

# Two Novel Calcium Phosphate Precipitation Techniques

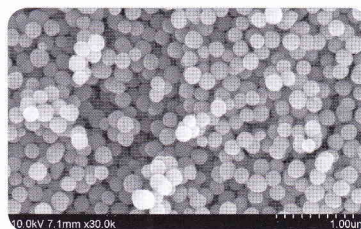
## New Approaches in Biomaterials

BY A. CUNEYT TAS, PHD, FORMER PROFESSOR OF BIOMEDICAL ENGINEERING AT YEDITEPE UNIVERSITY, ISTANBUL, CURRENT VISITING SCIENTIST AT THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING OF THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Society For Biomaterials (SFB) member Dr. Tas recently reported the novel use of two biomineralization solutions to separately synthesize monodisperse nanospheres of X-ray-amorphous calcium phosphate (ACP) and an apatite-like calcium phosphate with an extraordinary BET surface area of 900 m<sup>2</sup>/g. The first biomineralization medium was a completely inorganic solution with ion concentrations mimicking those of the DMEM cell culture solutions, named as BM-7<sup>1</sup> or DMEM-i.<sup>2</sup> The second biomineralization medium, depicted in the below table for preparing 1 L in deionized water, was a Tris-buffered synthetic body fluid (SBF) solution with a HCO<sub>3</sub> concentration of 27 mM (identical in value to that of the human blood plasma) and 125 mM Cl<sup>-</sup> concentration.<sup>3,4</sup>

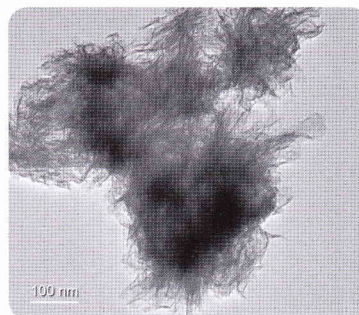
Chemical (g/L)	DMEM-i <sup>2</sup>	SBF <sup>3</sup>
NaCl	4.787	6.547
KCl	0.397	0.373
MgCl <sub>2</sub> ·6H <sub>2</sub> O	0.166	0.305
CaCl <sub>2</sub> ·2H <sub>2</sub> O	0.332	0.368
NaHCO <sub>3</sub>	3.701	2.268
NaH <sub>2</sub> PO <sub>4</sub> ·H <sub>2</sub> O	0.125	—
Na <sub>2</sub> HPO <sub>4</sub> ·2H <sub>2</sub> O	—	0.178
Na <sub>2</sub> SO <sub>4</sub>	—	0.071
(CH <sub>2</sub> OH) <sub>3</sub> CNH <sub>2</sub>	—	6.057

*Amorphous nanosphere synthesis:* DMEM-i solution was simply stirred and heated at 65°C for 1 hour. Autogenously forming ACP nanospheres were separated from the solution by membrane filtration, followed by drying at 37°C.<sup>2</sup> Although numerous methods are known to produce irregular-shaped ACP particles, this approach led to the synthesis of monodisperse nanospheres (175 nm diameter, 185 m<sup>2</sup>/g BET surface area) for the first time (Figure 1). ACP nanospheres may serve as biocompatible drug or biomolecule carriers in a number of oncological or pharmaceutical applications. The simplicity of ACP synthesis<sup>2,5</sup> is promising.



**Figure 1.** (FE-SEM): ACP nanospheres synthesized in DMEM-i.<sup>2</sup>

*Apatitic CaP synthesis:* The Tris-buffered synthetic body fluid (SBF) solution with a HCO<sub>3</sub> concentration of 27 mM, when refrigerated at +4°C in sealed glass bottles (non-agitated) over periods from 1 to 4 months, autogenously formed hydrated, carbonated apatitic calcium phosphate precipitates, which were found (upon lyophilization) to possess BET surface areas in the vicinity of 900 m<sup>2</sup>/g, regardless of the aging time (Figure 2).<sup>3</sup> Such high surface area biocompatible calcium phosphates may be useful in drug delivery and in orthopedic/maxillofacial bone tissue regeneration applications.



**Figure 2.** Transmission electron micrograph (TEM) of hydrated, carbonated apatitic CaP with a surface area of 900 m<sup>2</sup>/g.<sup>3</sup>

### REFERENCES

1. Temizel N, Giriskan G, Tas AC. Accelerated transformation of brushite to octacalcium phosphate in new biomineralization media between 36.5°C and 80°C. *Materials Science and Engineering C: Materials for Biological Applications*. 2011;31:1136-1143.
2. Tas AC. X-ray-amorphous calcium phosphate (ACP) synthesis in a simple biomineralization medium. *Journal of Materials Chemistry B*. 2013;1:4511-4520.
3. Tas AC. Grade-1 titanium soaked in a DMEM solution at 37°C. *Materials Science and Engineering C: Materials for Biological Applications* 2014;36:84-94.
4. Tas AC. Synthesis of biomimetic Ca-hydroxyapatite powders at 37°C in synthetic body fluids. *Biomaterials*. 2001;21:1429-1438.
5. Tas AC. Submicron spheres of amorphous calcium phosphate forming in a stirred SBF solution at 55°C. *Journal of Non-Crystalline Solids*. 2014;400:27-32.

# BIOMATERIALS FORUM!

OFFICIAL NEWSLETTER OF THE SOCIETY FOR BIOMATERIALS

Fourth Quarter 2014 • Volume 39, Issue 4



URBANA IL 61801-2920

1304 W GREEN ST

DEPT. OF MATERIALS SCIENCE & ENGINEERING

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

A. CUNNEY TAS, PHD

\*\*\*\*\*AUTO\*\*3-DIGIT 618

Permit No. 64

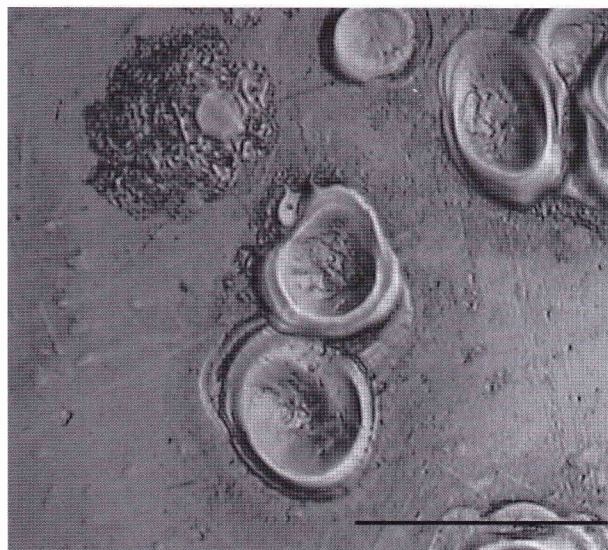
Bellmawr NJ

**paid**

US Postage

Standard

# Contents



## The Torch

- 2 From the Editor
- 3 From the President
- 8 Staff Update

## News & Updates

- 5 History  
*The Foundation for Society For Biomaterials*
- 6 Opinion  
*The Tenth Question*
- 10 Member News
- 12 Historical Flashback  
*Selective Luck Led One to Become a Pioneer in the Field of Biomaterials*
- 13 New Approaches in Biomaterials  
*Two Novel Calcium Phosphate Precipitation Techniques* ←
- 14 *Antioxidant Biomaterials Promote Healing By Combating Oxidative Damage*
- 16 SIG News  
*Biofunctional Relevance of Synthetic Mucin Mimics Formed by Affinity-Driven Filamentous Nanostructures*
- 19 *News from the Surface Characterization & Modification SIG*
- 20 *News From The Biomaterials & Medical Product Commercialization (BMPC) SIG*
- 21 Student Chapter Update  
*Professional Development Opportunities for Students*
- 22 Government News
- 22 New Journal of Interest
- 23 Industrial News
- 25 Education News  
*STEM Education and the Numbers Behind the Hype*
- 27 Book Review: No Time to Die
- 29 Coming Up in 2015

**On the cover:** Digital optical micrograph of inflammatory cell induced corrosion attack of a CoCrMo metal-on-metal total hip replacement acetabular component. Inflammatory cells (from the phagocytic mononuclear cell line, e.g., osteoclasts, neutrophils, macrophages, and foreign body giant cells) have been demonstrated to attach to and directly corrode CoCrMo alloy implant surfaces in-vivo. These cells all generate oxidative burst-like reactions generating reactive oxygen species, and utilize Fenton reactions that can directly corrode CoCrMo alloys in vivo. Scale bar = 50  $\mu$ m. Photo courtesy of Professor Jeremy Gilbert, Syracuse University.