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Energy conversion and spatiotemporal changes in atomic and molecular architecture of native bone

Abstract:

Spectroscopic, diffraction and microscopic studies of cortical bone of healthy newborn, adult and mature rats as well as human femur and tibia under osteoarthritis conditions are carried out. The systematic analysis of the experimental data has revealed the distinct consistencies of spatiotemporal changes in chemical bonds, structural and spectroscopic characteristics of bone architecture.
Summarizing the trends in the spatiotemporal behaviour of atom-molecular architecture, the bone-battery concept is suggested. According to the concept a mineralized bone is a kind of electric battery composed from negatively charged nanocrystals of hydroxyapatite Ca10(PO4)6(OH)2 immersed in a positively charged surrounding medium. This mineralized conglomerate is strongly charged in a newborn bone and discharges with age. The origin of the electric charges is conditioned by the non-stoichiometry of hydroxyapatite nanocrystals at their mineralization. Examining charge distributions in the organic and mineral matrices we bring forward a suggestion that the electrostatic interactions play an important role in age-related changes in bone under physiological conditions. New insight on electrostatic interactions, nanoenergies and redox reactions and their link with aging in bone is discussed.
This interdisciplinary research opens broad horizons for the further development of (i) new medical technologies, (ii) osteomimetic designing of environmentally friendly materials for storing and converting electrical energy, and (iii) electrochemical strategies to counteract bone aging processes. The work was carried out with financial support from the Russian Science Foundation grant 23-29-00172

Biography

Since 1996 **Andrey Pavlychev** is a professor at the St. Petersburg State University. He lectures “Electronic structure of solids”, “Quantum chemistry of polyatomics”, “Nanophenomena in solids”. He has published more than 180 papers on Molecular and Cluster Physics, Condensed Matter, Hierarchical Nanostructures, Material Science, Medical Physics and Engineering Science. He is the leader of research projects “Relationships between Hierarchical Organization of the Skeleton and Nanostructure of Bone Tissue” supported by the Russian Basic Research Foundation and “Spatiotemporal Changes in Atom-molecular Architecture of Bone Tissue: The Basis of a Novel Convergent Technology” supported by the Russian Scientific Foundation