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Visualization of Sulfur Impregnation on Single Fibre Level for Chemical Thermo Mechanical Pulp

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In pulp & paper industry, even small improvements in efficiency can generate significant decrease in energy consumption and also reduction in the environmental impact. One key parameter during Chemical Thermo Mechanical Pulp (CTMP) impregnation is even distribution of sodium sulphite (Na2SO3) [1]. This study aims at deciding the necessary XRF image quality for a laboratory setup capable of process relevant homogeneity measurements of sulfur distribution in wood fibres. Hence, the necessary spatial and spectral resolution to be able to visualize sulfur impregnation into single wood fibers needs to be retrieved. The first part of the study is synchrotron measurements of different elemental distributions. Measurements on single fibre level has been performed at the synchrotron facility APS, Advanced Photon Source, at the Argonne National Laboratory in the USA. Several different CTMP samples manufactured at different operating conditions were used, and elemental mapping images were retrieved by using a synchrotron beam with one micrometre scanning step. One example of sulfur distribution is shown in Figure 1.

The impregnation of sulfur and other elements into the wood fibres for varying production parameter settings are also investigated in the synchrotron images. From the pulp process perspective, significant uneven distribution of sulfur between fibres are revealed in the images of CTMP samples. Another detail worth noting is that, on individual fibre level, the sulfur impregnation is concentrated mainly in the fibre shell.

Studies of XRF imaging to improve paper productions processes exists. One example is calcium measurements for improving the coating of paperboard [2]. However, measurement of individual paper fibers is a greater challenge due to their small size of about 20 µm. Since the objective is direct sulfur distribution measurements on site at paper mills, XRF imaging must be achievable on site. To achieve this, a scanning imaging setup for energy dispersive X-ray fluorescence (ED-XRF) is the goal. Figure 2 shows how degenerating the spatial resolution blurs information about sulfur distribution inside the fibers, and eventually also the visualization of single fibers are lost. A system consisting an X-ray tube equipped with polycapillary focusing optics must hence be capable of about 10 µm resolution. Apart from spatial resolution, the spectral resolution also needs consideration. The use of an X-ray tube instead of a synchrotron will increase the spectral background and the sulfur signal might be lost. In this work, a setup using a sealed titan box and helium atmosphere to improve spectral performance is considered [1].

For the further development of the methodology, the spatial resolution that still contains the necessary homogeneity information is extracted. The background and achieved spectral resolution is characterized.

[1] Rahman, H. Aspects of optimizing pulp fibre properties for tissue and packaging materials, PhD Thesis, Mid Sweden University (2021).
[2] Norlin, B. Reza, S. Fröjdh, C. Nordin, T. Precision scan imaging for paperboard quality inspection utilizing X-ray fluorescence. Journal of Instrumentation. 2018, Volume: 13, Article number C01021.

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