

Functionalizing surfaces through EPD of HA/Y₂O₃ coatings



colloidal processing

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INTRODUCTION

It was shown that the incorporation of Y₂O₃ as dispersed second phase to hydroxyapatite (HA) influences the sintering behavior producing favorable effects in view of improving the processing of HA materials for implantable devices [ref].

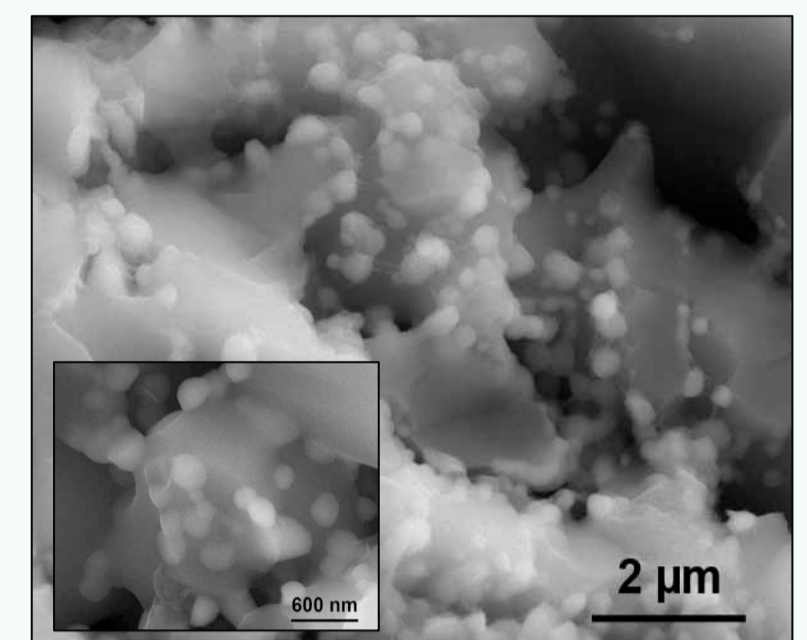
Particularly, comparison of a highly dispersed 10 wt.% Y₂O₃ – synthetic HA composite with the matrix material revealed that the presence of yttria:

§ delays the grain boundary migration maintaining the open porous structure

§ delays the mechanisms of HA decomposition to calcium phosphates

§ favors the presence of OH⁻ vacancies useful for the conductive properties of HA

This would permit to set higher sintering temperatures favoring densification and to control the decomposition mechanisms to make HA materials with designed porosity having both structural and functional properties.



SEM-SE micrographs of the fracture surface of a high dispersed Y₂O₃ –HA composite

OBJECTIVES

- Preparation of well-dispersed Y₂O₃ - HA composite by aqueous colloidal processing
- Electrophoretic Deposition of Y₂O₃ - HA suspensions on steel substrates
- Production of tailored functional coated surfaces

STARTING MATERIALS

HA

Commercial Ca₁₀(PO₄)₆OH₂
(Ca : P ratio 1.67 : 1) from Plasma-Biotal
True density ~ 3.11 g/cm³
Specific Surface Area ~ 1.08 m²/g BET
d_{BET} ~ 1.8 μm

Y₂O₃

Y₂O₃ 99.995% TREO from OVERACK
True density ~ 4.7 g/cm³
Specific Surface Area ~ 13 m²/g BET

DISPERSANT

Polyacrylic Acid (PAA)
ACROS Organics

BINDER

Carboxymethyl cellulose (CMC)

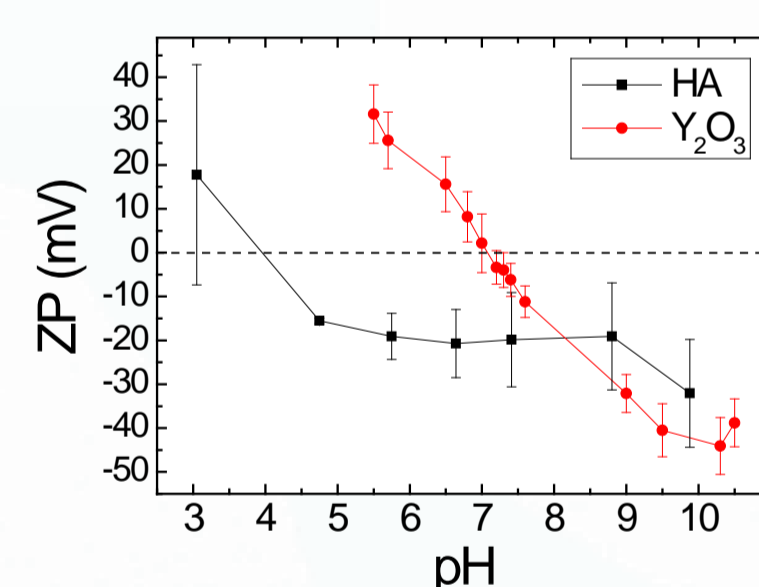
SUBSTRATE

Stainless Steel 304

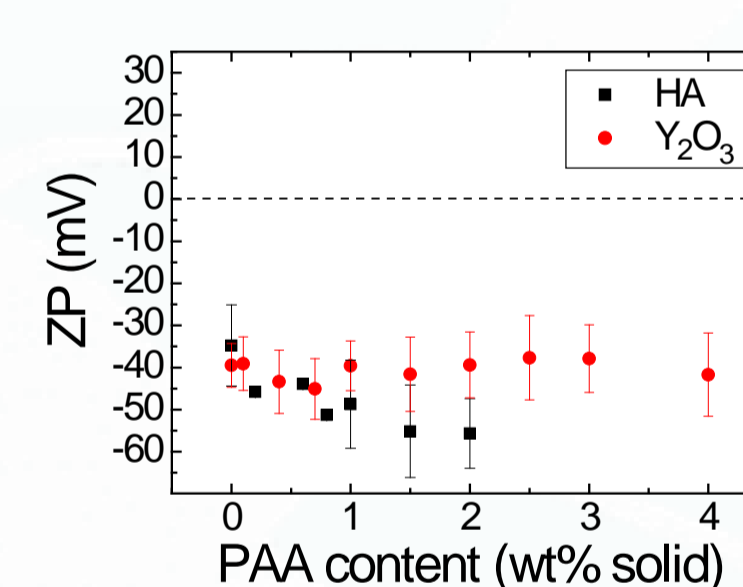
PROCESSING CONDITIONS

- § solid content: 30 vol.% (??? wt%) in distilled H₂O
- § HA content: 93.16 vol.% solid (90 wt% solid)
- § Y₂O₃ content: 6.84 vol.% solid (10 wt% solid)
- § PAA content: 4 wt% Y₂O₃ + 1 wt% HA
- § ball milling: 4 hours
- § pH = 10 for the stabilization of the suspension

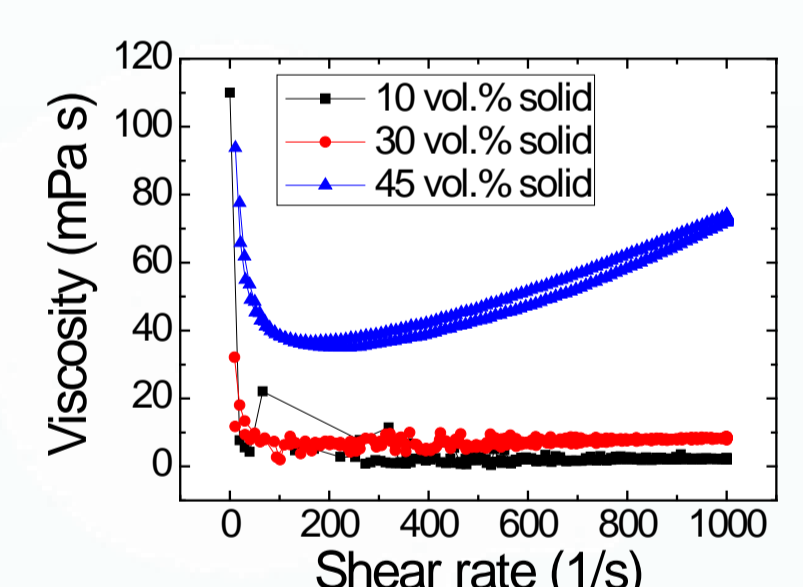
Zeta Potential of HA and Y₂O₃ powders vs pH (sin PAA)



Zeta Potential of HA and Y₂O₃ powders vs PAA concentration (pH =10)

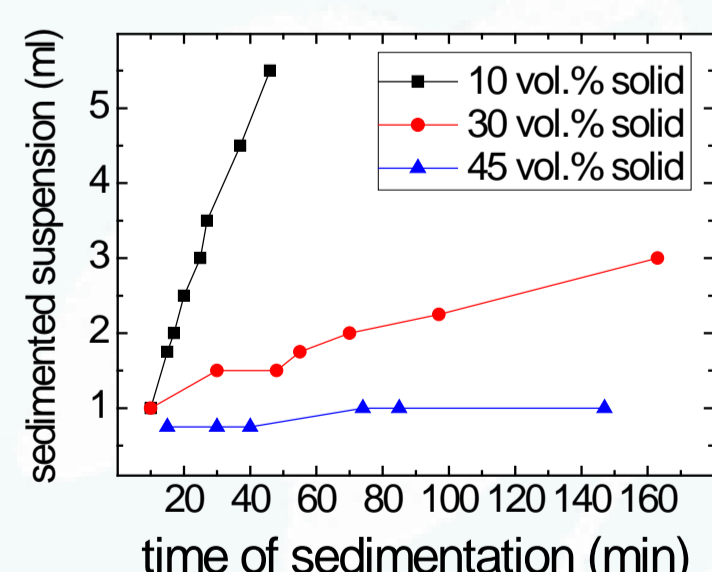


Flow curves



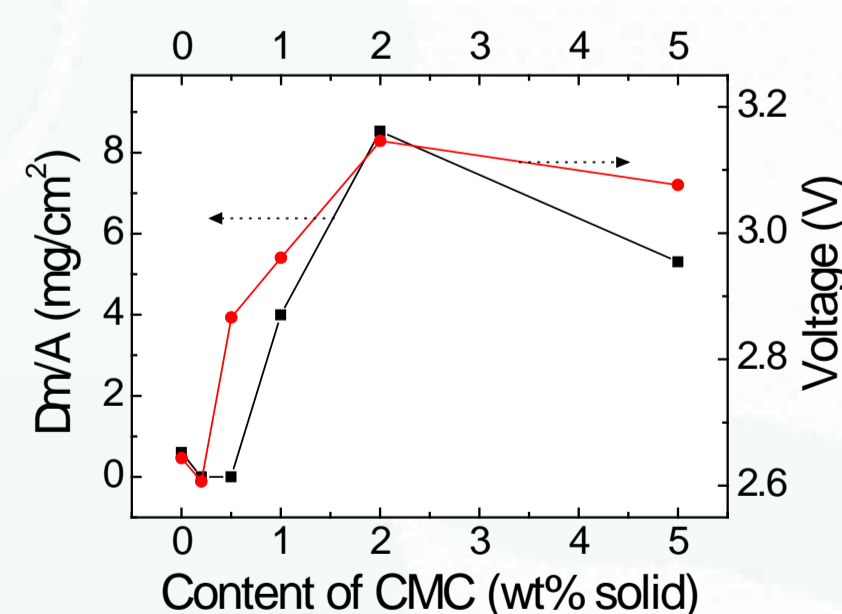
EPD PROCESSING

Sedimentation test in a graduated cylinder



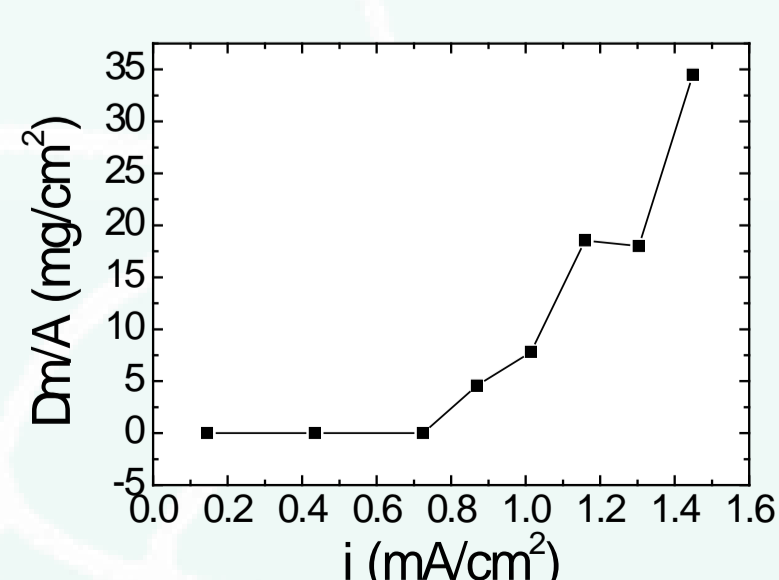
Variation of mass per unit area and Starting voltage vs CMC content

EPD time: 10 min, current intensity: 1 mA/cm²



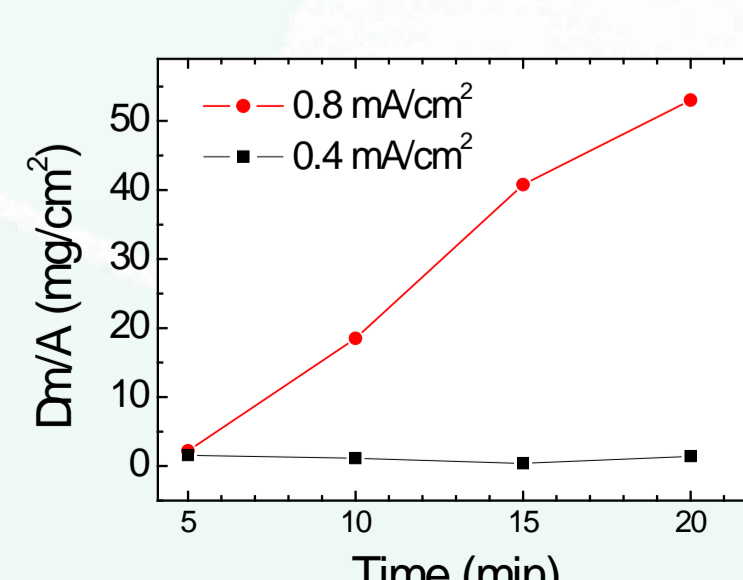
Variation of mass per unit area vs current density

EPD time: 5 min, 2 wt.% solid CMC



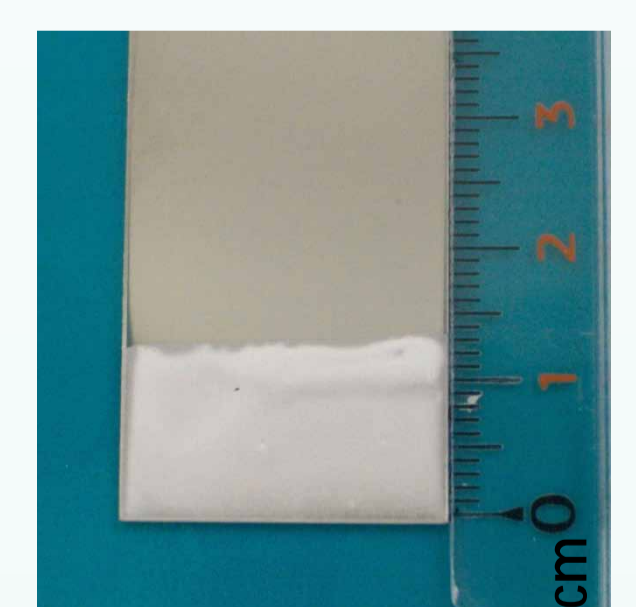
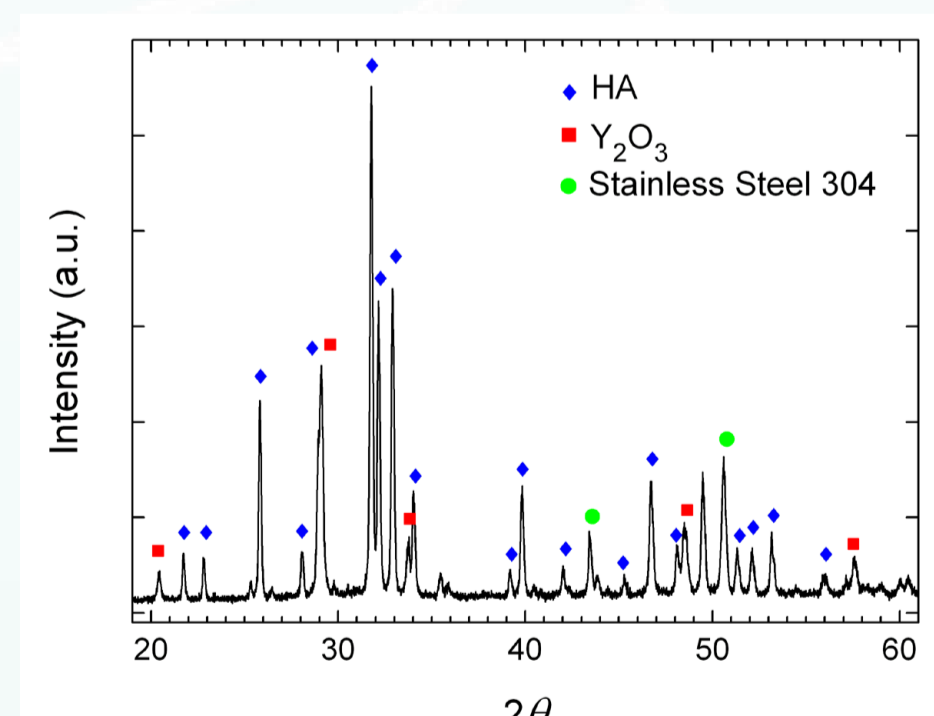
Variation of mass per unit area vs time

EPD time: 5 min, I: 6 mA, 2 wt.% solid CMC



RESULTS

XRD spectrum of the coating



CONCLUSIONS

- § Stainless steel surfaces were coated of HA - Y₂O₃ particles homogeneously dispersed in aqueous suspensions by EPD
- § Uniform HA - Y₂O₃ layers were obtained optimizing the EPD processing conditions