MS18 Biomineralogy and bioinspired materials

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Biomimetic and biological crystallization of amorphous precursors: from spherulites to functionally graded materials

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Abstract

Biominerals are hybrid ceramics evolutionary honed to high-performance materials with exceptional damage tolerance. Their biosynthesis typically involves the biologically-controlled crystallization of transient amorphous precursors in a shape-preserving, thus “pseudomorphic” manner. Biominerals are often praised for their exquisite control over this process, as some biominerals are known to be (nearly) single-crystalline. While earlier studies highlighted the homogenous textures of specific biominerals, complex textures are far more widespread yet challenging to account for. Here, we propose that polycrystalline biominerals with textures gradually varying with depth can be interpreted as functionally graded materials that enhance their endurance against sharp and blunt contact damage by stress delocalization [1]. We further demonstrate that spherulitic transformation bio-inspired crystallization setup readily yields such complex texture in techniques if reaction parameters are well-controlled [2]. Ultimately, a closer look at the mechanistic preconditions for spherulitic growth and the ultrastructure of ACC [3] allows for a conceptional understanding of the underlying physicochemical processes.

References

[1] D Wallis, J Harris, CF Böhm, D Wang, P Zavattieri, P Feldner, B Merle, V Pipich, K Hurle, S Leupold, LN Hansen, F Marin and SE Wolf. Progressive changes in crystallographic textures of biominerals generate functionally graded ceramics. Mater. Adv. 3, 1527–1538 (2022). DOI: 10.1039/d1ma01031j

[2] J Harris, I Mey, M Hajir, M Mondeshki, and SE Wolf. Pseudomorphic transformation of amorphous calcium carbonate films follows spherulitic growth mechanisms and can give rise to crystal lattice tilting. CrystEngComm 17, 6831–6837 (2015). DOI: 10.1039/C5CE00441A

[3] SM Clark, B Colas, DE Jacob, JC Neuefeind, HW Wang, AK Soper, PI Schodder, P Duchstein, B Apeleo Zubiri, T Yokosawa, V Pipich, D Zahn, E Spiecker and SE Wolf. The nano- and meso-scale structure of amorphous calcium carbonate. Sci. Rep. 12, 6870 (2022). DOI: 10.1038/s41598-022-10627-9