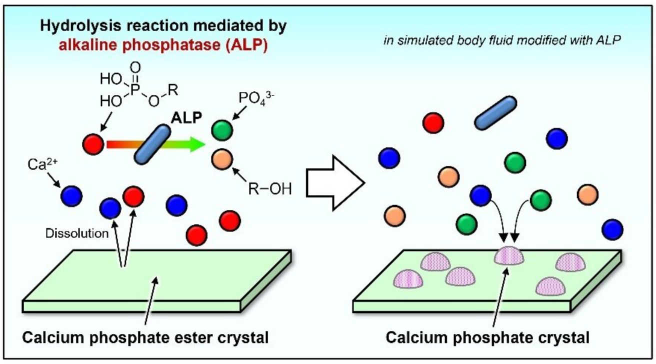
Bone, heal thyself: Toward ceramics tailored for optimized bone self-repair

3 June 2022



Transformation of a salt of calcium ions and phosphate esters into hydroxyapatite mediated by alkaline phosphatase (ALP). Credit: Department of Inorganic Biomaterials, TMDU

Your chance of breaking a bone sometime within the next year is nearly 4%. If you're unlucky enough to need a bone replacement, it'll probably be based on a metal part. Unfortunately, metal parts are sometimes toxic over time, and will not help your original bone regrow. Calcium phosphate ceramics—substitutes for the bone mineral hydroxyapatite—are in principle an ideal alternative to conventional metals because bone can eventually replace the ceramic and regrow. However, applications of such ceramics in medical settings have been limited by insufficient control over the rate of absorption and replacement by bone after implantation.

Now, in a study recently published in *Science and Technology of Advanced Materials*, researchers from TMDU and collaborating partners have studied the effect of the carbon chain length of a phosphate ester ceramic containing calcium ion on the rate of its transformation into hydroxyapatite mediated by alkaline phosphatase which presents in our bones. This work will help move bone regeneration research from laboratories to medical use.

"Medical professionals have long sought a means of healing bone fractures without using implanted medical devices, but the underlying science that can make this dream a reality isn't yet fully elaborated," explains lead author Taishi Yokoi. "Our careful analysis of the effect of the ceramic's ester alkyl chain length on hydroxyapatite formation, in a simulated body fluid, may help develop a novel bone-replacement biomaterial."

The researchers report two main findings. First, most of the studied ceramics underwent chemical transformations into particulate or fibrous hydroxyapatite within a few days. Second, smaller alkyl groups facilitated faster chemical reactions than larger alkyl groups. Because the rate-limiting step of hydroxyapatite formation is dissolution of the ceramic, the greater solubility imparted by smaller alkyl groups sped up production of hydroxyapatite. Such knowledge gives a means of tailoring the speed of bone regrowth.

"We now have specific chemical knowledge on how to tailor the rate of hydroxyapatite growth from calcium phosphate ceramics," says Yokoi. "We expect that this knowledge will be useful for bench researchers and medical practitioners to more effectively collaborate on tailoring bone reformation rates under medically relevant conditions."

The results of this study are important for healing bone fractures after surgery. By using chemical insights to optimize the rate of bone reformation after implantation of calcium phosphate ceramics, patient outcomes will improve, and returns to the hospital years later for further repairs will be minimized.

More information: Taishi Yokoi et al, Transformation behaviour of salts composed of calcium ions and phosphate esters with different linear alkyl chain structures in a simulated body fluid modified with alkaline phosphatase, *Science and Technology of Advanced Materials* (2022).

[DOI: 10.1080/14686996.2022.2074801](https://dx.doi.org/10.1080/14686996.2022.2074801)

Provided by Tokyo Medical and Dental University