



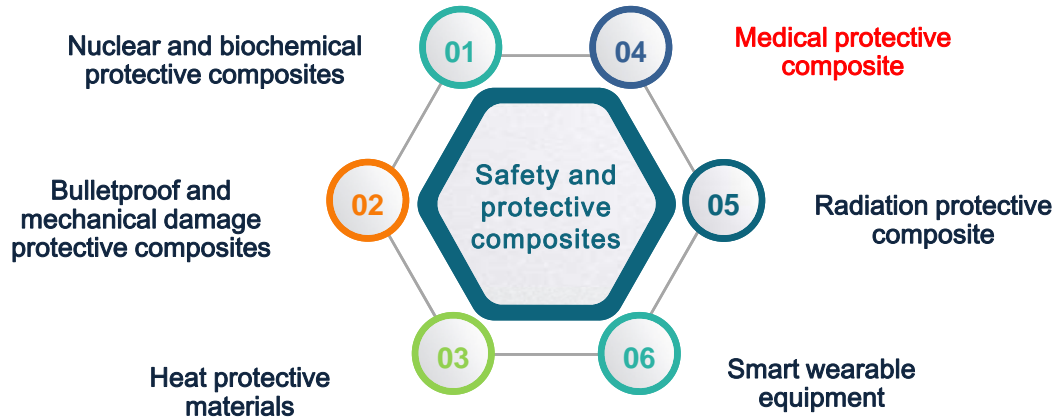
Preparation of PLA/pearl powder composite nanofiber scaffold and research of osteointroductivity

NanTong University China

National & Local Joint Engineering Research Center of Technical Fiber Composites for Safety and Protection



Research direction



Medical protection and health materials

- 1 composite scaffold materials
- 2 Superhydrophobic material
- 3 Medical filtration/dialysis material
- 4 Antibacterial materials
- 5 Medical dressing materials/debride
- 6 Elastic conductive fabric for health monitoring

Research Background

Function

1. Compressive capacity
2. Metabolism of mineral salts

Construction

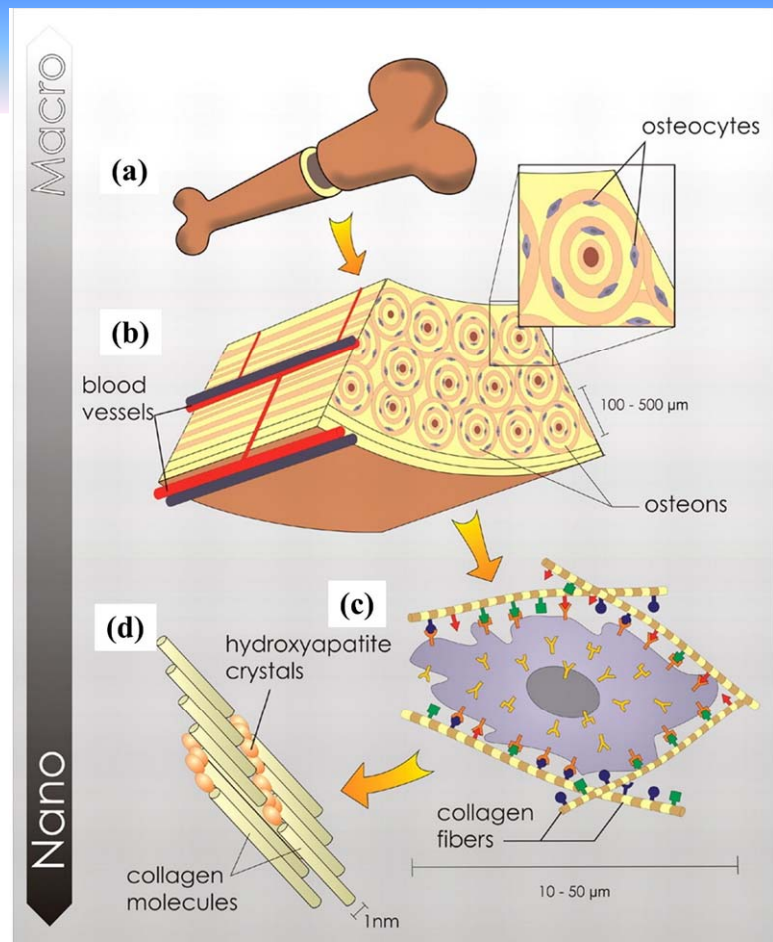
n Periosteum, bone tissue, marrow and cartilage

Composition

1. Organic: 30%, collagen et al
2. Inorganic: 60%, HA et al
3. Water, 10%

Structure

1. Macro: compact bone , cancellous bone
2. Micro: collagen , nano HA



Bone tissue in different scale

Stevens M. M., et al., Science, 2005, 310(5751): 1135-1138.

Research Background

Bone defect

trauma, tumor, disease

Threatening the human



Bone repairing materials

1. Original bone

Limited resource

Causing additional trauma

2. Allogeneic bone

Effect of immune rejection

Spreading of disease

3. Artificial bone

Wild resource

Easy to fabricate

Artificial bone repairing materials

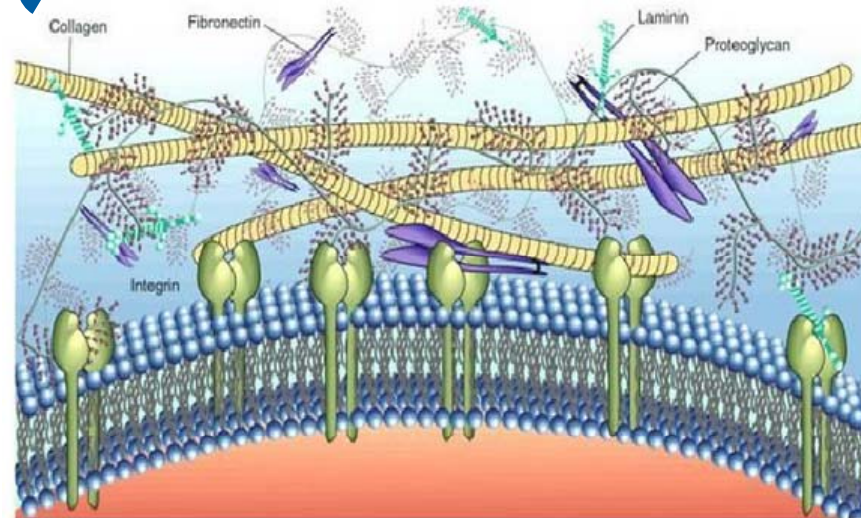
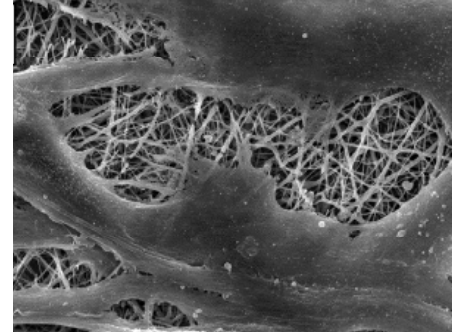
- **Metal** (Ti, Ni, Mg et al)
- **Inorganic non-metal materials**
(bioceramic, HA, carbon-based materials et al)
- **Organic materials** (natural or synthesis polymers)
- **Composite materials**

Research Background

Bone repair nanofibrous scaffold

- For cell
Mimic the extracellular matrix, accelerate cell adhering and proliferation

- For bone structure
Mimic the nanoscale collagen fiber

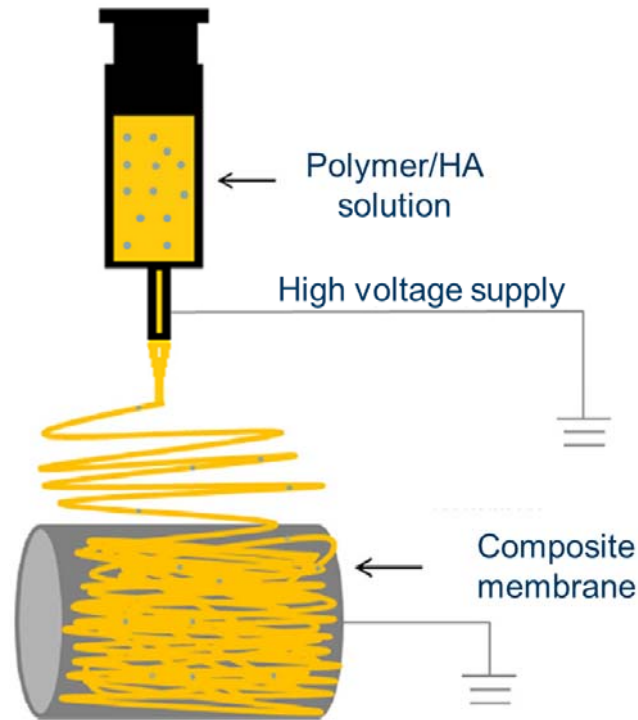


Schematic diagram of ECM

Zhang Y. Z., et al. Biomacromolecules, 2005, 6(5): 2583-2589.

Research Background

Incorporation of bioactive materials including HA and BMP can enhance bone repairing ability.

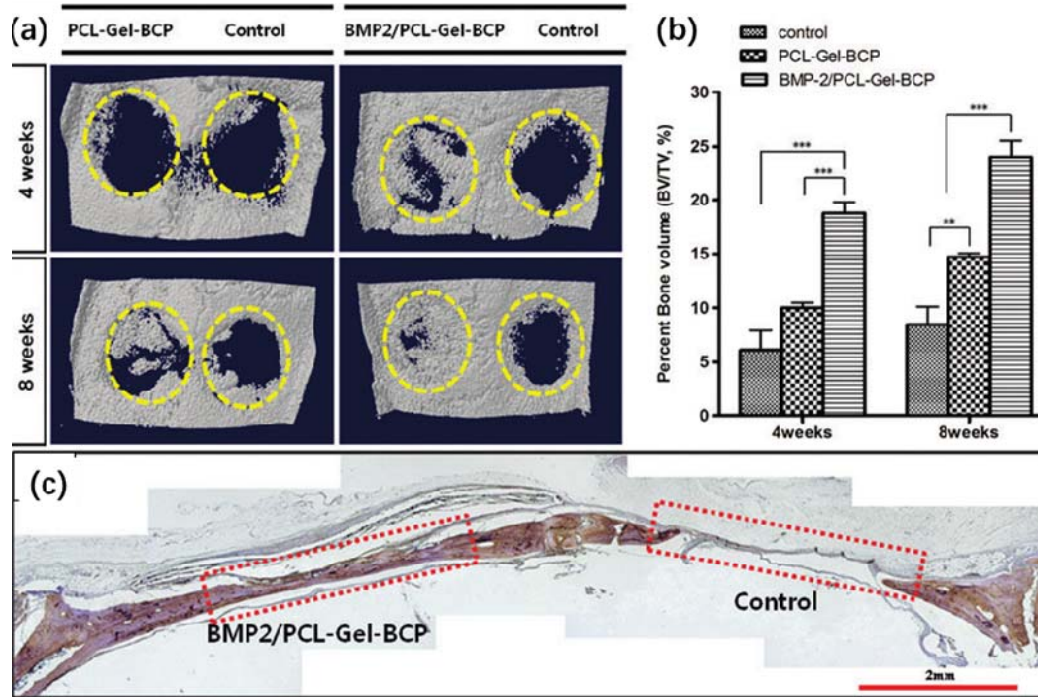


Bone repairing nanofiber scaffold

Pristine polymer nanofibers obtain good biocompatibility, while are weak at bioactivity and osteoconductivity, which limits the application in bone regeneration.

Izabella R., et al. *Materials Science and Engineering: C*, 2012, 32(8): 2583-2589.

Research Background



Bone repairing nanofiber scaffold

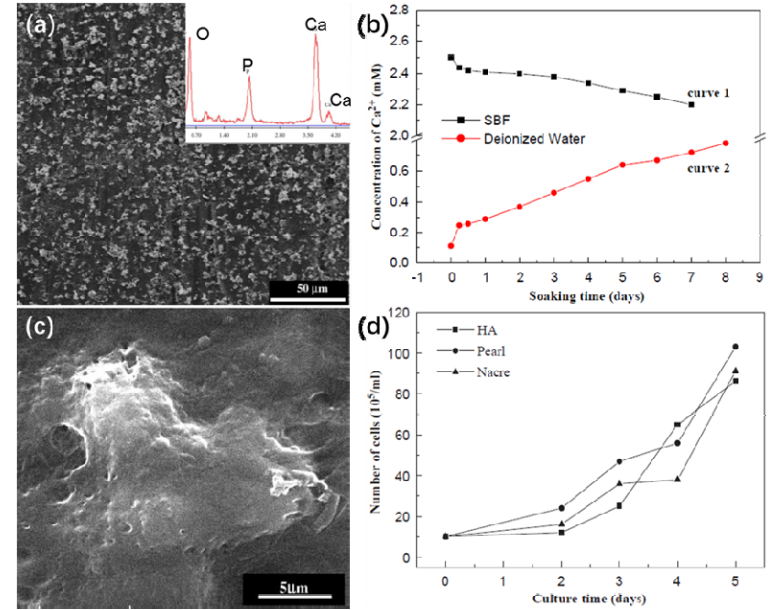
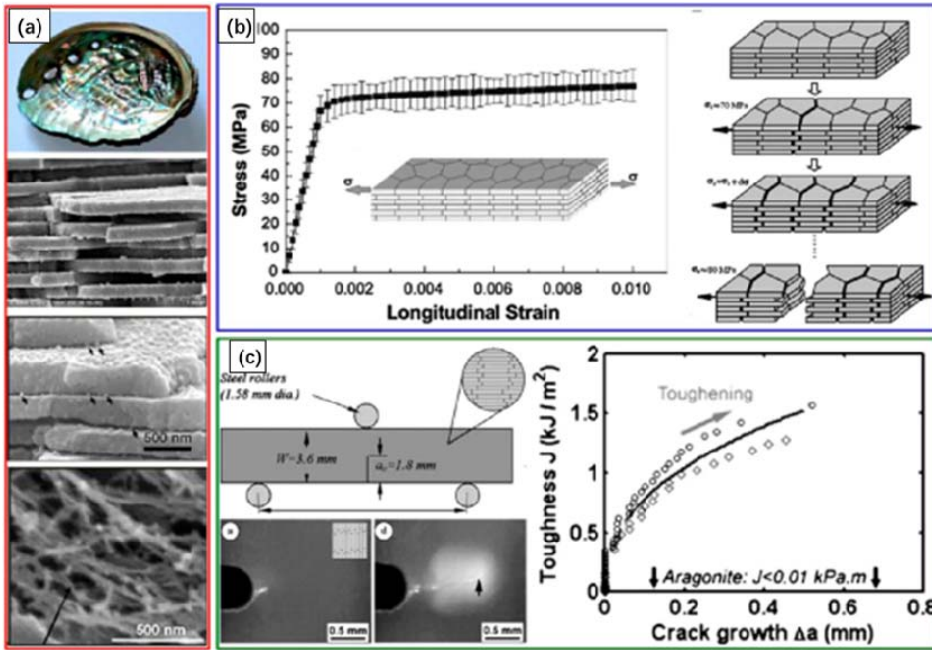
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Kim B. R., et al. Tissue Engineering Part A, 2014, 20(23-24): 3279-3289.

Research Background

Pearl powder

1. Natural composite : CaCO_3 , bone growth factor
2. Biocompatibility
3. Osteoconductivity



(a) SEM morphology and EDS analysis of the particles deposited on the surface of pearl plate after SBF soaking for a week. (b) Variation curves of Ca^{2+} concentrations of SBF and deionized water indicating the dissolution of pearl in deionized water and HA deposition from SBF. (c) osteoblasts on pearl surface proliferate. (d) Developing curves of osteoblasts showing the proliferation trend on the surface of different materials

Surface morphology

Surface morphology of PLA/pearl powder nanofibers

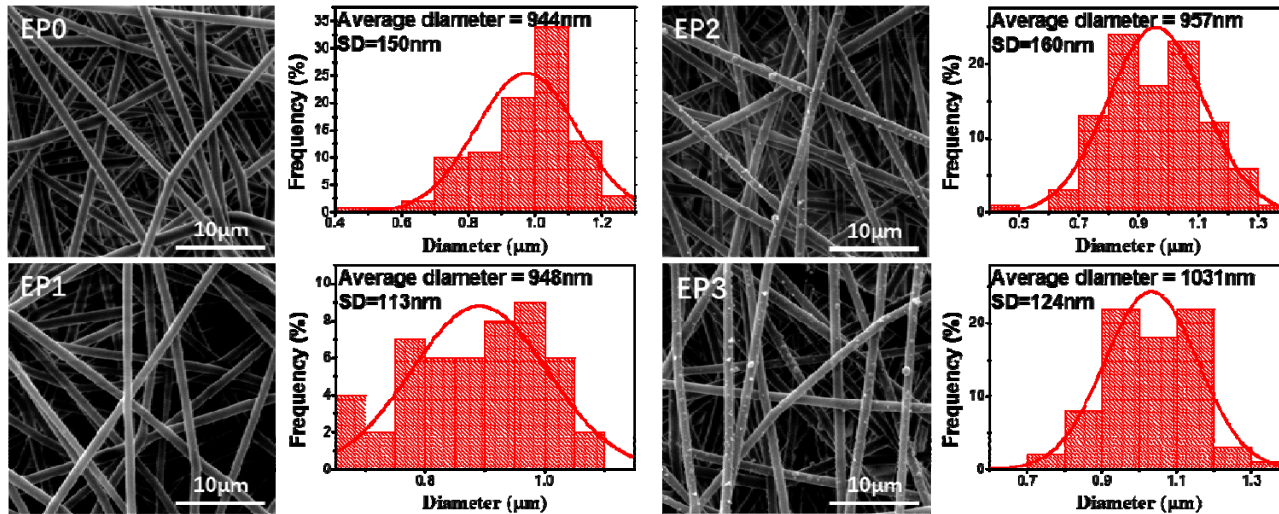


Fig. 1 SEM images and diameter distribution of PLA and PLA/pearl nanofibrous mat.

1. The diameter was slightly increased with pearl powder concentration increasing.
2. Pearl powder can well distributed on the nanofiber surface.

TEM

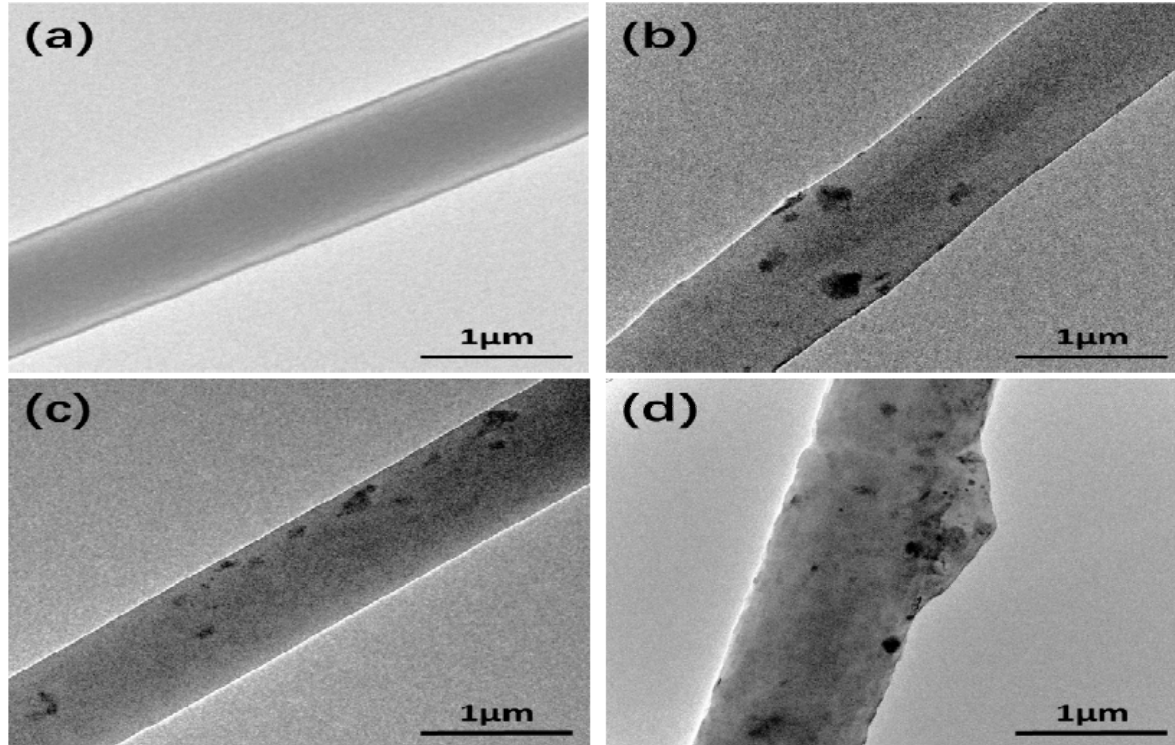


Fig. 2 TEM images of (a) EP0, (b) EP1, (c) EP2 and (d) EP3.

Contact angle

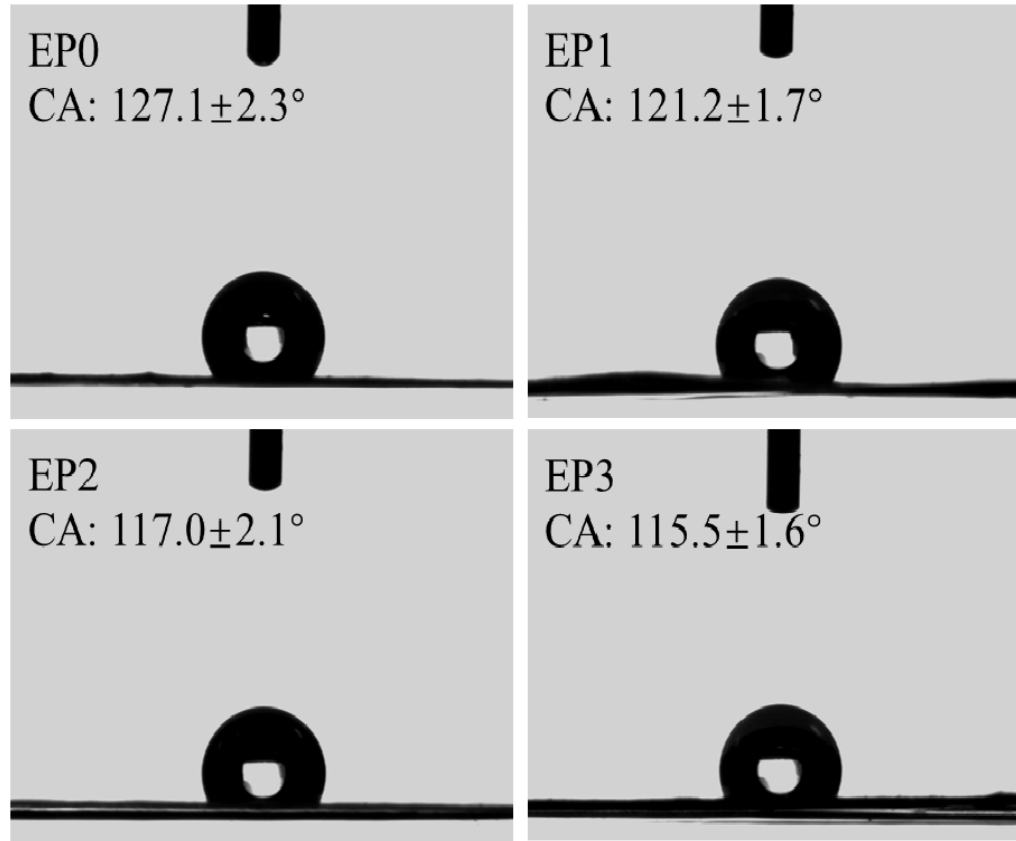


Fig. 3 Water contact angle of PLA and PLA/pearl nanofibrous mats.

Mineralization

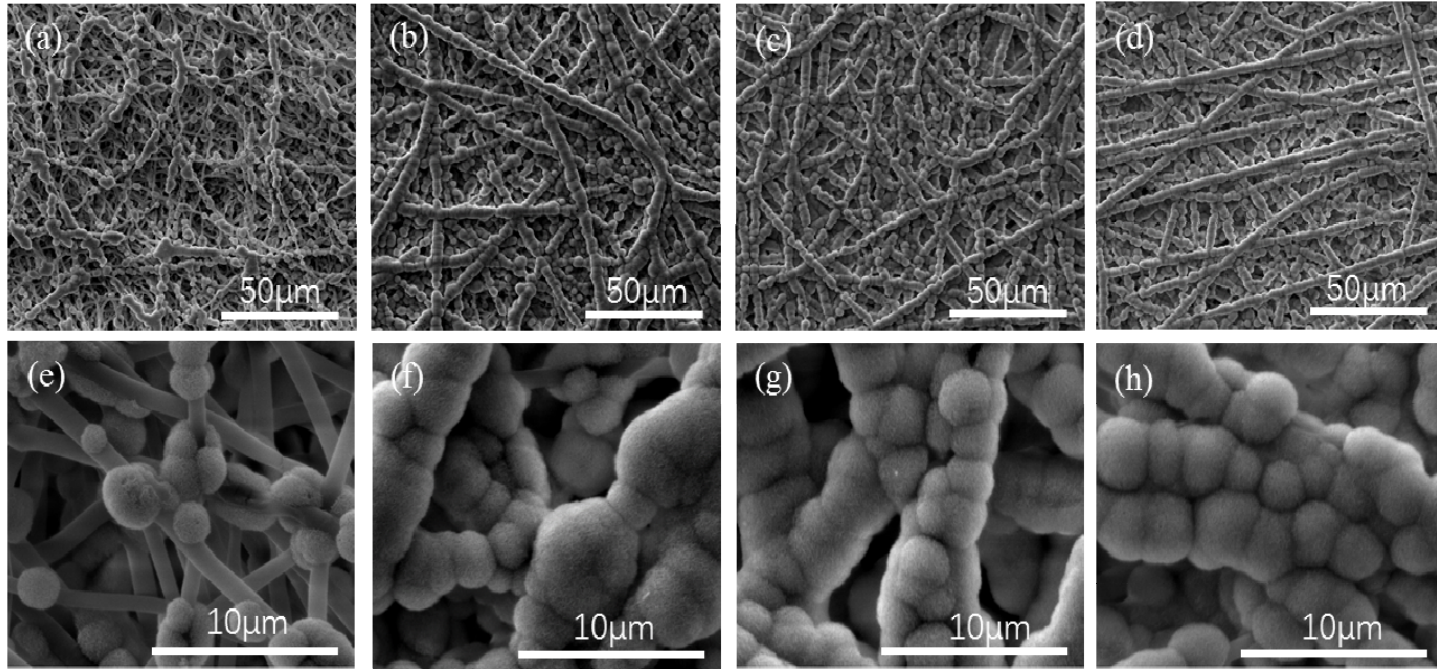


Fig. 4 SEM pictures of mineralized samples for a week: (a) EP0, (b) EP1, (c) EP2 and (d) EP3. (e-h) are high magnification of (a-d).

HA nanoparticles were generated and distributed along the axial direction of nanofibers

FT-IR and XRD

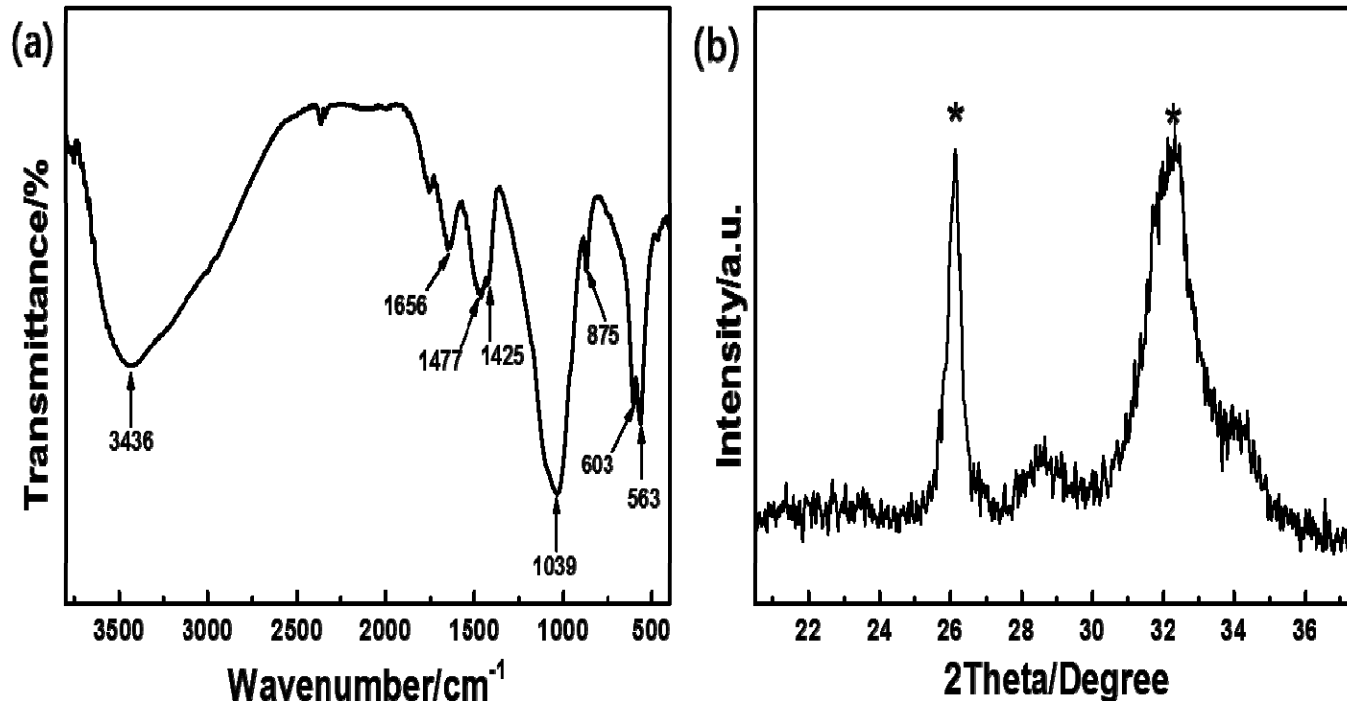
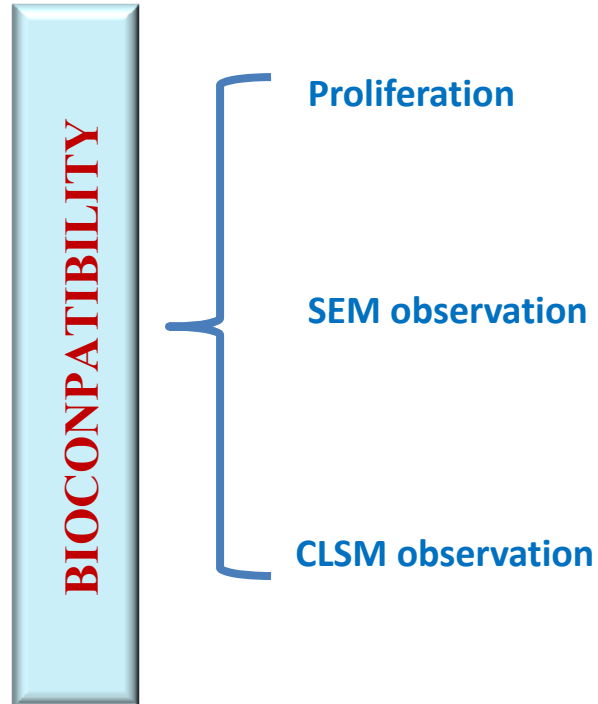
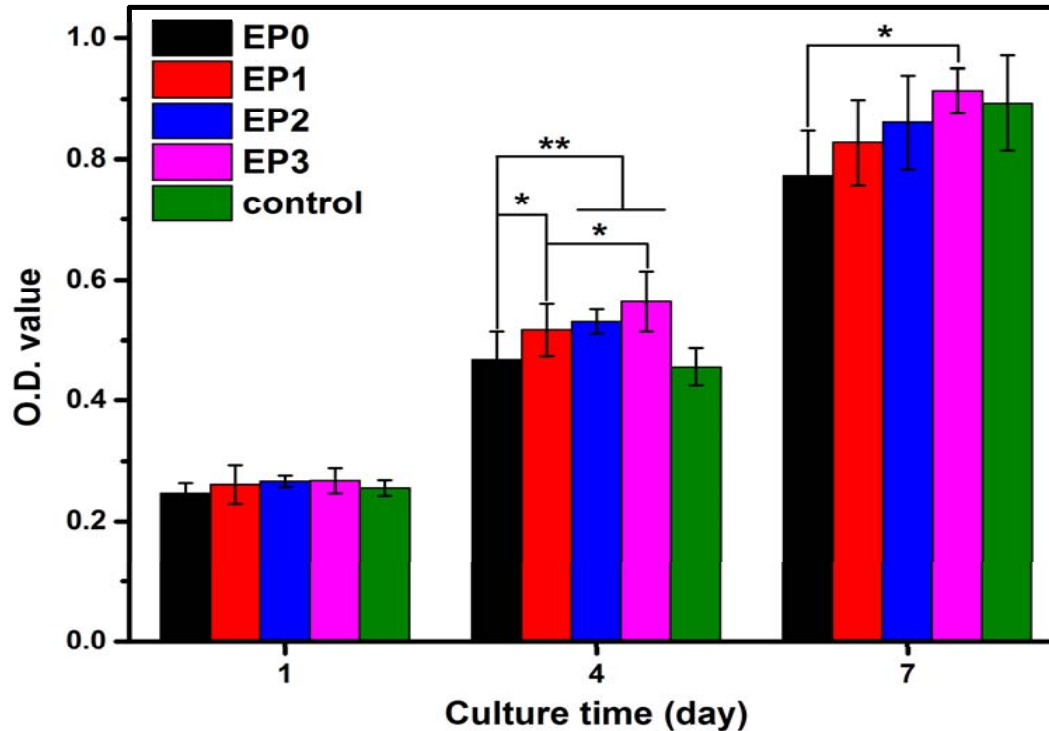


Fig. 5 (a) FT-IR and (b) XRD spectrums of deposited HA particle.

Cytotoxic investigation



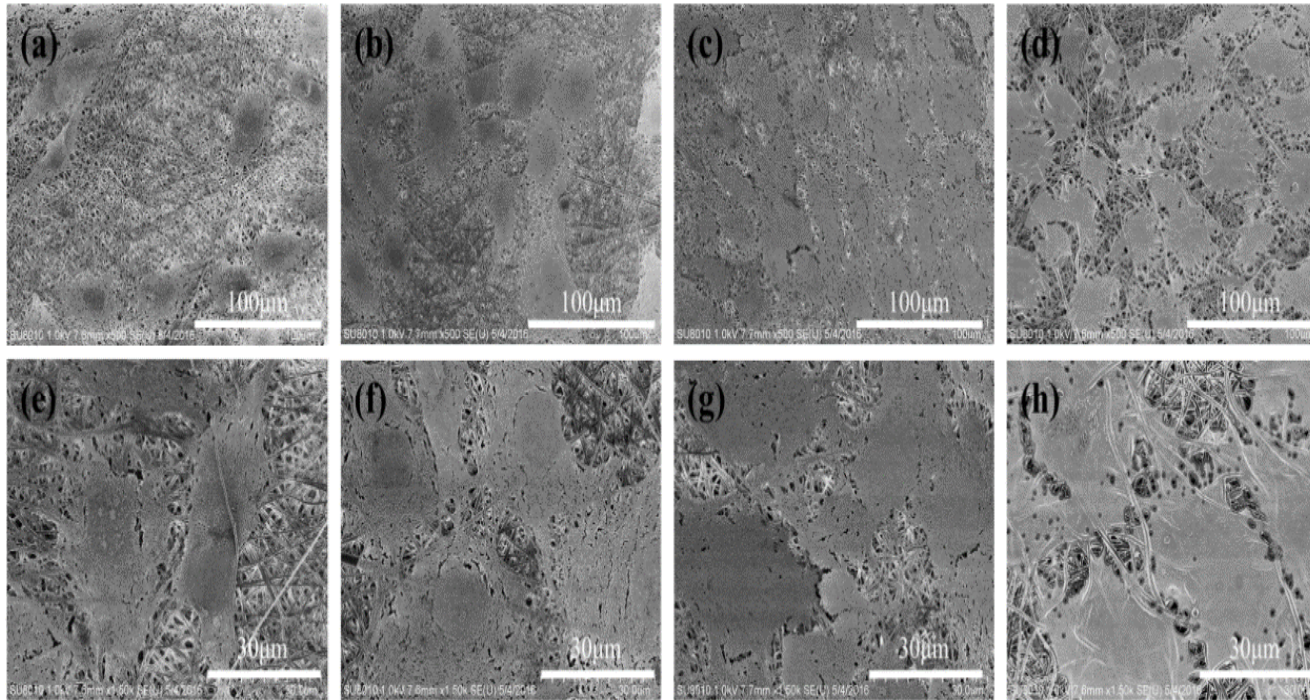
Biocompatibility



The proliferation and cell morphology were improved with pearl powder increase

Fig. 6 Proliferation of MC3T3s after seeding on PLA and PLA/pearl scaffolds for 1, 4 and 7 days. (*P<0.05 and **P<0.01)

Biocompatibility—SEM



The proliferation and cell morphology were improved with pearl powder increase

Fig. 7 The SEM images of MC3T3s growth on (a) EP0, (b) EP1, (c) EP2 and (d) EP3 for 3 days. (e-g) are high magnification of (a-d) respectively.

Confocal laser scanning microscopy images

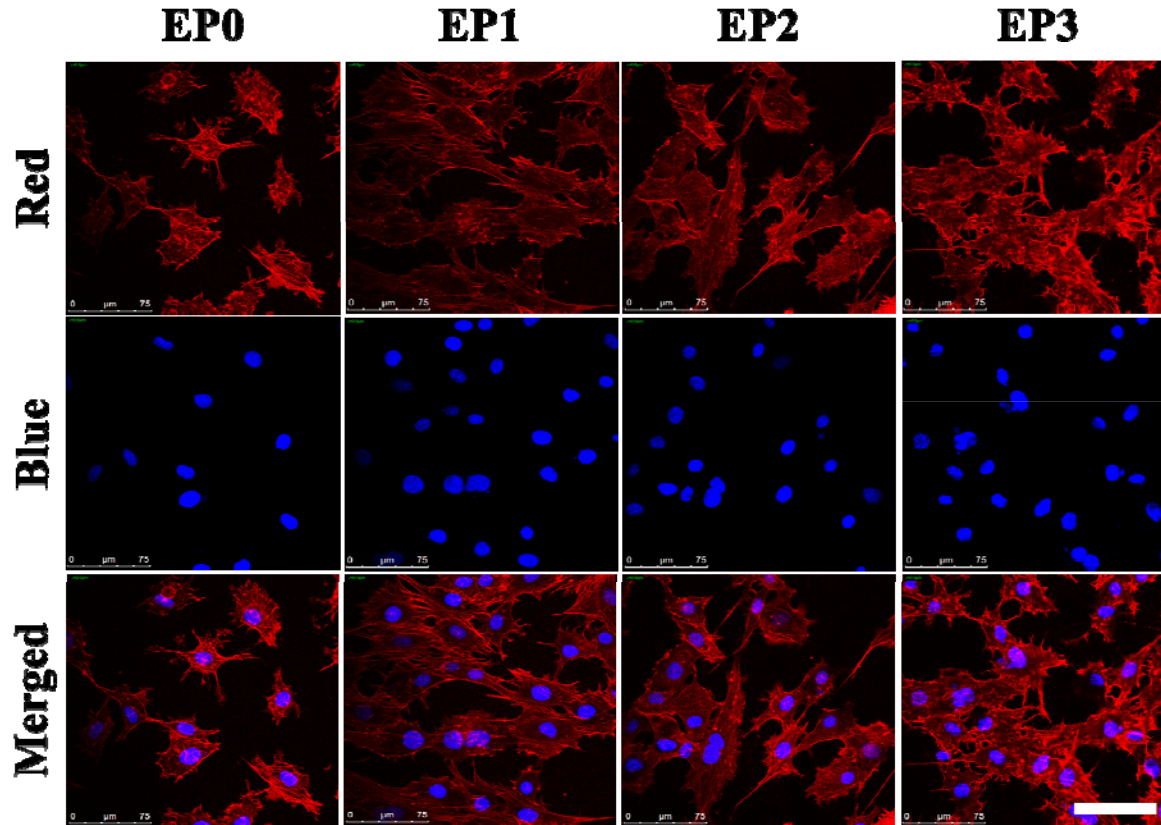


Fig. 8 Confocal laser scanning microscopy images of MC3T3s seeded on PLA and PLA/pearl nanofiber scaffolds after culturing for 3 days. (Scale bar = 75 μm)

Osteoconductivity

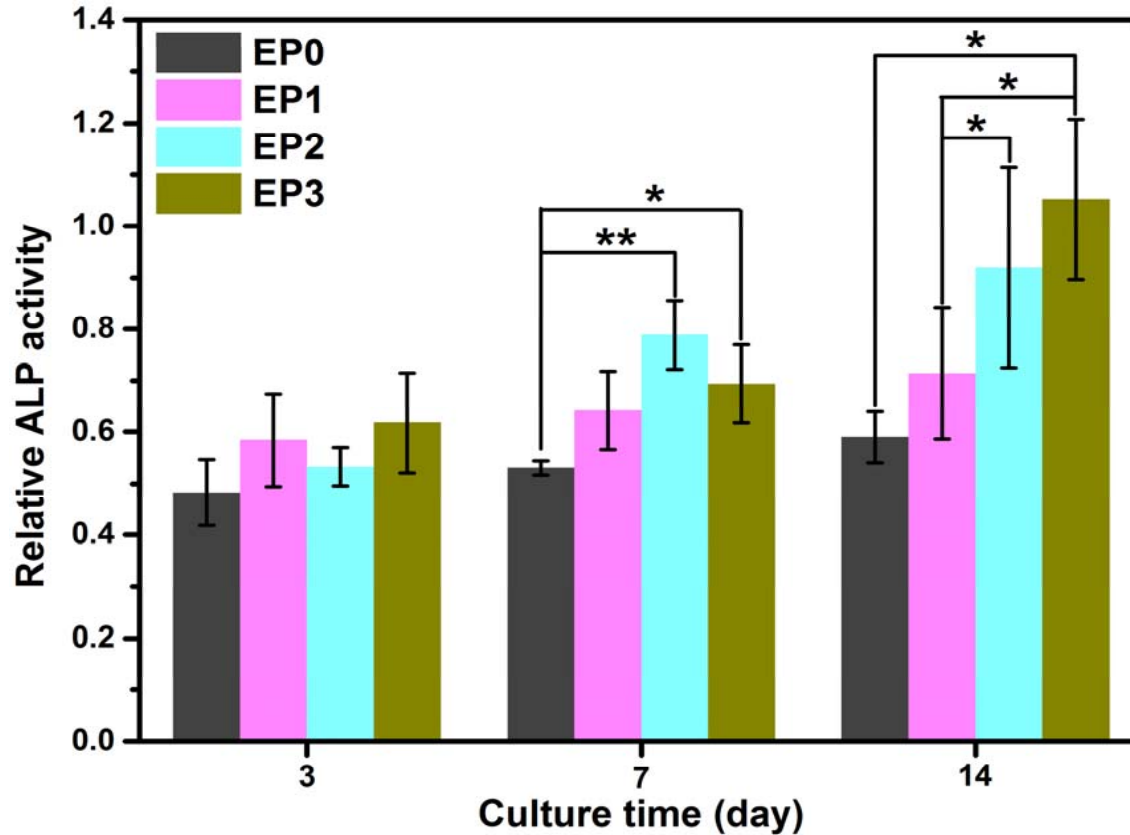
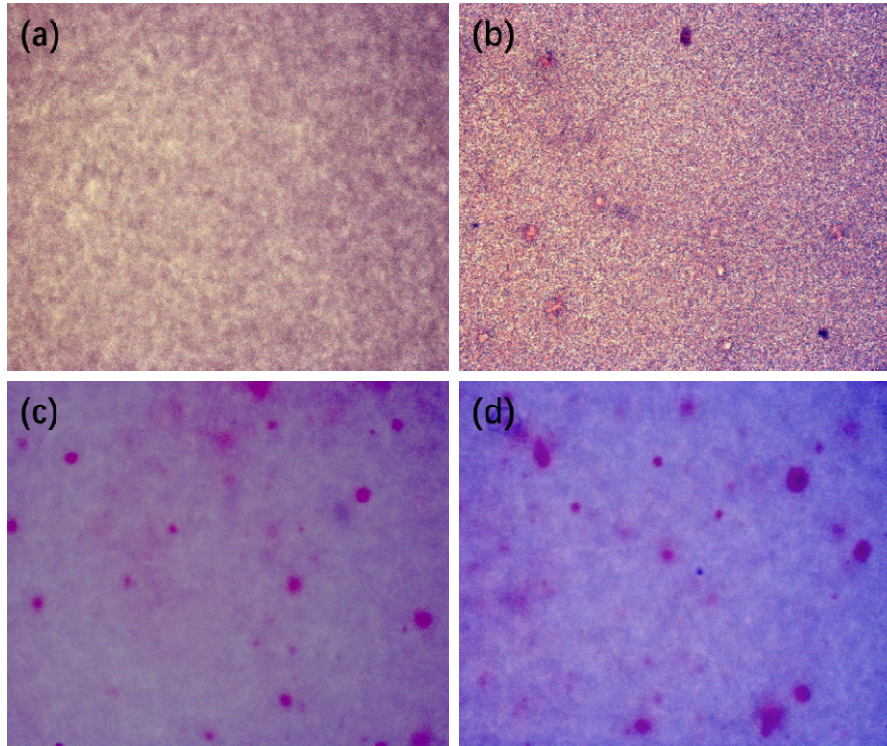


Fig. 9 In vitro ALP activity of MC3T3s after differentiation on PLA and PLA/pearl powder nanofiber scaffolds for 3, 7 and 14 days. (* $P < 0.05$ and ** $P < 0.01$)

Pearl powder can improve the ALP activity

Osteoconductivity



**Pearl
powder
can
accelerate
the
generation
of calcium
nodule**

Fig. 10 Microscopy pictures of mineralized matrix stained with Alizarin Red S after MC3T3s conducted culturing on (a) EP0, (b) EP1, (c) EP2 and (d) EP3 for 2 weeks ($\times 400$).

Conclusion

1

The diameter of well-fashioned PLA/pearl powder nanofiber will increase with the pearl powder increasing, distributing on the fiber surface homogenously to enhance the hydrophilicity.

2

Pearl powder could accelerate the deposition of HA and the fiber surface was fully covered by HA particles with prayer beads shape after a week mineralization, while pure PLA fiber surface was partially covered.

3

Composite nanofibers obtain better biocompatibility, the proliferation and differentiation of which were enhanced with pearl powder increased, while pure PLA seems not show the osteoconductivity.

Thank you!

