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Electrospun PCL/Merwinite and Zn-Doped Merwinite Composite Fibers for Bone Tissue Engineering Applications

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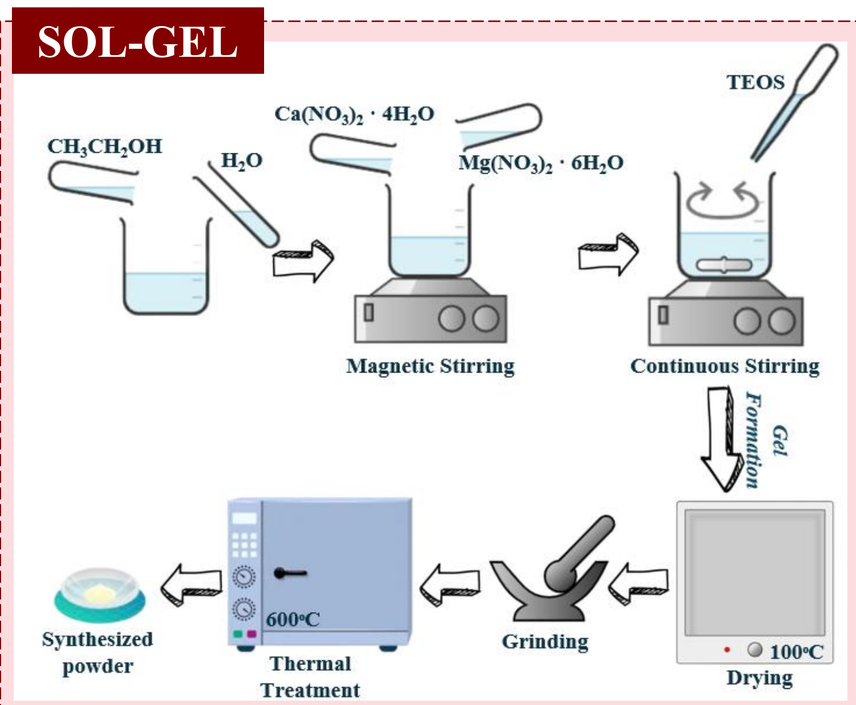
Abstract

This study reports the fabrication of electrospun composite fibers based on merwinite (MW, $Ca_3Mg(SiO_4)_2$) and Zn-doped MW (MW-Zn) for bone tissue engineering applications. Merwinite powders were synthesized via the sol–gel method, dried, calcined at 600 °C, and incorporated into polycaprolactone (PCL) suspensions for electrospinning. By tuning parameters such as voltage, flow rate, and collector distance, continuous fibrous networks with embedded ceramic particles and interconnected porosity were obtained. SEM and FTIR analyses confirmed phase incorporation and uniform particle dispersion, while MTT assays on MC3T3 cells demonstrated high cytocompatibility, with Zn-doped fibers promoting enhanced cell viability. These results highlight the potential of electrospun MW-based composites as bioactive fibrous scaffolds for bone regeneration.

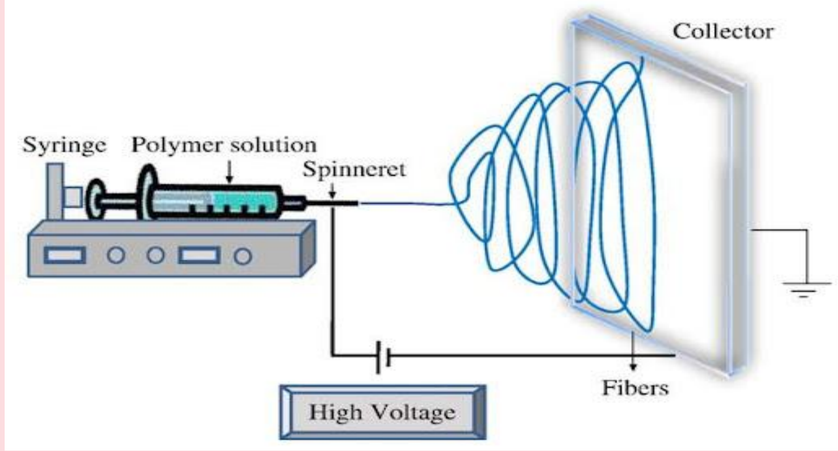
Aim

The aim of the study was to fabricate electrospun composite fibers based on merwinite and Zn-doped merwinite in a PCL matrix and to investigate their structural, morphological, and biological performance for bone tissue engineering applications.

SOL-GEL

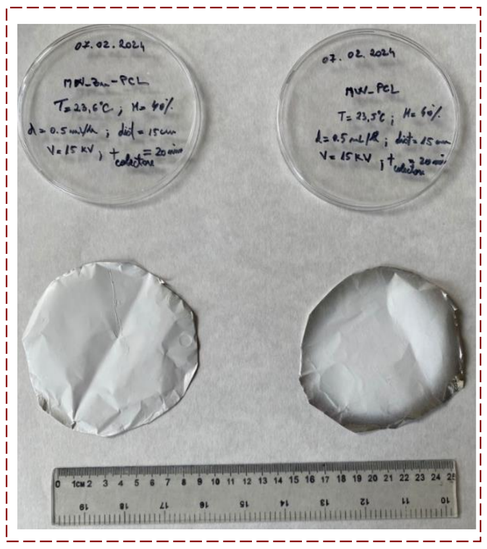


MATERIALS & METHODS



ELECTROSPINNING

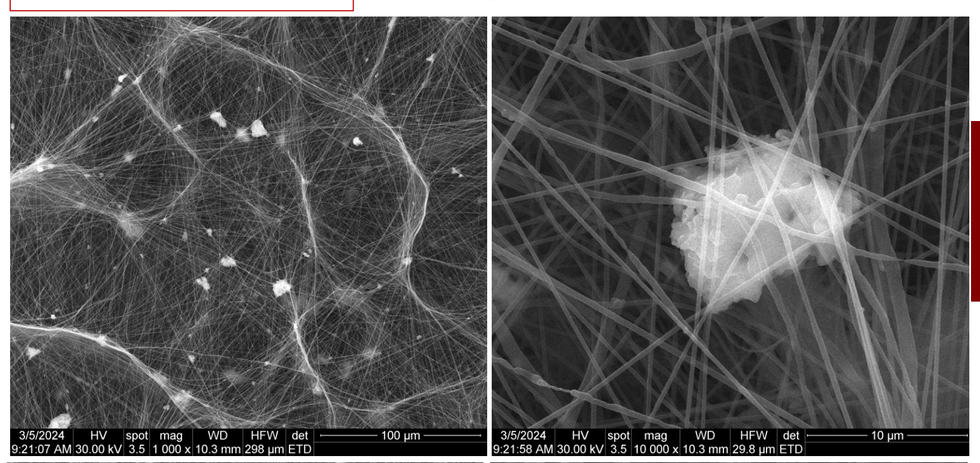
COLLECTED FIBERS

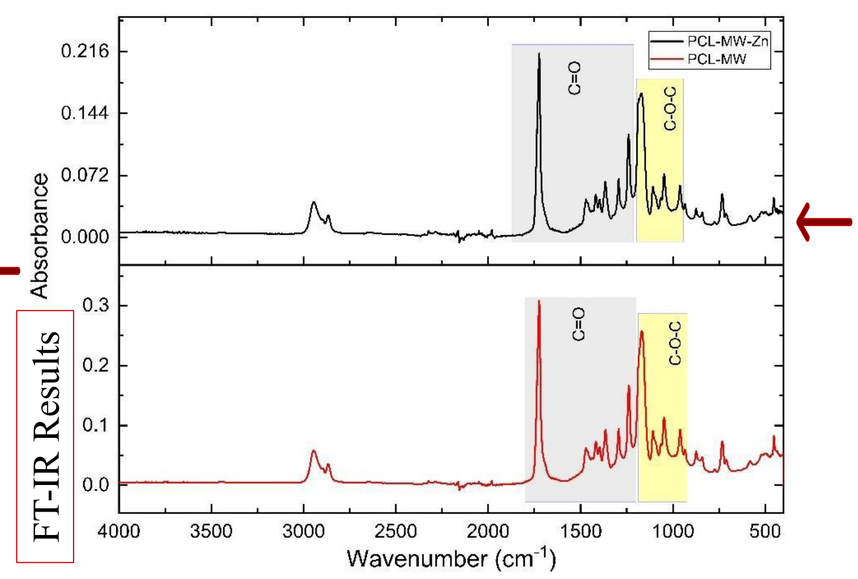


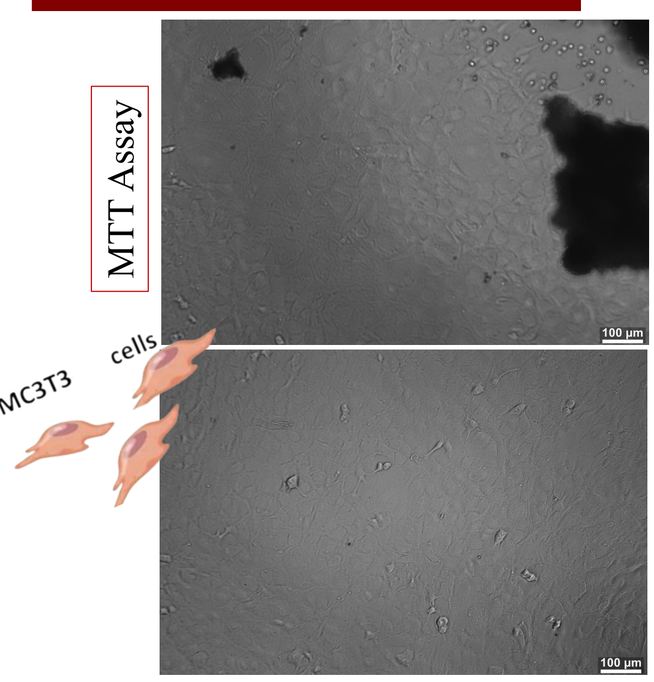
Electrospinning Parameters

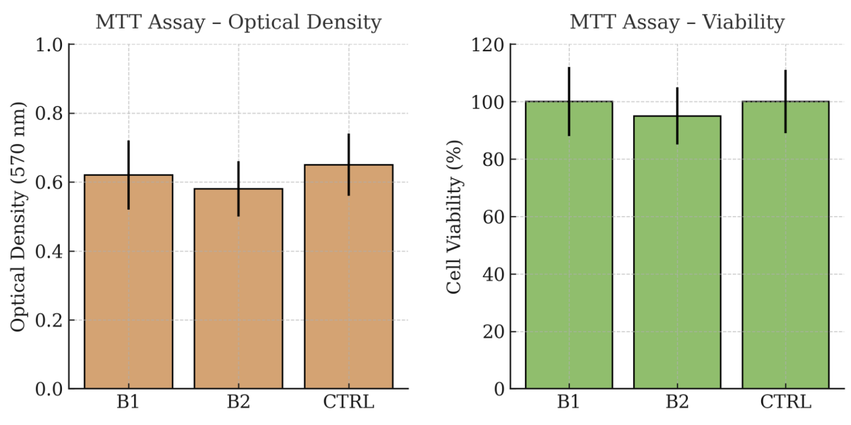
PARAMETER	TEST	PCL-MW	PCL-MW-Zn
FEEDING RATE	0.5 mL/h	0.5 mL/h	0.5 mL/h
APPLIED VOLTAGE	15 kV	15 kV	15 kV
NEEDLE-COLLECTOR DISTANCE	15 cm	15 cm	15 cm
TEMPERATURE	23 °C	23.5 °C	23.5-24 °C
HUMIDITY	39-40 %	40 %	40 %
TIME	5 min	20 min	20 min

SEM Results









Discussion

- Electrospun PCL/MW and PCL/MW-Zn fibers formed uniform, interconnected fibrous networks resembling native ECM.
- Zn^{2+} doping improved fiber homogeneity and ceramic particle dispersion within the polymeric matrix.
- MTT assays (direct contact on MC3T3 cells) demonstrated good cytocompatibility, with Zn-doped fibers enhancing cell viability compared to undoped ones.

Conclusions

- Electrospun composite fibers containing MW and MW-Zn within a PCL matrix were successfully fabricated.
- Fibers exhibited favorable morphology, bioactivity, and cytocompatibility.
- Zn-doping led to improved biological response.
- Such composites are promising candidates for bone tissue engineering applications.
- Future work will focus on electrospinning optimization and extended *in vitro*/*in vivo* studies.

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