Polycaprolactone Scaffolds Functionalized with Natural Molecules and Kefiran for Skin Tissue Engineering

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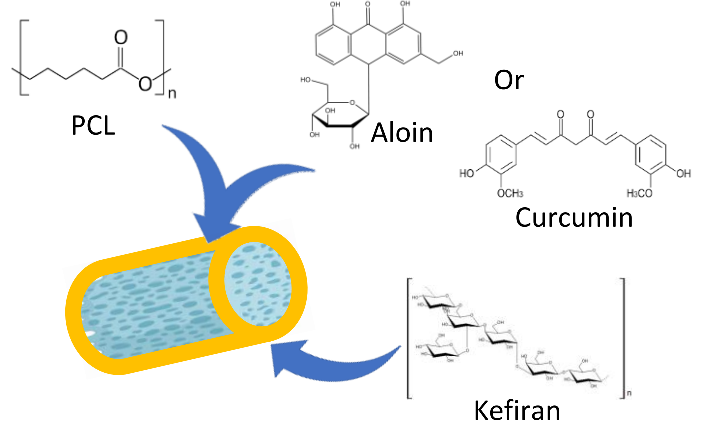
1. INTRODUCTION

Skin, as a critical organ for survival, necessitates effective healing strategies. Tissue engineering presents an innovative alternative to traditional methods by developing skin substitutes that mimic the extracellular matrix. This study explored the potential of porous polycaprolactone (PCL) fiber scaffolds enhanced with natural molecules such as Aloin and curcumin, and coated with kefiran, for skin regeneration applications. PCL, a biodegradable polymer, is recognized for its processability, flexibility, and compatibility with other polymers [1]. Natural compounds like aloin and curcumin promote cell growth and regeneration while providing antibacterial, anti-inflammatory, and anticancer properties [2]. Additionally, kefiran, an exopolysaccharide derived from kefir grains, contributes biodegradability, biocompatibility, and antibacterial effects [3]. This integrated approach holds promise for advancing skin tissue engineering towards more effective regenerative therapies.



2. EXPERIMENTAL METHODS

2.1. Electrospinning process

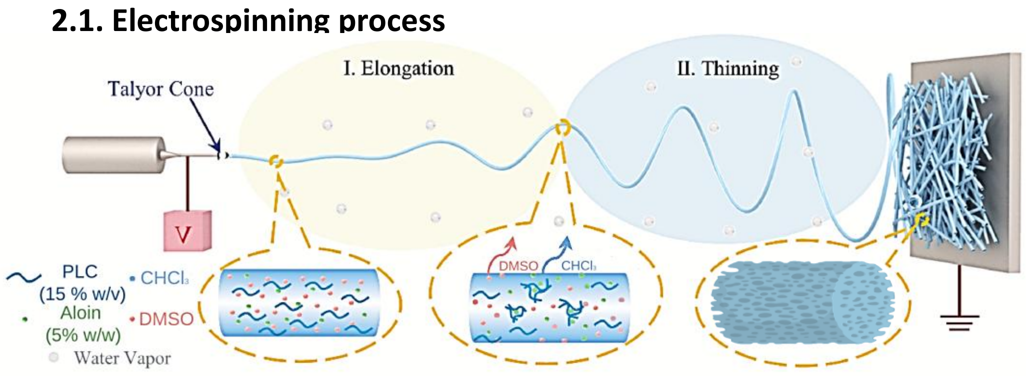


Fig 1. Scheme of electrospinning process

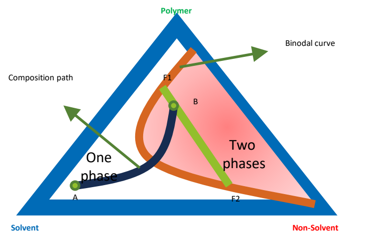


Fig 2. Ternary phase diagram system during electrospinning process

2.2. Kefiran Coating

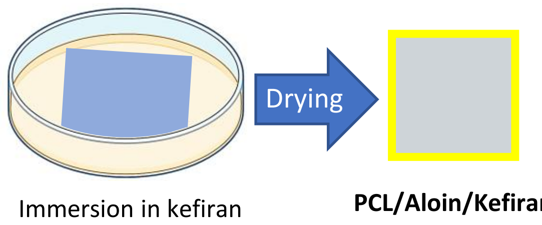


Fig 3. Scheme of kefiran coating

2.3. Analysis of degradation, water absorption and release of Aloin

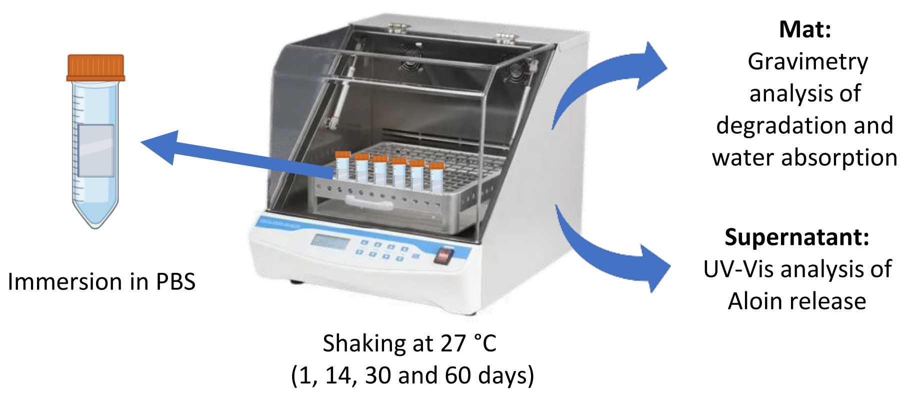


Fig 4. Scheme of the characterization of scaffolds immersed in PBS

3. RESULTS AND DISCUSSION

3.1. SEM Analysis of electrospun scaffolds with aloin

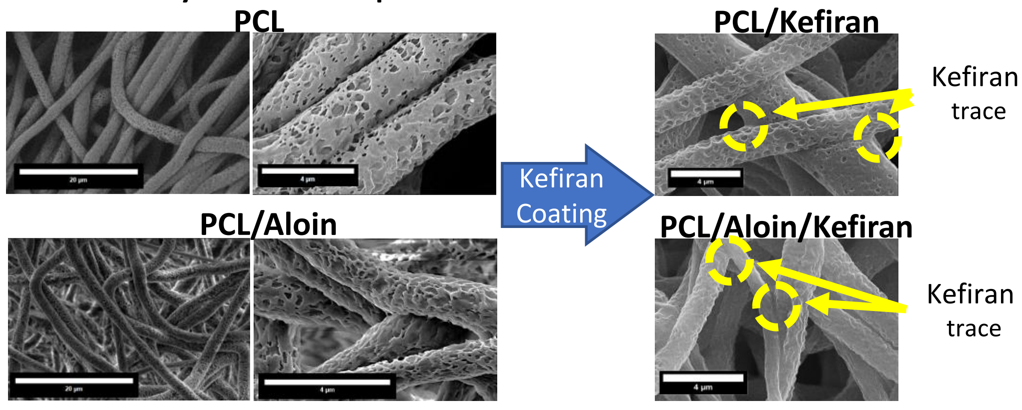


Fig 5. SEM images of electrospun mats before and after kefiran coating

3.2. Analysis of degradation at 60 days

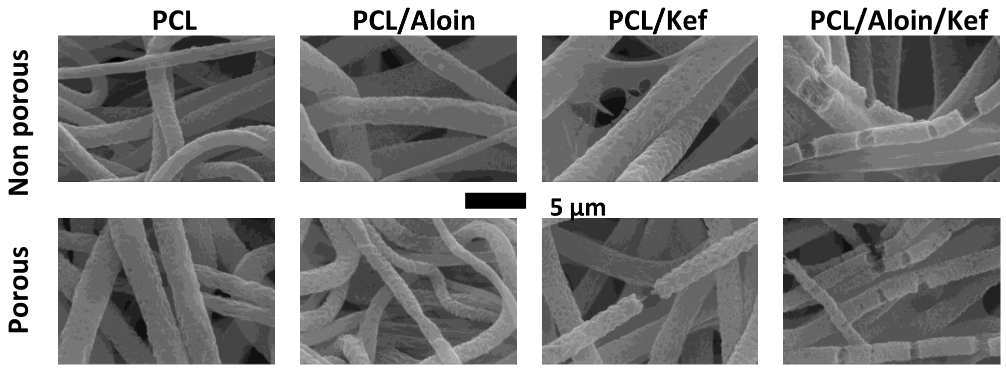


Fig 6. SEM images of electrospun mats at 60 days of immersion in PBS

ACKNOWLEDGMENTS

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REFERENCES

[1] Garcia, G. et al. Int. J. Biol. Macromol. 2024, 273, 132891.
[2] Li, W. et al. RSC Adv., 2022, 12, 27300-27308.
[3] Shokraei, S. et al. J Appl Polym Sci. 2021; 138:e50547.

3. RESULTS AND DISCUSSION

3.3. Analysis of degradation at 60 days in PBS and aloin release

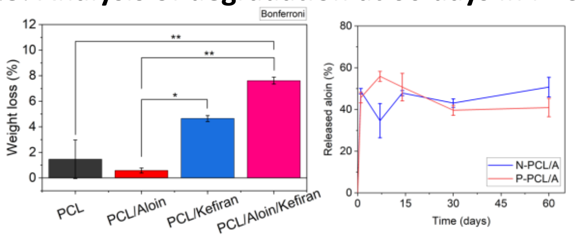


Fig 7. Weight loss of electrospun mats at 60 days of immersion in PBS. *p<=0.05, *p<=0.01, *p<=0.001, and released of aloin of porous and non-porous PCL/A mats

Kefiran-coated scaffolds experience greater mass loss, up to 8%, likely due to kefiran release from the scaffold's surface. A rapid release of aloin, around 48%, was observed on the first day, followed by a slow release to 56% and after a gradual reabsorption. By day 30, equilibrium was reached, with a release of 43%.

3.4. SEM Analysis of electrospun scaffolds with curcumin

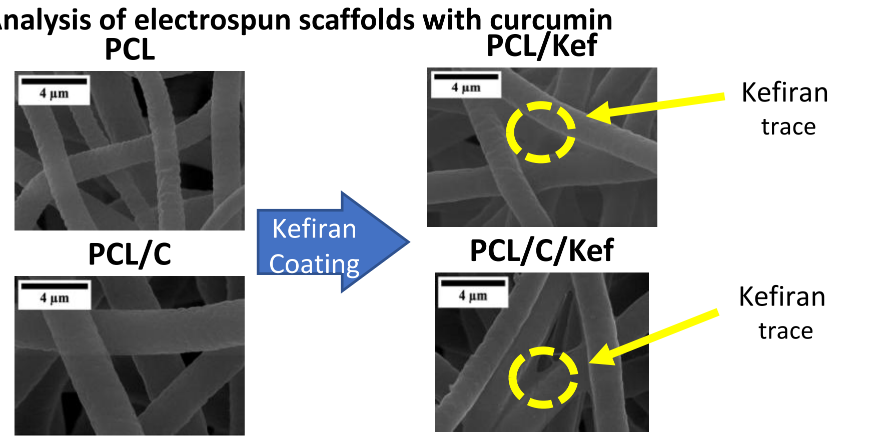


Fig 8. SEM images of electrospun mats before and after kefiran coating

3.5. Biological characterization

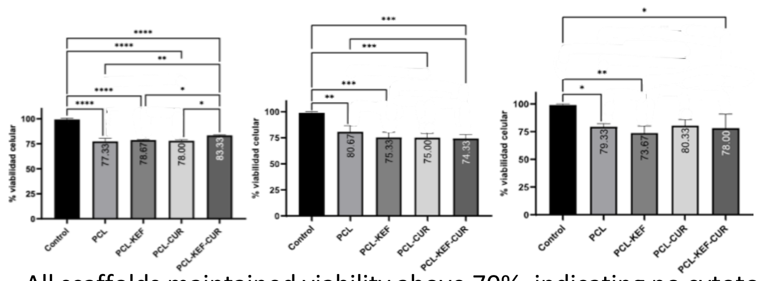
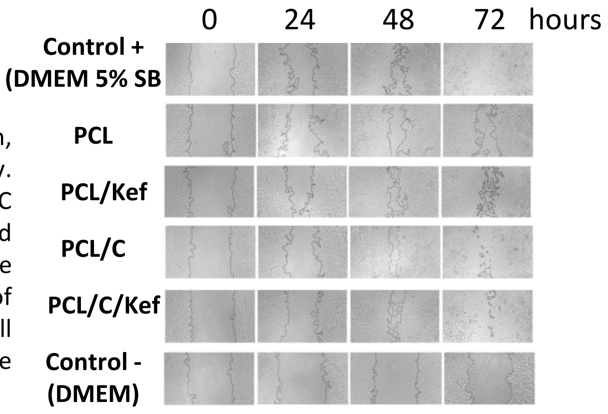


Fig 9. Viability of HUVEC cells treated with scaffold extracts.

All scaffolds maintained viability above 70%, indicating no cytotoxicity. The absence of major differences over time supports their biocompatibility.

Fig 10. Migration assay of HUVEC cells treated with extracts



All scaffolds supported cell migration, indicating good biocompatibility. However, PCL/C and PCL/KEF/C promoted the most rapid and complete wound closure, likely due to the bioactive properties of curcumin, which may enhance cell motility and support tissue regeneration..

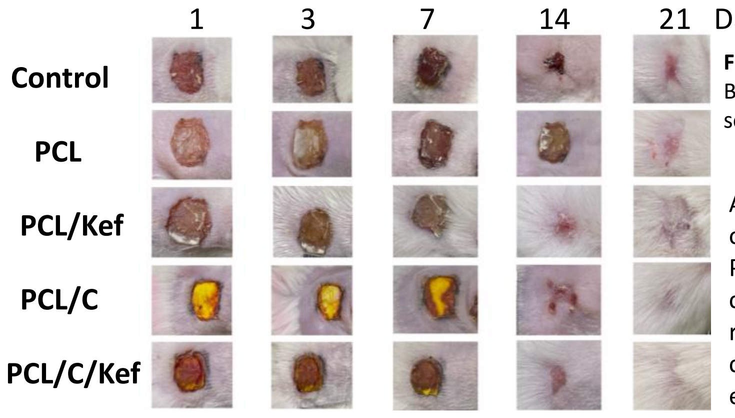


Fig 11. Wound closure in BALB/c mice treated with the scaffolds

All groups showed healing over time, but PCL/C and PCL/KEF/C led to faster closure and better tissue regeneration, highlighting curcumin's beneficial effect.

4. CONCLUSION

Functionalized PCL scaffolds with curcumin, aloin, and kefiran showed enhanced biodegradability, maintained high cell viability, and supported cell migration. Notably, PCL/C and PCL/C/KEF accelerated wound healing, highlighting the synergistic effect of natural compounds and kefiran. These results suggest strong potential for skin regeneration applications.