Ultra-high Magnetic Fields Provide New Insights into Bone-like Materials

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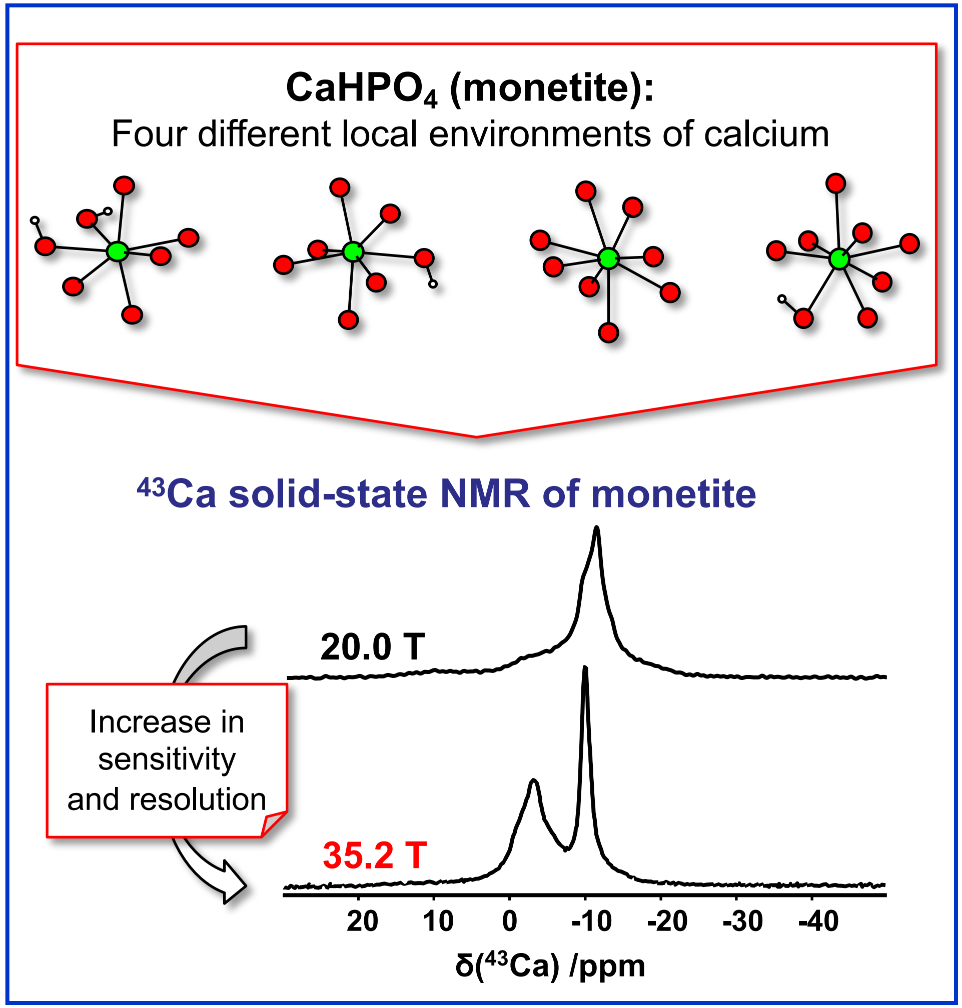
Calcium is abundantly present in living organisms, most notably in mineralized tissues like bone and teeth. However, determining the local vicinity of calcium within such complex materials is far from trivial. In particular, techniques like Nuclear Magnetic Resonance (NMR) spectroscopy are highly challenging, because the NMR-active isotope, ^{43}Ca, is a spin 7/2 nucleus of poor natural abundance (0.14%) and low Larmor frequency.

Ultra-high and homogeneous magnetic fields are particularly suited to tackle the poor receptivity of calcium-43. This user collaboration utilized the MagLab's 35.2T Series Connected Hybrid (SCH) magnet to study a series of synthetic biomaterials, both crystalline and amorphous, using ^{43}Ca solid state NMR. They find that the SCH's unprecedented levels of sensitivity and resolution can, for example, resolve calcium environments in $CaHPO_4$ for the first time using a one-dimensional ^{43}Ca NMR experiment at 35.2T, a resolution that was not previously possible at 20.0T (see Figure).

Such analyses open the frontier for future, more detailed investigations of calcium environments in a variety of calcium-containing materials of great interest, including biomaterials, mineralized tissues, cement, and concrete. These in-depth structural analyses will allow a much more complete understanding of these materials, including the atomic-scale origin of their properties.



Facilities and instrumentation used: Series Connected Hybrid Magnet of the DC Magnet Facility.

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