Mineralized Collagen-Based Composite Materials for Bone Regeneration and Clinical Translation

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Abstract

Complex hierarchical architectures are ubiquitous in natural hard tissues, which comprise an elaborate assembly of hard and soft phases spanning from the nanoscale to the macroscale. The elegant architectures grant unique performance in terms of strength and toughness, but the biomimetic fabrication of synthetic materials with highly consistent structural and mechanical characteristics with natural counterparts remains a great challenge. The self-assembled mineralized collagen fibrils are ubiquitous in most mammalian calcified tissues such as bone and dentine, which are hierarchically organized by collagen fibrils and hydroxyapatite (HAp) crystallites giving these tissues unique hierarchical architectures and specialized functions. Therefore, many efforts have concentrated on the thorough understanding of the collagen-medicated biomineralization processes and the biomimetic synthesis of the unique architectures for applications such as bone-defect repair and regeneration. In our studies, we synthesized mineralized collagen fibrils via molecular self-assembly biomimetic mineralization. The biomimetic mineralized collagen fibrils are an organic/inorganic hybrid material resembled the self-assembly of *in vivo* nanocomposites from nanoscale to micrometer scale, which has been applied for the fabrication of biomimetic bone grafting materials showing great promise and success in clinical applications. Beyond that, a centimeter-size artificial lamellar bone is successfully fabricated for the first time *via* a well-orchestrated "multiscale cascade regulation" strategy combining multiple techniques of molecular self-assembly, electrospinning, and pressure-driven fusion from molecular to macroscopic levels. The bulk artificial lamellar bone that is composed of hierarchically assembled mineralized collagen fibrils with a waiver of any synthetic polymer highly resembles the chemical composition, multiscale structural organization and rotated plywood-like structure of natural lamellae, thus achieving a good combination of lightweight and high-stiffness, -strength, and -toughness.

Bio

Prof. Xiumei Wang is currently a professor at the school of Materials Science and Engineering, Tsinghua University. She obtained her Ph.D. degree in Materials Science and Engineering at Tsinghua University, China, in 2005, and continued her postdoctoral fellow at the University of Rochester and Massachusetts Institute of Technology, MA, USA from 2005 to 2008. She started her professional career in Tsinghua University from 2008. Her researches mainly focus on: 1) Engineering biomaterials to direct the stem cells fate; 2) Designing bioactive hydrogels to promote typical tissue regeneration; 3) Biomimetic bone substitutes for bone regeneration and clinical translation. She published over 170 SCI papers, filed 19 patents, several books and book chapters. She is the executive member of the Chinese Society for Biomaterials and served the co-Editor-in-Chief of Tissue Engineering Part C-Method and the editorial member of Frontier of Materials Science, Regenerative Biomaterials, Biomaterials Research. She was honored "the State Natural Science Award 2011" by the State Council of the P.R. China, Science and Technology Award of Beijing, Science and Technology Award of Shandong Province, Chinese

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