Characterization and assessment of PolyHIPE scaffolds suitability for tissue engineered blood vessel

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INTRODUCTION

PolyHIPEs are remarkable for their highly porous structure, characterized by an internal phase that makes up over 74% of the emulsion [1]. This structure enhances cell penetration and ingrowth. We use Poly(glycerol sebacate) methacrylate (PGS-M), a UV-curable derivative of Poly(glycerol sebacate) PGS, to create tubular PolyHIPE scaffolds with diameters ranging from 4 mm to 5.5 mm. Our goal is to gain a deep understanding of these scaffolds' mechanical properties and structure for their application in 3D cell culture in tissue engineering.

OBJECTIVES

1. Evaluate the potential of tubular PolyHIPE scaffolds with varying diameters, ranging from 4mm to 5.5, for tissue-engineered blood vessel.
2. Characterise the mechanical properties of the tubular polyHIPE scaffolds to understand their strength, elasticity and overall structural integrity.
3. Conduct a comprehensive morphological analysis of the tubular polyHIPE scaffolds using scanning electron microscopy (SEM) to assess their 3D structure, surface features, porosity and pore interconnectivity.

METHOD & MATERIALS

A PolyHIPE scaffold is produced using the emulsion templating method, during which the PGS-M undergoes crosslinking when exposed to UV light, resulting in the formation of a sponge-like scaffold.

This process is rooted in the preparation of an emulsion composed of two immiscible liquids which are deionised water and PGS-M where the deionised water, the internal phase, is dispersed in PGS-M, the continuous phase. The emulsion is then consistently mixed at 300 rpm to maintain uniform pore sizes in the PolyHIPE scaffold.

The emulsion is further processed by injecting it into four tubular moulds of varying diameters prior to the curing stage. During this solidification step, the tiny water droplets solidify in place, essentially becoming templates within the scaffold. These solidified templates are subsequently removed, leaving behind interconnected pores in the scaffold, creating a porous matrix.

Scaffold design

The tubular scaffold will have internal diameter ranging from 4.0cm to 5.5cm increment by 0.5cm. The wall thickness of the scaffold will remain consistent at 2cm.

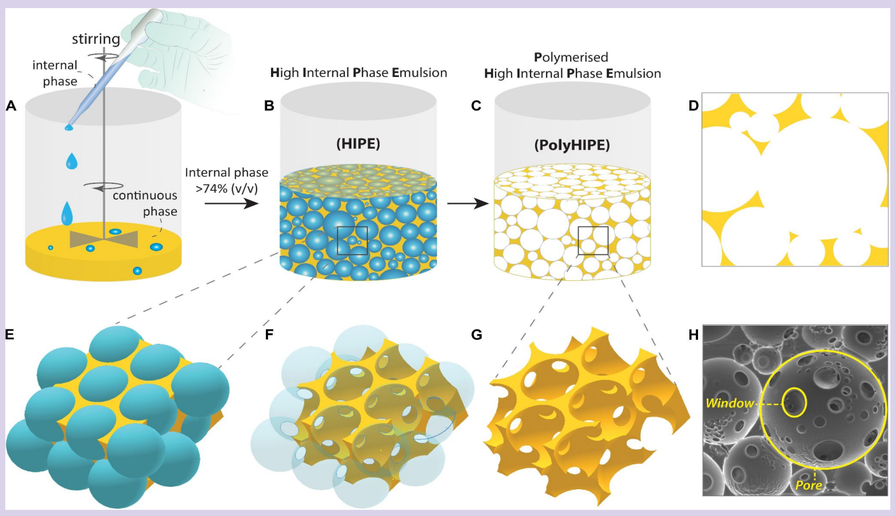

Figure 1: Image describing polyHIPE fabrication [1]

RESULTS & ANALYSIS

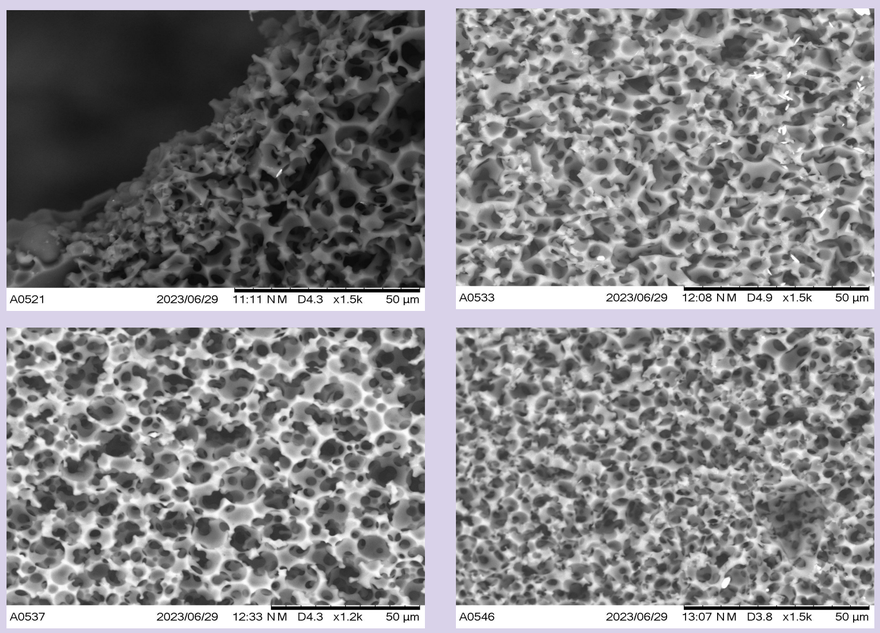

Figure 2 : Selective electron microscopy (SEM) images at high magnification, 2a) the porosity of scaffold with 4.0mm internal diameter, 2b) the porosity of scaffold with 4.5mm internal diameter, 2c) the porosity of scaffold with 5.0mm internal diameter, 2d) the porosity of scaffold with 5.5mm internal diameter.

PolyHIPE Scaffold Pore Size: The polyHIPE scaffolds are measured to have 90% of porosity. This uniformity is facilitated by a constant mixing rate as mentioned previously. The high level of porosity within the scaffold creates an environment that not only allows for enhanced cell infiltration and tissue integration but also promotes cell attachment, proliferation, and differentiation due to the interconnected pores. A consistent pore size contributes to efficient pore interconnectivity, allowing for the easy transport of fluids, nutrients, and cells within the scaffold, which is particularly important for tissue engineering applications [2].

Tensile Test Results: The results of the tensile test on dry and wet dog bone-shaped scaffolds reveal significant findings. Firstly, dry scaffolds are more fragile than their wet counterparts, indicating that moisture removal reduces elasticity and increases susceptibility to fractures. Secondly, dry scaffolds have a higher elastic modulus, showcasing increased stiffness and resistance to deformation compared to wet scaffolds. Lastly, dry scaffolds are more rigid and prone to snapping under stress. These observations underscore the significant influence of moisture on scaffold mechanical behavior.

CONCLUSION

This study comprehensively evaluated the potential of PolyHIPE scaffolds for use as in-vitro tissue-engineered blood vessels. Their unique characteristics, driven by a high internal phase and excellent pore interconnectivity, position them as promising candidates for this application. The uniform pore sizes, achieved through consistent mixing, facilitate efficient interconnectivity for seamless fluid, nutrient, and cell transport—a crucial aspect of blood vessel creation. Additionally, our research underscores the significant impact of moisture content on scaffold behaviour, where dry scaffolds exhibit increased fragility and stiffness compared to wet ones. These insights emphasize the need for precise moisture control in tissue engineering. In summary, our study advances scaffold design optimization for tissue-engineered blood vessels, enhancing their potential in regenerative medicine and biomedicine.

REFERENCES

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