Ca 2p Photoelectron Spectroscopy of Surfaces of Cortex and Subchondral Femoral Bone in Intact and Damaged Areas

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Abstract:

Bone is one of the most complicated hierarchically organized nanostructured material in nature. Material science, biological and medical research discloses the complex hierarchy of the skeleton designs from macro- to nanolevels. Specifically, nanolevel studies of bones encounter great difficulty mainly because electronic and atomic structure as well as molecular architecture of their nanoblocks are not fully understood. This gap prevents from successful solution of many fundamental and clinically relevant problems such as the development of new methods of medical imaging at subcellular levels and medical diagnosis of skeletal pathology at early stage too. X-ray absorption spectroscopy, as it was shown [1], provides a sensitive evaluation of relationships between hierarchical organization of bone and its local electronic and atomic structure. In this study we used X-ray photoelectron spectroscopy to investigate surface of cortex and subchondral bone in intact and degeneratively damaged by osteoarthritis areas. The tibia cortex medial and lateral condyles of the femur resected during total knee arthroplasty in patients with medial compartmental knee osteoarthritis were used as samples. Their preparation is discussed [2]. Table 1 demonstrates the spectroscopic characteristics such as the Ca $2p_{1/2}$ binding energy (BE) and full-width-half-maximum (FWHM), measured for the samples from their proximal sides of rat cortex and femur bone cuts. The characteristics of the distal side surface of the cuts are also examined. The difference between the Ca^{2+} surface states of healthy and arthritic areas is revealed. It is discussed within the 3DSL model [1]. Perspectives for development of novel methods of medical imaging of the subhondral bone at the subcellular level are discussed too.

Keywords: bone tissue, hierarchical nanostructures, photoelectron spectroscopy, knee joint, subchondral bone, surface states, osteoarthritis.

Phase	Ca $2p_{½}$ BE/eV	FWHM/eV
Hydroxyapatite	350.75	1.6
Cortex (mature rat)	350.65	1.8
Subchondral, intact area, sample 1	350.55	2.2
Subchondral, sclerotic area, sample 2,	A-comp 350.55 B-comp 350.05 C-comp 351.95	1.9 2.0 2.0
Subchondral, intact area, sample 2	350.45	1.7
Subchondral, Sclerotic area, sample 2.	A-comp 350.45 B-comp 350.05	1.6 1.6

Table 1: The spectroscopic parameters of the Ca $2p_{½}^{-1}$ surface states of cortex and damaged (sclerotic) and healthy areas of femoral condyles in knee osteoarthritis patient. The error of the measured data is ±1% or ±0.1 eV, respectively.

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Reference:

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