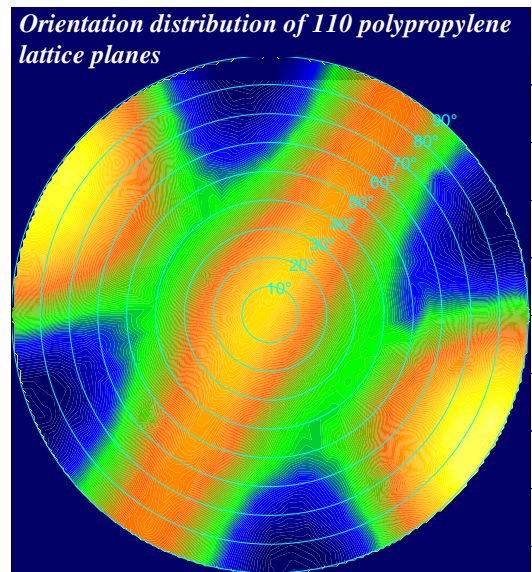


Microstructure

More detailed information about nature of the crystallinity can often be obtained. The shape of the crystalline peaks is related to the polymer microstructure. While this has often been interpreted as “crystallite size” it is usually better understood in terms of “crystalline perfection”. The “long period” measured by Small Angle X-ray Scattering (SAXS) gives the lamellar spacing (between alternating crystalline/amorphous blocks). This microstructure can lead to understanding and control of bulk properties.

Orientation

Orientation of the polymer and filler crystallites is often caused by processing and can impart important properties to the material (mechanical, optical, conductive, etc). We investigate these effects by measuring diffraction patterns in different geometries (reflection, transmission, tilted, grazing incidence).

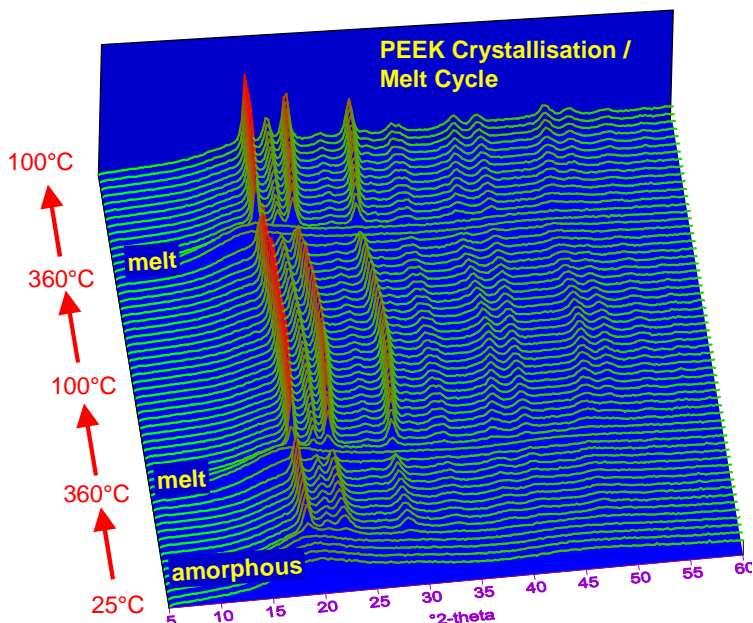


The figure above is a graphical representation of the orientation distribution of crystallites in an injection moulded polypropylene box. The orientation was introduced by the direction and velocity of injection in relation to the mould geometry. To make this measurement, the intensity of a single reflection was followed as the specimen was tilted about two axes.

Characterised by Expertise

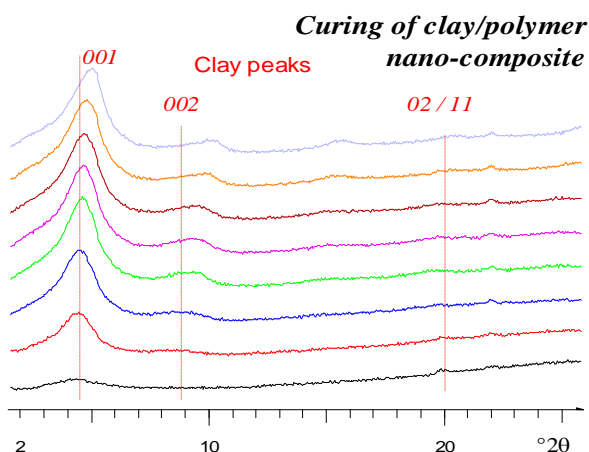
In Situ Studies

It is also possible to study transformations that occur during processing. The plot below follows the development of PEEK crystallinity recorded *in situ* during crystallisation / melt cycles as the temperature was raised and lowered to and from 360°C. Programmed temperature treatments are available.



Dynamic Phenomena

Efficient data collection lets us follow other changes, e.g. development of orientation and structure while curing a clay / polymer nano-composite.



This brochure gives a few examples of the information we can obtain by XRD about polymers and composites. We are always pleased to bring our wide experience to bear on different materials, either using a tried and tested solution, or by inventing something novel.

Information from XRD

- Crystallinity
- Orientation (crystalline and amorphous)
- Crystalline microstructure
- Non-crystalline periodicity and size
- Phase identification and quantification
- Crystal structure variations (e.g. by lattice parameters)
- Dynamic studies
- *In situ* studies at process temperatures

Examples of materials studied

Catalysts, ceramics, clays, coatings, colloids, composites, foods, liquid crystals, liquid suspensions, metals, paints, pigments, pharmaceuticals, polymers, nano-composites, nano-inorganics and -organics, semiconductors, surfactants.

To learn more about XRD in MSG and how it can be applied to your interests, please contact Barbara Middlemiss

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