Ultra-Slow Hygroscopic Motion of Pine Cone Inspires New Soft Actuators

By YAN Fusheng (Staff Report)

Picture yourself wandering through a peaceful forest – the air filled with the fragrance of pine trees, while your eyes catch glimpses of unusual objects scattered on the ground. These objects are pine cones, nature's extraordinary marvels capable of changing their shapes in response to humidity.

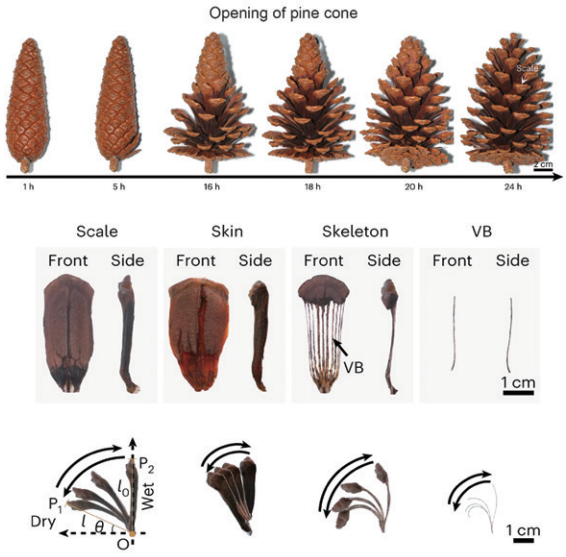
Pine cones have long been known to open and close their scales based on environmental humidity, a process called hygroscopic deformation. But what if I told you that there's more to this fascinating story, a secret hidden within the ultra-slow motion of pine cones?

In a recent study published in Nature Materials, a research team led by Dr. WANG Shutao at the Technical Institute of Physics and Chemistry (TIPC) of the Chinese Academy of Sciences and Dr. LIU Huan from the Beihang University has uncovered new details about the hygroscopic motion of pine cones, revealing the critical role of unique structures called vascular bundles (VB).

These bundles consist of parallelly arranged spring and square microtubular heterostructures. The spring microtubes cause a much larger hygroscopic deformation along the longitudinal axis direction than the square microtubes, bending the vascular bundles and driving the movement of the pine cone scales.

The researchers also found that the outer sclereids, a layer of cells with excellent water retention, enable the ultra-slow motion of the scales. This ultra-slow motion had previously gone unnoticed in the world of pine cone research, but now, this discovery is transforming our understanding of their hygroscopic behavior.

Inspired by these findings, the research team designed innovative soft actuators that mimic the ultra-slow and controllable motion of pine cones. The motion velocity of these soft actuators is nearly two orders of magnitude lower than those of reported humidity-driven actuators, making them highly suitable for applications in camouflage and scouting in stealth.



The typical slow hygroscopic geometric reshaping of a pine cone and its hierarchical components of scale, skin, skeleton and vascular bundle (VB). (Image by TIPC)

As you stroll through the forest and spot a pine cone, take a moment to appreciate its remarkable story. The humble pine cone not only represents millions of years of evolution and adaptation but also serves as an inspiration for cutting-edge technologies that could shape our future.

Reference

Zhang, F., Yang, M., Xu, X., Liu, X., Liu, H., Jiang, L., & Wang, S. (2022). Unperceivable motion mimicking hygroscopic geometric reshaping of pine cones. *Nature Materials, 21*(12), 1357–1365. doi:10.1038/s41563-022-01391-2