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Compositional Control of Strontium-Substituted Hydroxyapatite Governs Bioactivity and Mechanical Response in Electrospun PCL/Gel Scaffolds

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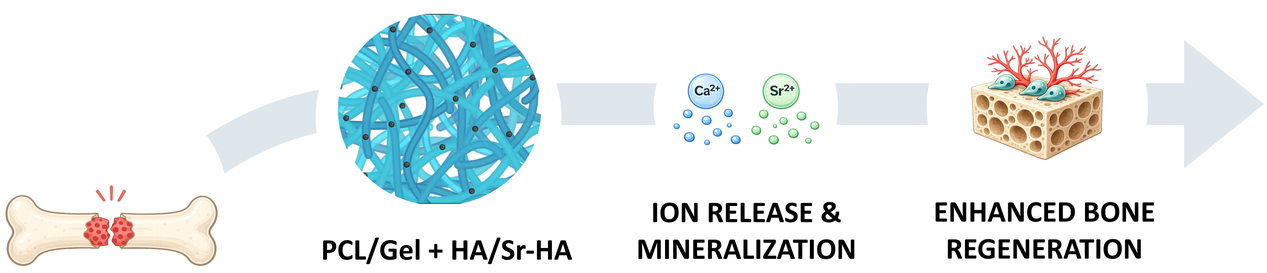
INTRODUCTION

Critical-sized bone defects require advanced biomaterials able to support bone regeneration

Electrospun PCL/Gel scaffolds mimic the native extracellular matrix but with limited bioactivity

HA improves osteoconductivity, while **Sr substitution** provides additional biological stimulation

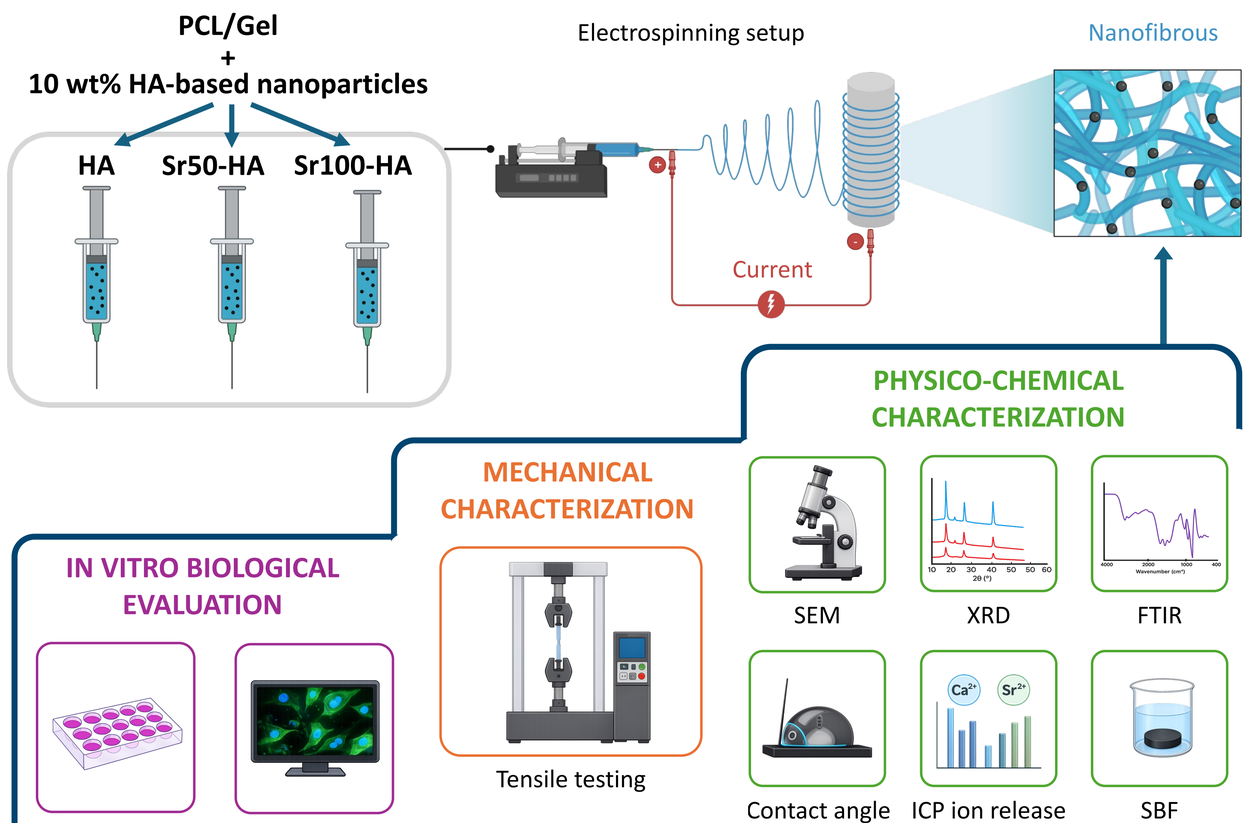
No systematic comparison of Sr-substituted HA compositions in electrospun PCL/Gel scaffolds



AIM

Evaluate the influence of **Sr substitution degree** on the **physicochemical**, **mechanical**, and **biological** performance of electrospun PCL/Gel scaffold

METHOD

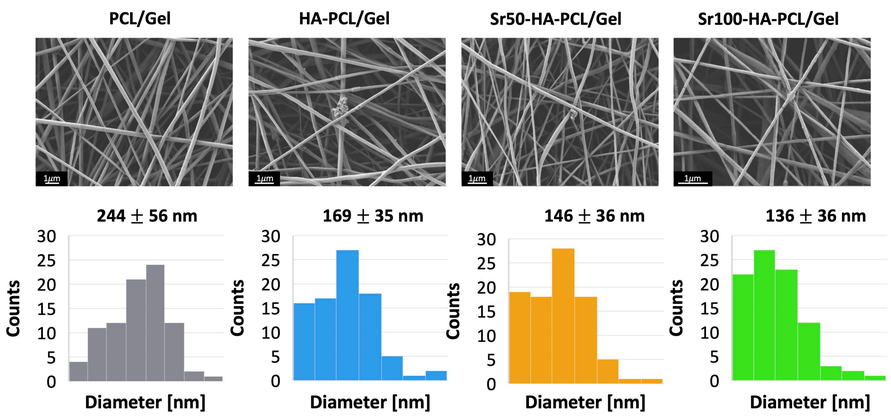


RESULTS & DISCUSSION

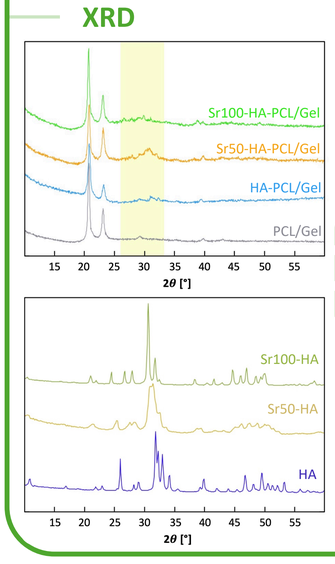
PHYSICO-CHEMICAL CHARACTERIZATION

SEM

All formulations exhibited a uniform, bead-free fibrous morphology, with apatite incorporation leading to progressively smaller fibre diameters

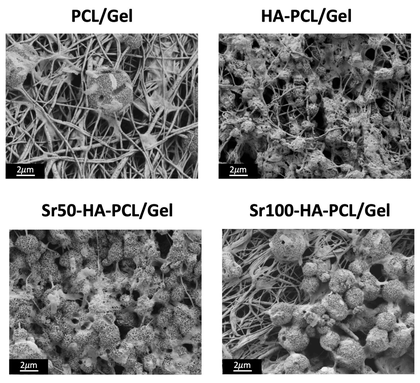


XRD

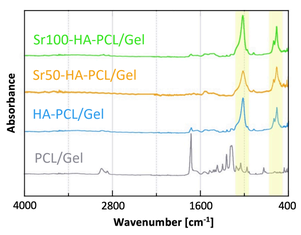


Sr induced structural changes

SBF



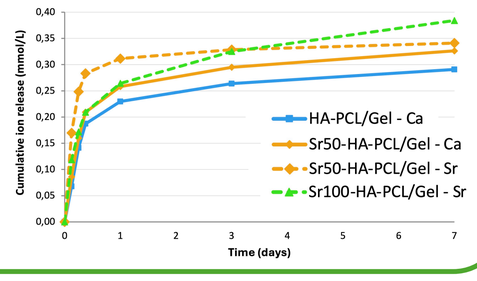
FTIR confirmed apatite formation after 21 days in SBF



HA-containing composites promoted enhanced biomimetic mineralization compared with PCL/Gel

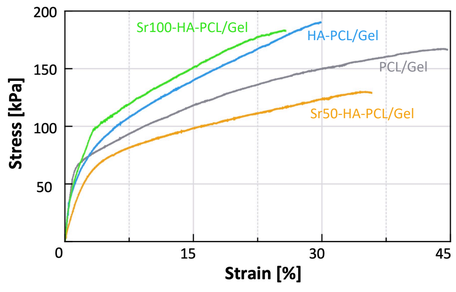
ICP ion release

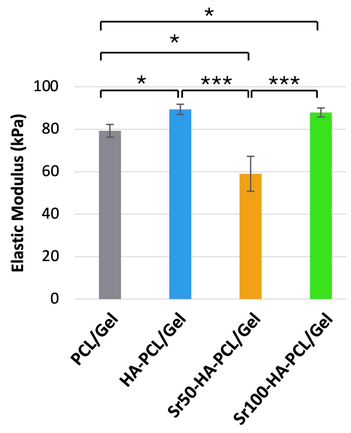
Sr50-HA-PCL/Gel promoted higher early ion release, while Sr100-HA-PCL/Gel exhibited a more sustained release profile over time



MECHANICAL CHARACTERIZATION

HA-PCL/Gel and Sr100-HA-PCL/Gel provided the most effective mechanical reinforcement, while Sr50-HA-PCL/Gel exhibited reduced stiffness despite its intermediate composition



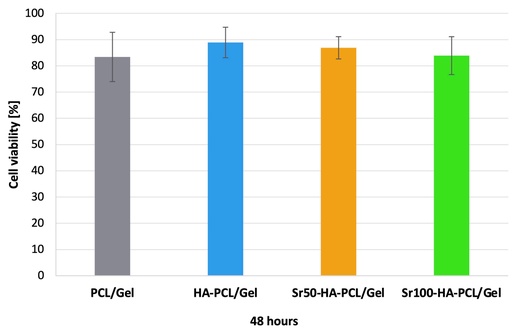


*p < 0.05 ***p < 0.001

IN VITRO BIOLOGICAL EVALUATION

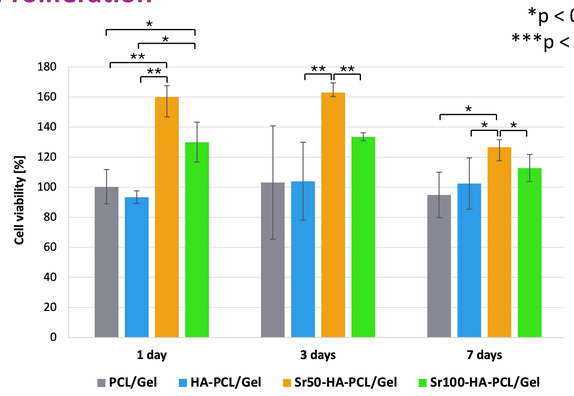
Cytocompatibility

All formulations exhibited cell viability above 80%, indicating no cytotoxic effects



Proliferation

*p < 0.05
***p < 0.001



Sr-containing composites enhanced early cell proliferation, with Sr50-HA-PCL/Gel showing the strongest effect

CONCLUSIONS

Enahnced mineralization
HA-based fillers preserved electrospinnability and promoted biomimetic mineralization in SBF

Tunable mechanical properties
Sr substitution modulated scaffold stiffness

Favorable biological response
All scaffolds maintained cytocompatibility, with enhanced cellular activity in Sr-containing composites

Tailored scaffold for bone regeneration
Controlled Sr incorporation offers a versatile strategy to optimize multifunctional scaffolds

Sr50-HA-PCL/Gel Highest early cell proliferation

Sr100-HA-PCL/Gel Highest stifness

Sr-HA substitution level acted as a compositional tuning parameter governing the balance between mineralization, mechanical properties and biological response in electrospun PCL/Gel scaffolds