Crystal Growth of Amorphous Calcium Phosphate to Apatite in Bone-Mimetic Nanocomposites

Lotsari, A.[1], Rajasekharan, A.K.[1] and Andersson, M.[1]

[1] Department of Chemistry and Chemical Engineering, Chalmers University of Technology, Gothenburg, SE-412 96, Sweden, Sweden

In order to compensate the increasing clinical need for bone repair and regeneration, novel bioinspired materials must be developed. One way to design and produce such materials is by trying to mimic the natural bone growth processes and exploit the advances in additive manufacturing (3D printing) [1]. The design incorporates a polymeric matrix (that could play the role of collagen) which has a strict alignment, structure and space confinements and calcium phosphates (CaP) which are being used in a similar manner as in nature for the mineral phase of bone. The transformation from amorphous CaP to crystalline hydroxyapatite (HAp) is achieved through an aging route analogous to the natural mineralization procedure for bone growth [2].

But even in natural bone formation, the nucleation and crystallisation mechanisms are not yet well understood and the subject has been a debate for decades. In this work, we try to reveal the early crystallisation stages by studying the structural transformation of amorphous calcium phosphate to crystalline apatite in our bone-mimetic mineral/polymer nanocomposite system. This synthetic system is a suitable analogue for the apatite/collagen natural composite - the bone's basic building block- but it is stripped of any biological component, thus making it possible to study the inorganic growth mechanisms.

For this study we employ transmission electron microscopy techniques in order to identify if the crystalline phases resemble the natural bone's structure down to the atomic level, determine the chemical composition and the crystal's orientation relationship with the polymer matrix [3]. Moreover, we study the 3D confinement of the mineral crystals within the matrix and if a hierarchical structure can be maintained over different length scales, similar to the natural bone's design.

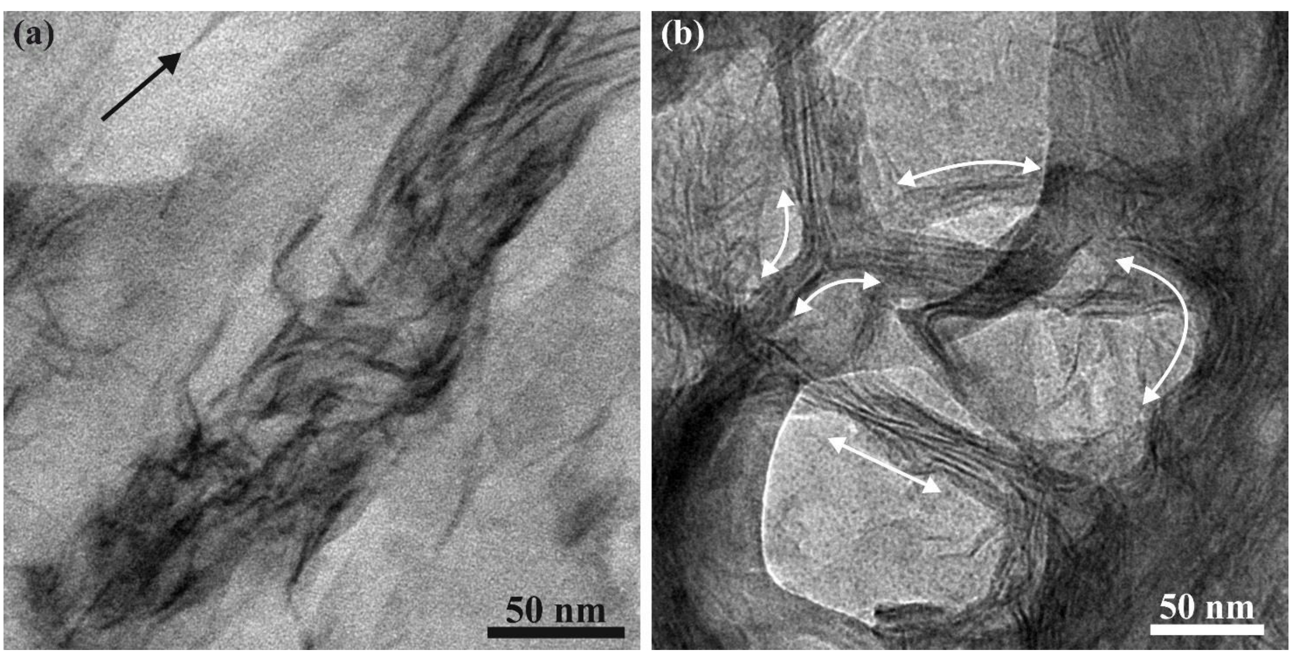

Figure 1: BF TEM images of the apatite/polymer composite (a) along the polymer fibrils and (b) normal to the polymer fibrils. The microstructure resembles the natural bone's morphology viewed along the same orientations.

References

[1] Rajasekharan A.K., Bordes R., Sandström C., Ekh M., Andersson M. *Small* **1700550** (2017).

[2] W-X. He, A. K. Rajasekharan, A. R. Tehrani-Bagha and M. Andersson, *Advanced Materials* **27**, 2260-2264 (2015).

[3] A. Lotsari, A.K. Rajasekharan, M. Halvarsson, M. Andersson. "Transformation of Amorphous Calcium Phosphate to Bone-like Apatite". *Under revision in Nature Communications.*

Acknowledgements: A.L. acknowledges Chalmers Area of Advance "Nanoscience and Nanotechnology" for the financial support.