INDUSTRIAL PILOT PROJECT

Next generation plant biostimulants being developed using X-ray absorption spectroscopy

THE INDUSTRIAL CHALLENGE

Arevo produces environmentally friendly plant biostimulants to increase plant growth, while keeping soils healthy and reducing nutrient losses to a minimum. The aim is to produce slow-release plant nutrition, which in composition as well as performance can be adapted to different environmental conditions. For this development, Arevo needs to be able to define the chemical properties in detail, such as the cationic environment in the biostimulants synthesized from the amino acid arginine which binds to polyphosphate(s) and metal ion(s). More detailed characterisation tools are additionally needed for REACH classification and for verification of product stability tests, in order to formulate proper storage instructions for the end consumer.

WHY USING A LARGE-SCALE FACILITY

Detailed understanding about how the reactants are chemically bonded could not be obtained with available in-house techniques such as powder X-ray diffraction (XRD) and infrared spectroscopy (FTIR). Laboratory scale analysis however show that there is no, or little, crystallinity with different synthesis methods. Therefore, analytical techniques suitable for identifying the oxidation state and chemical environment of cations in amorphous materials are required, and X-ray absorption spectroscopy (XAS) at a synchrotron facility is an excellent technique for this purpose due to high resolution, high quality in data collected, and rapid analysis where each shift at a beamline permits high sample throughput.

HOW THE WORK WAS DONE

Material from two promising biostimulants produced by Arevo were analysed with XAS using the Balder beamline of MAX IV Laboratory, Lund. A total of 30 samples were produced with different synthesis strategies and analysed both as received and after ageing/storage. The full XAS regime was used in these measurements, both for the K-edge X-ray absorption profile of the cation of relevance for the product which provides XANES information, but also the extended X-ray absorption (EXAFS). The XANES analysis permits identification of oxidation state, while EXAFS was used for fitting bonding distances in reference materials to those observed in the products. Beamline manager Dr. Kajsa Sigfridsson Clauss, MAX IV, and beamline scientist Dr. Konstantin Klementiev, MAX IV, are gratefully acknowledged for their excellent support.

Figure 1 Arevo's biostimulants were milled to a fine powder and then pressed to a disk for mounting at the Balder beamline at MAX IV Laboratory.

THE RESULTS AND EXPECTED IMPACT

It was possible to identify the cation oxidation state in Arevo's samples to record i) chemical differences between diverse synthesis pathways and ii) potential changes in product chemistry due to storage. Storage of up to 1 year influenced the oxidation state only to a minor extent, which suggests that the product could likely be stored by customers without affecting its intended use. This is information that cannot be obtained reliably without the use of synchrotron-based X-ray absorption. Arevo plans to obtain REACH classification for the biostimulant for future commercialization.

"The possibility to use synchrotron-based X-ray absorption spectroscopy to analyze the chemical structure of our plant biostimulants was a great way for Arevo to expand our product portfolio."
/Regina Gratz, Arevo

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