INDUSTRIAL PILOT PROJECT

Scanning SAXS/WAXS imaging of process-induced polymer morphology in injection-moulded polymer materials.

THE INDUSTRIAL CHALLENGE

Most of the opening devices on Tetra Pak® packages are produced by injection moulding. This manufacturing technique induces a heterogeneous composition in the through-thickness direction of the produced material, i.e., a layered structure, where the thinnest layers are as thin as 0.01 mm. The material used is composed of a semi-crystalline polymer. The long-term goal is to develop an experimental methodology for identifying and characterising process-induced morphology throughout the thickness of injection-moulded polymer components.

WHY USING A LARGE-SCALE FACILITY

Synchrotron-based Small- and Wide-Angle X-ray Scattering (SAXS/WAXS) scanning is suitable to determine the number of different layers, as well as the quantification of the individual thicknesses of the respective layers and the corresponding polymer microstructures present throughout the thickness in the injection-moulded part. This is not possible in a standard laboratory X-ray equipment, partly due to the too large X-ray beam size (typical around 0.9 mm) compared to the sample thickness (i.e. 0.6 mm) and also to the small thickness of the layers to be identified and characterised. At Tetra Pak, polarised optical light microscopy has previously been used to visualise the layers, while limited to non-pigmented samples and not providing the possibility to determine the crystalline microstructure.

HOW THE WORK WAS DONE

Due to its outstanding workflow for the scanning of SAXS/WAXS we used the cSAXS beamline X12SA of the Swiss Light Source (SLS) at the Paul Scherrer Institute (PSI) in Switzerland. The focused beam has a spot size of around 0.024 mm, which is sufficiently small to resolve our thinnest layers. Samples produced with different injection moulding settings were produced and evaluated. Due to the pandemic of Covid-19, the scheduled beam time was changed to a remote setting that was run from Chalmers with the support of beamline scientist Dr. Manuel Guizar Sicairos being fundamental.

THE RESULTS AND EXPECTED IMPACT

In a true collaborative and innovative way, we finally achieved successful measure-ments. An easy-to-use workflow, optimising the data collection and data visualisation has been continuously refined. This is done to facilitate Tetra Pak® to perform such experiments independently in the future. In several positions on our sample plate, the layers have been identified, their thicknesses measured, and microstructure defined. As shown in the Figure 1 below, a shish-kebab structure is found in the outer layers (blue), symmetrical spherulites in the centre (pink), and elongated spherulites (yellow) in-between. The results have significantly increased our understanding in how the process settings influence the microstructure during the injection moulding process.

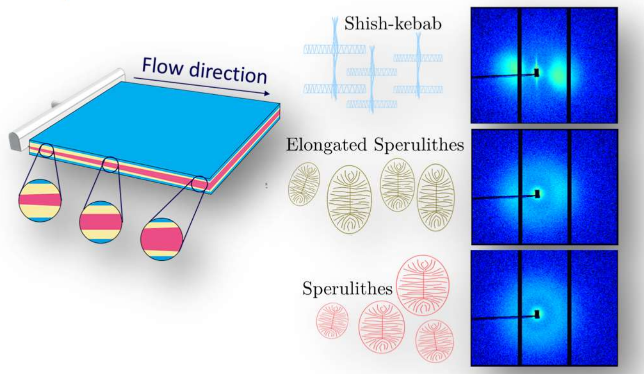

Figure 1. Process-induced layered structure with different crystalline polymer structures/morphology in the through-thickness direction of the injection moulded plate/top measured.

"This collaboration with Chalmers has increased our awareness, knowledge, and potential of advanced experimental techniques that will become available soon at MAX IV near Tetra Pak® in Lund." /Johan Elgebrant, Manager Injection Moulding - Tetra Pak

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