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Evaluation of antibacterial activity and cell viability of silver-copper and silver-zinc co-doped beta-tricalcium phosphate (β-TCP) by spray pyrolysis

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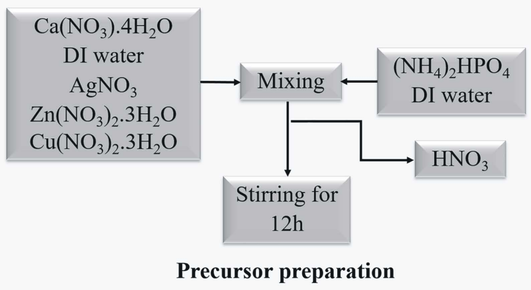
Abstract

Beta-Tricalcium phosphate (β-TCP) particles are popular in the applications of medical science and material due to the significantly simulates the mineralogical structure of natural bones. However, βTCP lacks of antibacterial activity. In order to overcome this problem doping β-TCP with silver, zinc and copper are proposed. In this context, incorporation silver-zinc and silver-copper co-doped β-TCP was carried out using spray pyrolysis (SP) method. The results indicated that 5.75 mol% AgZn co-doped β-TCP (contain 2.87 mol% Ag and 2.87 mol% Zn) were better antibacterial activity and cell viability than those 5.75 mol% Ag-doped β-TCP and 5.75 mol% AgCu co-doped β-TCP (contain 2.87 mol% Ag and 2.87 mol% Cu). The antibacterial activity and cell viability mechanism of Ag-, AgCu- and AgZn co-doped β-TCP are also discussed.

Research Focus

Experimental procedure



Precursor preparation

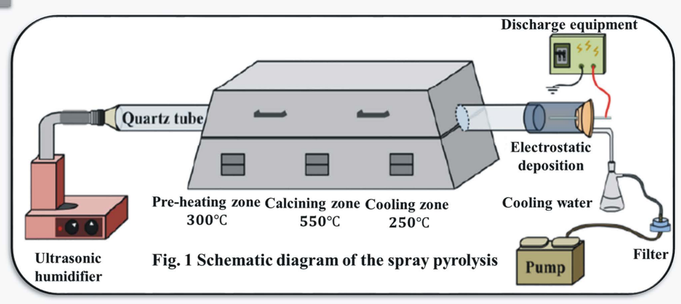


Fig. 1 Schematic diagram of the spray pyrolysis

XRD

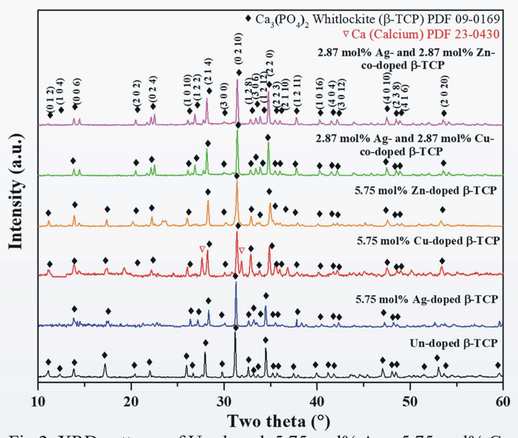


Fig 2. XRD patterns of Un-doped, 5.75 mol% Ag-, 5.75 mol% Cu-, 5.75 mol% Zn-, 2.87 mol% Ag/and 2.87 mol% Cu and 2.87 mol% Ag/ 2.87 mol% Zn co-doped β-TCP powders

TEM

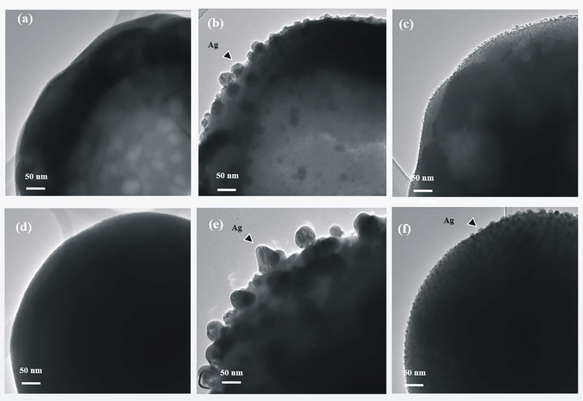


Fig 3. TEM images of (a) Un-doped, (b) 5.75 mol% Ag-, (c) 5.75 mol% Cu-, (d) 5.75 mol% Zn-, (e) 2.87 mol% Ag/2.87 mol% Cu and (f) 2.87 mol% Ag/2.87 mol% Zn co-doped β-TCP powders

SEM

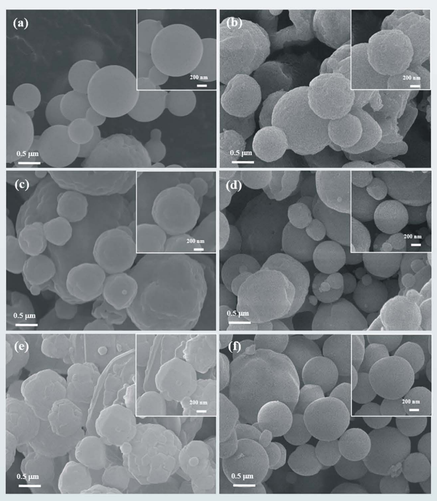


Fig 4. SEM images of (a) Un-doped, (b) 5.75 mol% Ag-, (c) 5.75 mol% Cu- (d) 5.75 mol% Zn-, (e) 2.87 mol% Ag/2.87 mol% Cu and (f) 2.87 mol% Ag/ 2.87 mol% Zn co-doped β-TCP powders

EDS

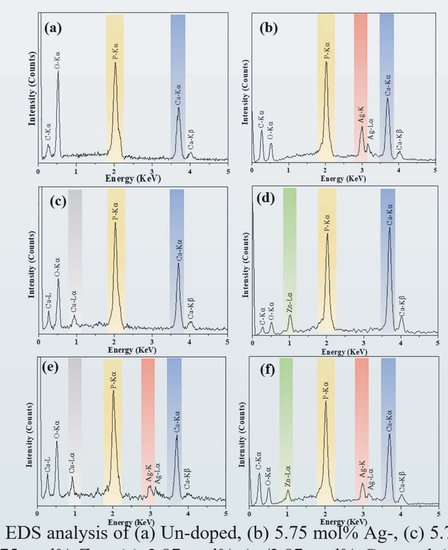


Fig 5. EDS analysis of (a) Un-doped, (b) 5.75 mol% Ag-, (c) 5.75 mol% Cu-, (d) 5.75 mol% Zn-, (e) 2.87 mol% Ag/2.87 mol% Cu-, and (f) 2.87 mol% Ag/2.87 mol% Zn co-doped β-TCP powders

Antibacterial activity

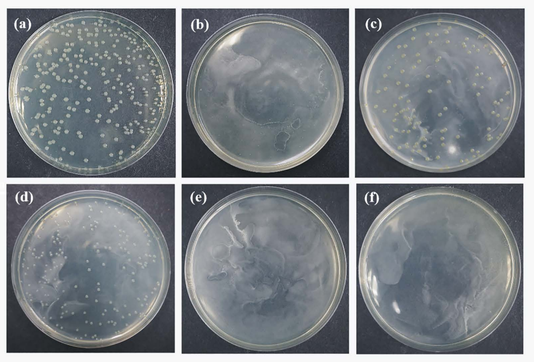


Fig 6. Photographs of antibacterial test result of (a) Un-doped, (b) 5.75 mol% Ag-, (c) 5.75 mol% Cu-, (d) 5.75 mol% Zn-, (e) 2.87 mol% Ag/2.87 mol% Cu, and (f) 2.87 mol% Ag/2.87 mol% Zn co-doped β-TCP powders against *E. Coli* bacteria

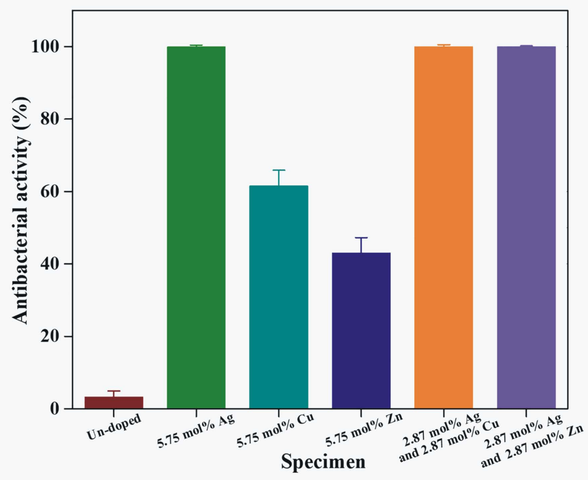


Fig 7. Antibacterial activities of Un-doped, 5.75 mol% Ag-, 5.75 mol% Cu, 5.75 mol% Zn-, 2.87 mol% Ag/2.87 mol% Cu and 2.87 mol% Ag/2.87 mol% Zn co-doped β-TCP powders against *E. Coli* bacteria

Cell viability

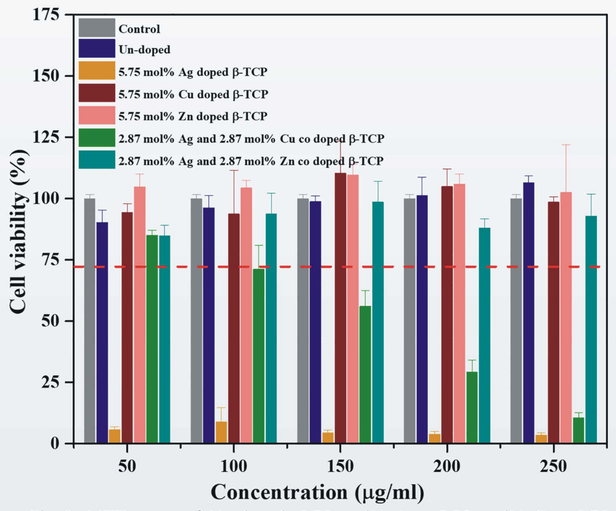


Fig 8. MTT assay of Un-doped, 5.75 mol% Ag-, 5.75 mol% Cu-, 5.75 mol% Zn-, 2.87 mol% Ag/2.87 mol% Cu and 2.87 mol% Ag/2.87 mol% Zn co-doped β-TCP powders on MC3T3-E1 cell incubated for 3 days.

Discussion

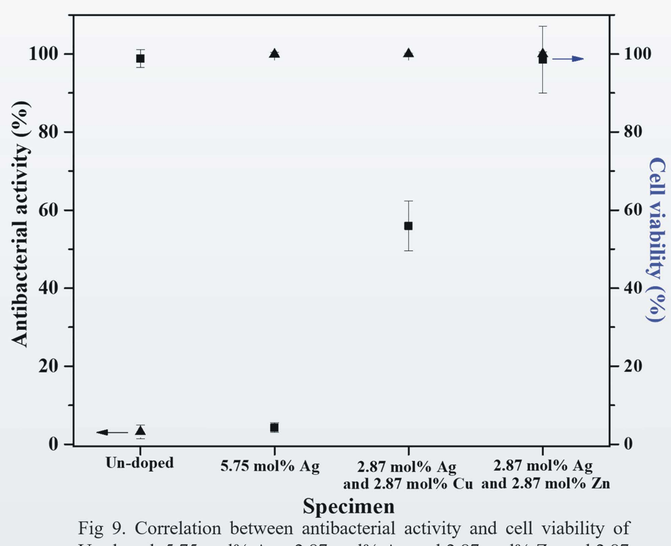


Fig 9. Correlation between antibacterial activity and cell viability of Un-doped, 5.75 mol% Ag-, 2.87 mol% Ag and 2.87 mol% Zn and 2.87 mol% Ag, and 2.87 mol% Cu co-doped β-TCP powders

Summary

1. The characterizations demonstrated that all samples have crystalline and spherical structure.
2. The antibacterial activity and cell viability test show that AgZn co-doped β-TCP has excellent antibacterial effect and non-toxic compared to Ag doped β-TCP and AgCu co-doped β-TCP.

Publication

Y.J. Chou, **H.S. Ningsih**, and S.J. Shih*, Ceramics International 46, 16708-16715 (2020), (IF :3.83)

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