Designing natural-based synthetic materials

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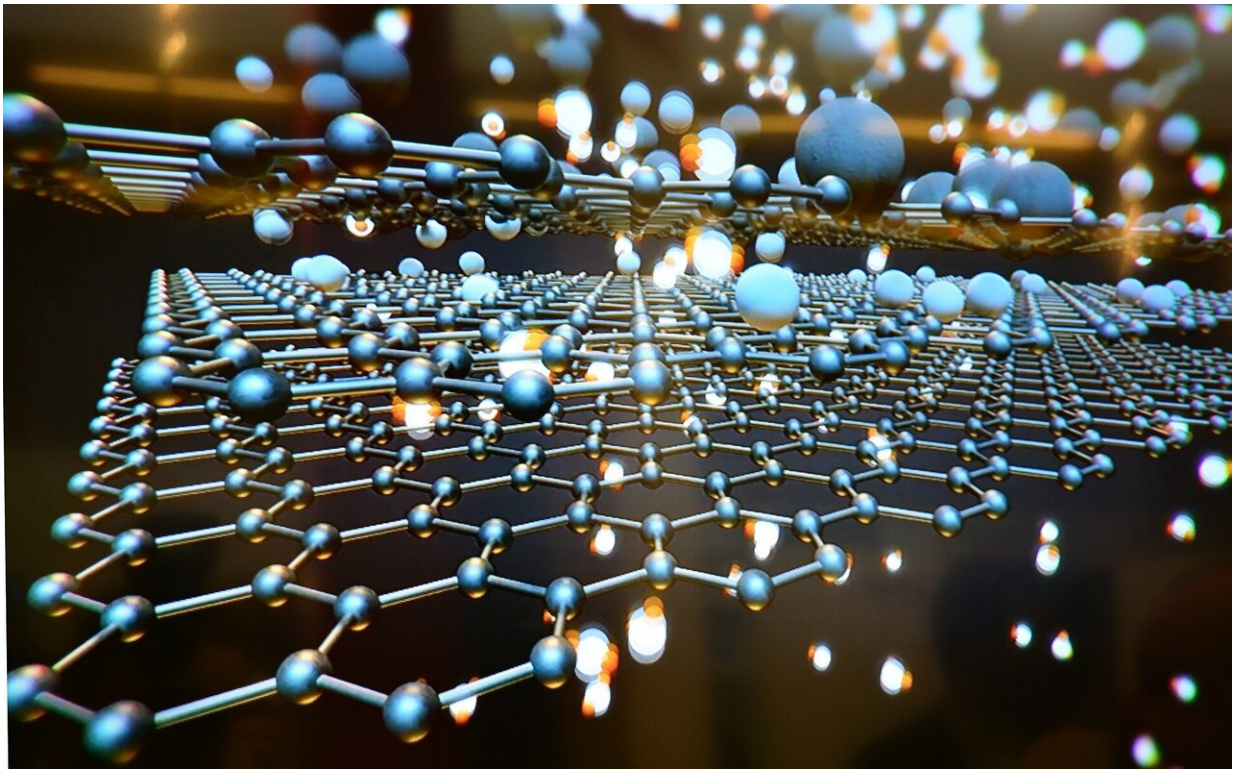

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Since the beginning of mankind we are developing and improving materials with better and more optimized material properties. By understanding how natural materials are made, one should be able to imitate and modify them. And that is exactly what Mark van Rijt and Bernette Oosterlaken (Chemical Engineering and Chemistry) did, both from a different perspective.

To build materials with exceptional tuned properties, nature uses a relatively small range of common and ordinary building blocks. These common building blocks are incorporated with both a high control over crystal morphology and a hierarchical control over their structure, from the nanometer scale to the millimeter scale. Many of these materials are hybrid and are composed of an organic and an inorganic part.

Often, the organic part assembles in a defined hierarchical structure and is mineralized with the inorganic part. The interplay between those materials leads to extraordinary properties. For example, calcium phosphate is strong but brittle, but when mineralized in a collagen matrix, like in bone, the final material exhibits strength and considerable toughness.

New synthesis strategy

Mark van Rijt investigated the incorporation of zinc oxide (ZnO) into organic templates. In this way a novel material with, hopefully, new high-end properties should be obtainable. However, ZnO is typically formed at a temperature that an organic template cannot survive. Hence, alternative methods are looked for including directly forming ZnO inside an organic template. For this it is vital the ZnO can first be synthesized at template friendly conditions.

Van Rijt therefore developed a new synthesis strategy after using advanced cryogenic transmission electron microscopy (CryoTEM) sampling experiments to investigate the formation of a common ZnO formation strategy in water in detail over time. After optimization, this highly controlled synthesis strategy allows for the formation of ZnO at temperatures as low as ~ 40 °C and can therefore now act as the basis for ZnO mineralization of sensitive organic templates.

Inspiration from nature

Bernette Oosterlaken worked with different organic templates to study the formation of a different mineral, magnetite. This iron oxide has the highest saturation magnetization of all naturally occurring minerals, leading to magnetic properties. Its magnetic behavior highly depends on the crystal size and shape and as such, by controlling the crystal habit, its magnetic behavior can be tuned.

Finding inspiration from nature, where high control over crystal size and shape is achieved even at ambient temperature and in aqueous media, Oosterlaken aimed for a similar control over crystal habit by providing an organic template for iron oxide formation. After time-resolved and in-situ techniques, combined with spectroscopic techniques, Oosterlaken managed to successfully mineralize one of the selected templates, collagen, with iron oxides.

The research of van Rijt and Oosterlaken gave a first insight in the factors driving the formation of mineral inside templates, and thus a very first step in the design of new natural-based synthetic materials.

More information: Connecting ZnO to Organic Templates'.: research.tue.nl/en/publication … to-organic-templates

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