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Fibers made from the blend of PCL and bioglass powder through the electrospinning technique for bone regeneration

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INTRODUCTION & AIM

Bone regeneration is a complex and challenging process due to its intricate physiology, which drives the development and evaluation of biomimetic structures for tissue engineering. Scaffolds, composed of fibers, offer an innovative approach by mimicking the extracellular matrix, promoting cell adhesion and growth. This study aimed to develop, characterize, and examine the biological properties of an electrospun scaffold made of poly(ε-caprolactone) (PCL) and bioceramic powder (BC), with the goal of creating a functional and biomimetic structure to enhance bone regeneration.

METHOD

The scaffolds were produced using the electrospinning technique, a bioactivity test was conducted with simulated body fluid, and the cell structure was analyzed through scanning electron microscopy (SEM) of the biomaterials. The fiber diameter was measured using ImageJ software. For chemical analysis, Energy-Dispersive X-ray Spectroscopy (EDS) and Fourier Transform Infrared Spectroscopy (FTIR) were performed. Cytotoxicity was assessed through the lactate dehydrogenase (LDH) release test in stem cells derived from primary teeth. The MTT test was conducted to evaluate cell viability.

RESULTS & DISCUSSION

The PCL/BC scaffolds were characterized in terms of their morphological and chemical properties. Optical microscopy and scanning electron microscopy (Fig. 1A and 1B-F) revealed that the scaffolds featured elongated and continuous fibers with no visible beads, with an average diameter of 3.8 ± 1.4 µm, ranging from 1.5 µm to 9.4 µm. EDS analysis (Fig. 2A) confirmed the presence of BC constituents (carbon, sodium, calcium, silicon, phosphorus, and oxygen) in the PCL fibers, indicating effective incorporation of BC powder. FTIR spectroscopy showed C=O interactions around 1700 cm^-1 and an OC-O band associated with PCL at approximately 1200 cm^-1 (Fig. 2B1). To assess the stability of the scaffolds, the samples were immersed in culture medium for 21 days (Fig. 2B2) and 30 days (Fig. 2B3), with no significant changes observed. Contact angle measurements indicated hydrophobicity for both PCL (127° ± 6) and PCL/BC (127° ± 2) scaffolds (Fig. 3A and 3B). After two minutes, the contact angle decreased to 79° (Fig. 3C), reflecting the expected hydrophilicity due to the incorporation of BC powder, which facilitated the absorption of the water deposited during the test. In biological evaluations, the PCL/BC scaffolds showed no cytotoxicity after one day based on LDH release (Fig. 4A). A statistically significant difference in LDH release was observed between the death control group and the other groups. Cell viability in the PCL/BC scaffolds was significantly higher compared to the control group (TCP), as shown in Fig. 4B.

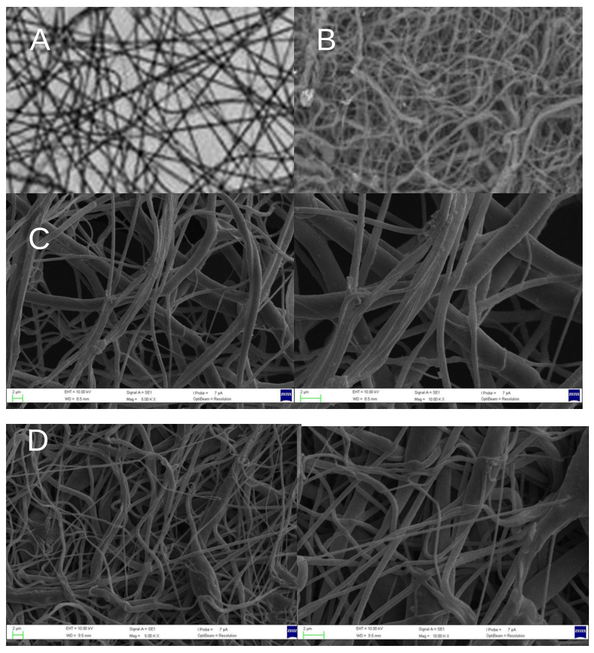
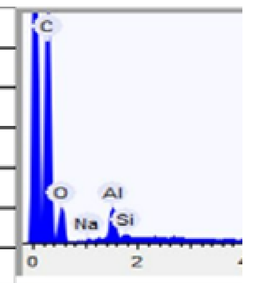


Figure 1: Characterization of the electrospun PCL/BC scaffolds. Optical microscopy PCL/BC scaffolds (A). MEV PCL/BC scaffolds (B). MEV PCL submerged in SBF for 21 days (C). MEV PCL/BC scaffolds submerged in SBF for 21 days (D).

A

Element	Weight %
Carbon	9.0
Sodium	7.0
Calcium	10.4
Silicon	5.6
Phosphorous	4.4
Oxygen	63.6



B

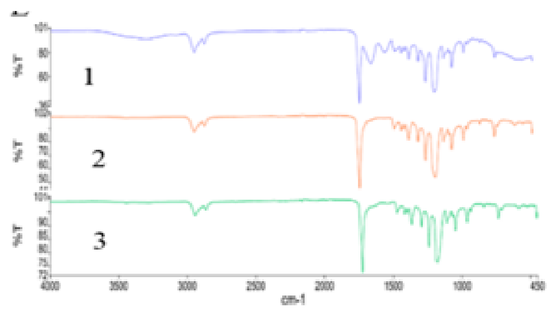


Figure 2: (A) Chemical elements by Energy Dispersive X-rays (EDS). (B) Fourier Transform Infrared Spectroscopy (FTIR) in: 1) 0 days, 2) 21 days and 3) 30 days.

Figure 3: Contact angle with water. A) PCL, B) PCL/BC and C) PCL/BC after 2 minutes.

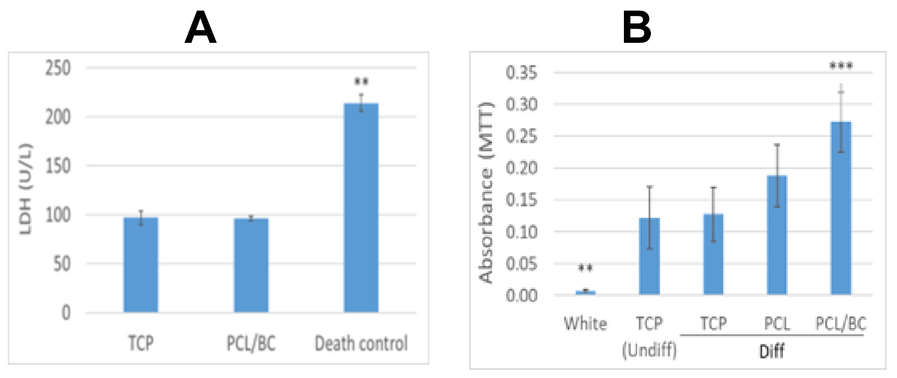


Figure 4: (A) Cytotoxicity by LDH. (B) Viability by MTT in stem cells cultured in PCL/BC scaffolds for 1 day, compared to the control or tissue culture plate (TCP). TCP refers to cells cultured directly in the wells of the plate, used as a control, “Death Control” for cells treated with Triton X-100, and “Blank” for wells with culture medium, without cells. Data are expressed as mean ± SD, with * p≤0.05 and ** p≤0.01.

CONCLUSION

In this study, the electrospun scaffolds composed of 15% PCL and 1% BC exhibited desirable features, including extended and uninterrupted fibers, along with increased hydrophilicity after just a few minutes. The lack of cytotoxicity and the high cell viability observed in the PCL/BC scaffolds suggest their promising potential for bone regeneration.

REFERENCES

S TOLOUE, EB et al. Ultra-thin electrospun nanocomposite scaffold of poly(3-hydroxybutyrate)-chitosan/mesoporous magnetic bioactive glasses for bone tissue engineering applications. International Journal of Biological Macromolecules, v. 254, n. 127860, p. 127860, 2024.

LIAN, H.; MENG, Z. Fabrication, characterization and osteoblast responses of poly (octanediol citrate)/bioglass nanofiber composites. Materials science & engineering. C, Materials for biological applications, v. 84, p. 123–129, 2018,

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