

"Enabling optimal use of feedstocks by fast spectroscopic methods"

Owing to large assets of well-managed forests and developed value chains, Sweden is well equipped for a transition to a sustainable society based on renewable raw materials and circularity. To achieve the ambitious goal of a carbon-neutral society by 2050, resource and energy efficiency are critical factors. However, the rapidly expanding development of increasingly advanced bio-based technologies, such as within the biorefinery concept, means that new demands are placed on the feedstocks' composition and purity. Most of the more advanced conversion and manufacturing processes currently under development are considerably more sensitive than today's established and relatively robust technologies. The right raw material in the right place is thus a prerequisite for utilizing the forest raw material's potential, maximizing process yields, and achieving satisfactory product quality.

The vision of a flexible and resource-efficient biorefinery is based on high-quality components being identified and sorted in a way that optimizes the utilization of the available resource in defined processes. Fast and accurate online characterization methods are a critical component. They can even be necessary to realize this vision, which is primarily based on the real-time availability of information on specific properties of the constituent materials, products, and by-products. With the help of spectroscopic technologies and specifically adapted mathematical calibration models, information flows can be generated, enabling process control that maximizes the benefit and minimizes the environmental impact. These methods can also be applied earlier in the value chain to measure and digitize the feedstock's material properties already in the forest. Several spectroscopic techniques are available, but further applied basic research is necessary to determine which is most suitable for each process. A particularly interesting spectroscopic method for measuring material composition is a neutron-based method that utilizes the neutron's ability to penetrate feedstock materials. However, several technical issues need to be investigated before the technology is ready for implementation in industrial handling chains of forest raw materials, where bulk handling of large heterogeneous material volumes is exceptionally demanding.

In step with increased digitization, more sensors, and significantly increased amount of information (so-called big data) along value chains and production processes, demands are placed on the development of robust algorithms that can sort and extract meaningful information from these massive amounts of data. Multivariate data analysis is today a prerequisite for managing and interpreting this information flow. With an ever faster generation of data, method development is required to build robust calibration models that have broad applicability. An additional dimension, which is still only in its infancy, is the possibilities that are opened up for even more advanced functions through the application of AI-based process technology based on deep learning.

Through its investment in the new MAX IV laboratory in Lund, Sweden has invested heavily in advanced synchrotron infrastructure, becoming the world's most brilliant radiation source. This facility enables world-leading basic research in new material concepts for advanced biomaterials and products with improved properties and functionality. Examples of future applications that are already generating considerable research interest are batteries and supercapacitors from biochar and new wood-based textiles, smart paper products, etc.

In summary, spectroscopy - both in the form of industrially useful, robust online applications and as a basic research-oriented high-resolution analysis technology - will be a crucial technology in the roadmap towards a modern, sustainable and circular society.