Flexible Minerals: Self-assembled Calcite spicules with Extreme Bending Strenght

FILIPE NATALIO,[1,*] MICHAEL KAPPL[2], HANS-JÜRGEN BUTT[2], WOLFGANG TREMEL[3]

[1] Institut für Chemie - Anorganische Chemie, Martin- Luther-Universität Halle-Wittenberg, Kurt Mothes Strabe 2, 06120 Halle, Germany.
[2] Max-Planck-Institut für Polymerforschung, Ackermannweg 10, D-55128 Mainz, Germany.
[3] Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität, Duesbergweg 10-14, D-55099 Mainz, Germany.
*corresponding author.

Mesoscale hierarchical structures with diverse functions are abundant in Nature normally driven by self-assembly processes. Silicatein-α – a protein involved in silica biomineralization that display intrinsic self-assembly properties – was used to fabricate microsized needles of $CaCO_3$ similar to the spicules of the calcareous sponge *Sycon sp*. The self-assembled spicules, 10 to 300 micrometers (mm) in length and 5 to 10 mm in diameter, are composed of aligned calcite nanocrystals. The spicules are initially amorphous but transform into calcite within months, exhibiting unusual growth along [100] scattering X-rays like twinned calcite crystals. Whereas natural spicules evidence brittle failure, the synthetic spicules show an elastic response, which greatly enhances bending strength. This remarkable feature is linked to a high protein content. With nano-thermogravimetric (nano-TGA) analysis, we measured the organic content of a single spicule to be 10 to 16%. The hierarchical organization, structural homogeneity and the alignment of the nanocrystals impart waveguiding properties even upon bending.