THERMAL INSULATION DESIGN BIOINSPIRED BY MICROSTRUCTURE STUDY OF PINGUIN FEATHER AND POLAR BEAR HAIR

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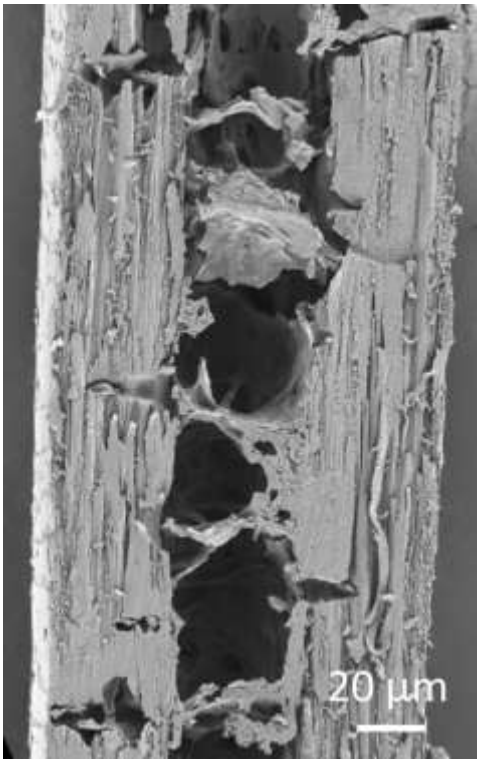

Figure 1. SEM micrograph of the longitudinal cut through the polar bear hair exposing the internal structure with hollow channels through the cortex.

In nature, thermal insulation structures, such as penguin feather and polar bear hair, are well developed; enabling the animals' survival in frigid waters. The detailed microscopy investigations conducted in this study, allowed us to perform microstructural analysis of these thermally insulating materials, including statistical measurements of keratin fiber and pore dimensions directly from high resolution Scanning Electron Microscope (SEM) images. We revealed many similarities in both materials: penguin feather and polar bear hair, and showed the importance of their hierarchically-organized porous structure. The porosity is present in the main shafts and also on the external surfaces. The hierarchical porosity observed in both materials at different structural levels that are often interconnected. The cortex is based on aligned bundles of keratin fibers, with the average diameter 0.3-0.6 µm and fibers run parallel to each other along the length of the shaft, see Figure 1. The keratin fibers have a similar diameter in the range of 0.14-0.18 µm, even though polar bear hair is composed of coiled-coil alpha-keratin and penguin feather of sheets of beta-keratin. Our findings from a unique comparison between two keratin-based materials, penguin feather and polar bear hair, shed new light on how their microstructure is optimized to form highly insulating materials [1]. High-resolution SEM allows us to observe their 3D structure, including statistical measurements of keratin fiber and pore diameters, in greater detail. These optimized thermal-insulator systems indicate the road maps for future development, and new approaches in the design of material properties.

References:

[1] S. Metwally, S. Martínez Comesaña, M. Zarzyka, P.K. Szewczyk, J.E. Karbowniczek, U. Stachewicz, "Thermal insulation design bioinspired by microstructure study of penguin feather and polar bear hair", Acta Biomaterialia, in press, 2019, doi.org/10.1016/j.actbio.2019.04.031

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