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978-1-107-41327-6 - Materials Research Society Symposium Proceedings: Volume 599:
Mineralization in Natural and Synthetic Biomaterials

Editors: Panjian Li, Paul Calvert, Tadashi Kokubo, Robert Levy and Cheryl Scheid
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**MATERIALS RESEARCH SOCIETY
SYMPOSIUM PROCEEDINGS VOLUME 599**

Mineralization in Natural and Synthetic Biomaterials

Symposium held November 29–December 1, 1999, Boston, Massachusetts, U.S.A.

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Materials Research Society

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Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press

32 Avenue of the Americas, New York NY 10013-2473, USA

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9781107413276

Materials Research Society

506 Keystone Drive, Warrendale, PA 15086

<http://www.mrs.org>

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First published 2000

First paperback edition 2013

Single article reprints from this publication are available through
University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, MI 48106

CODEN: MRSPDH

ISBN 978-1-107-41327-6 Paperback

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PREFACE

The papers in this volume represent the proceedings of Symposium DD, "Mineralization in Natural and Synthetic Biomaterials," held November 29–December 1 at the 1999 MRS Fall Meeting in Boston, Massachusetts. This symposium was devoted to addressing the principles of mineral formation in biological organisms, and the application of these principles to the synthesis of materials for medical implants and electronic devices. Seventy-six papers were presented in the symposium, all demonstrating the latest progress in the study of mineralization in biomaterials achieved by scientists in many different fields including materials science, chemistry, biology, engineering, and medicine.

The mineral present in human bone is nanocrystalline Ca-deficient apatite containing both stable and labile HPO_4^{2-} , CO_3^{2-} and PO_4^{3-} components. Owing to its resemblance to bone mineral, hydroxyapatite (HA) ceramic has been shown to be capable of both conducting bone formation and bonding to bone. Because of these biological properties, HA ceramic has been used as a bone substitute to repair bone defects, or as a coating applied on orthopaedic and dental implants to ensure better fixation of these implants in bone. The plasma-spraying technique is the most commonly used process today for producing HA coatings. The drawbacks of the plasma-spraying process include: (1) it cannot be effectively used to add HA coating to certain areas, such as undercut surfaces; (2) the HA coating formed by the plasma-spraying process is not always uniform in terms of composition and structure; and, therefore, (3) it is extremely difficult to define the plasma-sprayed HA coatings. These undesirable elements of the plasma-sprayed HA coating have prevented its acceptance by the global orthopaedic surgeon community. Simulating the formation of bone apatite in the body, the biomimetic approach for producing HA coating has recently drawn tremendous interest as a promising alternative to the plasma-spraying process. This is because using a biomimetic method allows the formation of a uniform and pure apatite coating on all surfaces exposed to an aqueous solution. Additionally, the body-temperature biomimetic process even enables biological molecules to be included in the coating as it forms. Moreover, the apatite coating produced with biomimeticism could be much more similar to bone apatite in composition and structure than the plasma-sprayed HA.

Depending on their composition and structures, materials may form apatite in the body as a result of their interaction with physiological solution. This formation of apatite can lead to the bonding of the implanted materials to bone and is thus highly desirable and beneficial to dental and joint implants. In other applications, however, the mineral formation could be disastrous. For instance, mineralization has been identified as a major cause of the failure of cardiac prostheses, and millions of people in the world have suffered from the formation of kidney stones.

Mineralization is the process by which minerals form in aqueous solutions. The control of mineral nucleation and growth is a key issue to many scientists no matter the objectives of their studies. The remarkable structures of bone, teeth and shells indicate that the mineralization process is well-controlled in biological systems. Not surprisingly, knowledge of biomineralization is significantly impacting the synthesis of biomaterials and thin films, the design of prostheses and other devices, and the treatment of diseases. An understanding of mineral formation and mineral-protein interaction in biological and non-biological systems provides benefits not only to those who want to add minerals to their products but also to those who wish to prevent mineral formation. It is our hope that this symposium and the resulting proceedings can stimulate the creation of new ideas, processes and collaboration which will eventually lead to materials and products of better performance.

It would have been impossible to organize such a symposium without generous contributions from the Whitaker Foundation, DePuy Inc., Baxter Healthcare Corporation, IsoTis B.V.,

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Kyocera Corporation and Stryker Howmedica Osteonics. We would also like to express our gratitude to our invited speakers, session chairs and the MRS staff for their support.

Panjian Li
Paul Calvert
Tadashi Kokubo
Robert Levy
Cheryl Scheid

February 2000

Cambridge University Press

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