A microfluidic platform for SAXS measurements of liquid samples

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Introduction

Small-angle X-ray scattering (SAXS) is a technique that can measure the size and shape of small particles such as proteins and nanoparticles using X-rays. At MAX IV, we are developing a microfluidic sample delivery platform to measure liquid samples containing proteins under flow using SAXS. One of the main advantages of using microfluidics is that the sample is continuously flowing, thus minimizing the risk of radiation damage as the sample is continuously refreshed. Other advantages include low sample volume and the possibility to study dynamic processes, e.g. mixing. To obtain good SAXS signals, the X-ray properties of the chip material are essential. The microfluidic chip must have low attenuation of X-rays, low background scattering, and high resistance to X-ray-induced damage, and preferably be low cost and easy to fabricate. In this work, we have evaluated the performance of two different polymer microfluidic chips for SAXS measurements.

Experimental procedure

In Figure 1, the setup is shown. The X-ray properties of two polymer microfluidic chips (Microfluidic ChipShop) were evaluated: a cyclo-olefin copolymer (COC, TOPAS) chip and a cyclo-olefin polymer (COP, Zeonor) chip. Both polymers are non-polar and amorphous. The microfluidic channels were injection-molded and sealed with a polymer foil. The microfluidic chips were 1.5 mm thick, the COC foil was 140 µm thick, and the COP foil was 188 µm thick. The microfluidic chips were mounted in a bespoke chip holder with the foil-coated side facing the detector. Syringe pumps (Nemesys, Cetoni) were used to control the fluid flows. The SAXS measurements were performed at CoSAXS beamline at MAX IV. The energy was 12.4 keV and the beam size was 50x60 µm^2.

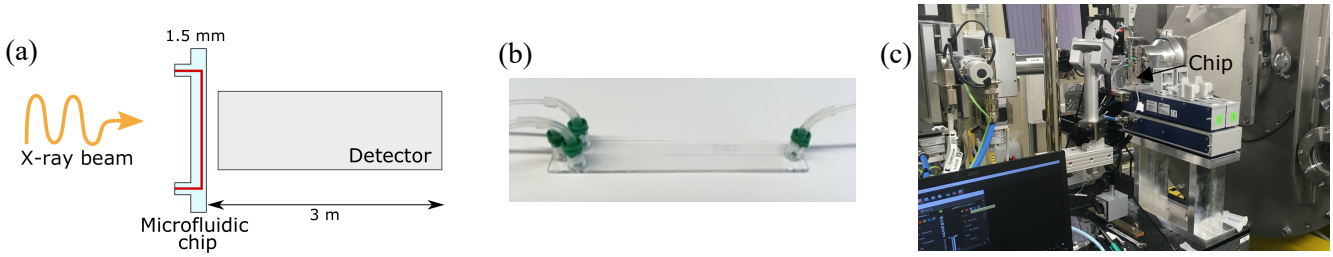

Figure 1. (a) Schematic of the setup. (b) The microfluidic chip. (c) The microfluidic chip mounted at CoSAXS beamline.

Results and Discussion

The two different polymer microfluidic chips were tested. Both COC and COP could withstand the intense X-ray beam, and no visible damage was identified on the chips. It was possible to collect scattering data from the sample in both chips. However, in the COP microfluidic chip, an intensity peak was observed at q=0.02 Å^{-1} arising from the chip material itself. This peak was not observed in the COC microfluidic chip. This background scattering from the COP chip material is not optimal as it could potentially hide the scattered signal from the analysed sample.

Conclusion

In this work we have developed a microfluidic sample delivery platform for SAXS measurements of liquid samples under flow. We have found that for SAXS measurements, COC is a more suitable chip material than COP as it gives less background scattering. We expect this microfluidic sample delivery platform to be a useful tool for academic and industrial users at MAX IV as it provides a way to study radiation-sensitive samples under flow.

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