NanoCT with in situ mechanical testing as a tool for 3D structural and mechanical characterization of biological samples

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With an intermediate resolution between light and electron microscopes, the commercial lab-based X-ray microscope (Xradia Ultra 810), here referred to as nanoCT, is a versatile new tool for the characterization of biological samples and for bioinspired materials research. With its mechanical in situ testing, the nanoCT is suited for structural characterization of complex 3D samples down to 50 nm resolution with and without loading. It allows for the observation of microstructural changes as a function of time and mechanical load. With its low energy X-ray source (Cr source, 5.4 keV) and Zernike phase contrast, the setup is ideal for analyzing low-density samples, such as polymers and soft tissues.

To demonstrate its potential, imaging experiments with biological samples were carried out at the Institute of Nanotechnology, Karlsruhe Institute of Technology. Samples of centric diatoms (*Thalassiosira*) and seed hairs from thistle (Cirsium vulgare) were characterized for their inner structure (Figure 1). Images were acquired in phase contrast, with an exposure time varying from 80 s to 160 s, depending on the sample, and 901 projections over 180° and a voxel size of $(64\ nm)^3$. In situ tensile and indentation nanoCT scans were carried out for the thistle hairs and diatoms, respectively. These scans were acquired in a reduced angle of 140° within the load stage setup. Image reconstruction was performed using a filtered back-projection algorithm.

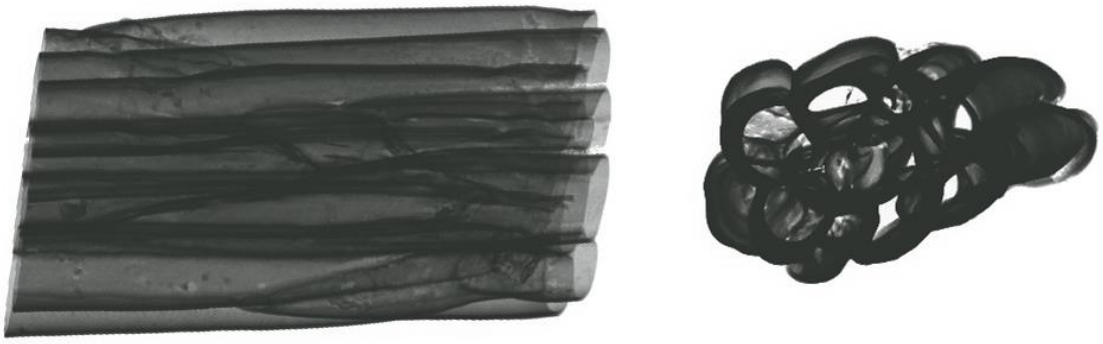

Figure 1: Volumetric reconstruction of the seed hair of the common thistle (Cirsium vulgare) in side- and top-views.