An Investigation of Biocompatible and Mechanical Properties of Bioactive Nanostructure Scaffold

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ABSTRACT :This study presents an investigation into the biocompatible and mechanical properties of a novel bioactive nanostructure scaffold, designed to promote tissue regeneration and repair. Tissue engineering and regenerative medicine hold significant promise for addressing various clinical challenges, and the development of effective scaffolds is a critical aspect of this endeavor.Transparent bio glass solution was prepared by SOL GEL METHOD lDissolve Ca-Si-P-Zr powder in acetone & 15% PMMA was dissolved in acetone Equal volumes of the transparent bio glass solution and the polymer mixture were added to obtain the scaffold material .The heat treatment was essential since the dissolubility of PMMA in these solvent mixture at room temperature is very low.The zirconium modified bio glass is synthesised successfully and it is confirmed by EDAX,FTIR analysis.Bioglass has been modified with the help of polymer it is confirmed by FDR analysis.Surface morphology of PMMA modified bio glass also visualised and it confirms that bio glass attached on the surface of PMMA matrix.so,it is also evidenced by the AFM results scaffold surface roughness was increased. Further fabricated bioglass loaded PMMA was evaluated by two methods: hemocompatibility and zebra fish analysis both the result revealed that synthesised scaffolds are biocompatible.The biocompatible and mechanical properties of bioactive nanostructure scaffolds is essential for advancing tissue engineering and regenerative medicine, enabling the development of tailored and effective scaffold systems for tissue regeneration applications.

**KEYWORDS :**Bioactive nanostructure Scaffold, Tissue Engineering, Regenerativemedicine, Biocompatibility, Mechanical properties, Biomaterials, Scaffold design, Scaffold fabrication, Cell culture, Cytotoxicity.

# INTRODUCTION

Tissue engineering and regenerative medicine have emerged as transformative fields with the potential to revolutionise medical treatments for a wide range of conditions, from organ failure to tissue defects [(Thiripelu et al., 2024)](https://paperpile.com/c/QAwU8E/l9yb). Central to the success of these innovative approaches is the development of biomaterial scaffolds that provide the necessary support and cues for tissue regeneration(Almatrafi et al., 2024). Among these scaffolds, bioactive nanostructure scaffolds have garnered significant attention due to their unique combination of biocompatibility and mechanical properties[(Shanmugam et al., 2013; Wei et al., 2020)](https://paperpile.com/c/QAwU8E/Bs8Tb+eZjq)[(Ajay et al., 2023; Chokkattu et al., 2023; Padarthi et al., 2023)](https://paperpile.com/c/QAwU8E/gGkSA+ovADC+03BIH)[(Dharman et al., 2023; S. Sindhu et al., 2023; Sreenivasagan et al., 2023)](https://paperpile.com/c/QAwU8E/MFpJ+E7Te+hmv8)[(Ramakrishnan et al., 2023; Shenoy & Maiti, 2023; J. S. Sindhu et al., 2023)](https://paperpile.com/c/QAwU8E/R8B8I+Gjsup+qtvCg)[(Kasabwala et al., 2021; Rajeshkumar & Lakshmi, 2021; Varghese et al., 2023)](https://paperpile.com/c/QAwU8E/gDTSL+oFUBx+ZRmVW)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/QAwU8E/8bGn+6QIo+HcHL)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Subramanian et al., 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/QAwU8E/8bGn+6QIo+HcHL+65dh7)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/QAwU8E/8bGn+6QIo+HcHL)This investigation delves into the biocompatible and mechanical properties of bioactive nanostructure scaffolds, aiming to provide insights into their suitability for tissue engineering and regenerative medicine applications[(Moris et al., 2022; Viishaal Srikanth Srivatsa & Manogaran, 2024)](https://paperpile.com/c/QAwU8E/vF1G+vTMf). The biocompatibility of these scaffolds is paramount to ensure that they do not trigger adverse immune responses or toxicity when in contact with living cells and tissues(Saadh et al., 2024). Additionally, understanding the mechanical properties of these scaffolds is essential, as they must provide the necessary mechanical support to ensure structural integrity during tissue regeneration[(Sathya et al., 2024; Syed et al., 2019)](https://paperpile.com/c/QAwU8E/9UNhK+AnQ6).This research contributes to the broader understanding of bioactive nanostructure scaffolds, offering insights into their potential applications in tissue engineering, regenerative medicine, and clinical practice[(Grumezescu & Grumezescu, 2019)](https://paperpile.com/c/QAwU8E/Gg9DX). The combination of biocompatibility and mechanical strength makes these scaffolds promising candidates for addressing critical challenges in tissue regeneration and repair[(Paramasivam et al., 2023)](https://paperpile.com/c/QAwU8E/nBr1). As we move forward, exploring their performance in preclinical and clinical settings holds the promise of transformative advancements in healthcare and regenerative therapies [(Schitea et al., 2020; Semitela et al., 2020)](https://paperpile.com/c/QAwU8E/qyG67+pV1Co).

# MATERIALS AND METHODS



Figure 1: Scaffold

Transparent bio glass solution was prepared by SOLGEL METHOD ——> Dissolve Ca-Si-P-Zr powder in acetone & 15% PMMA was dissolved in acetone ——> Equal volumes of the transparent bio glass solution and the polymer mixture were added to obtain the scaffold material ——> The heat treatment was essential since the dissolubility of PMMA in these solvent mixture at room temperature is very low.

# RESULTS

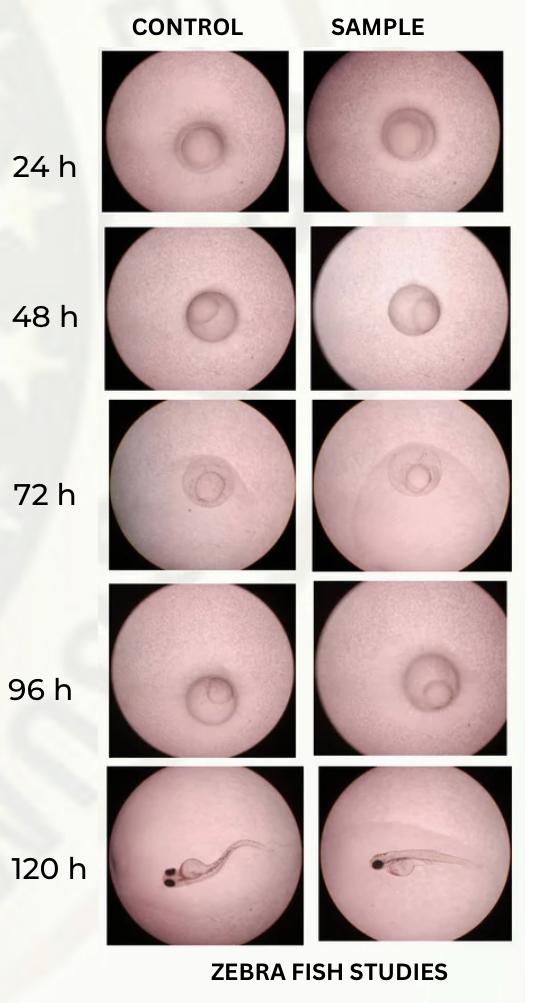
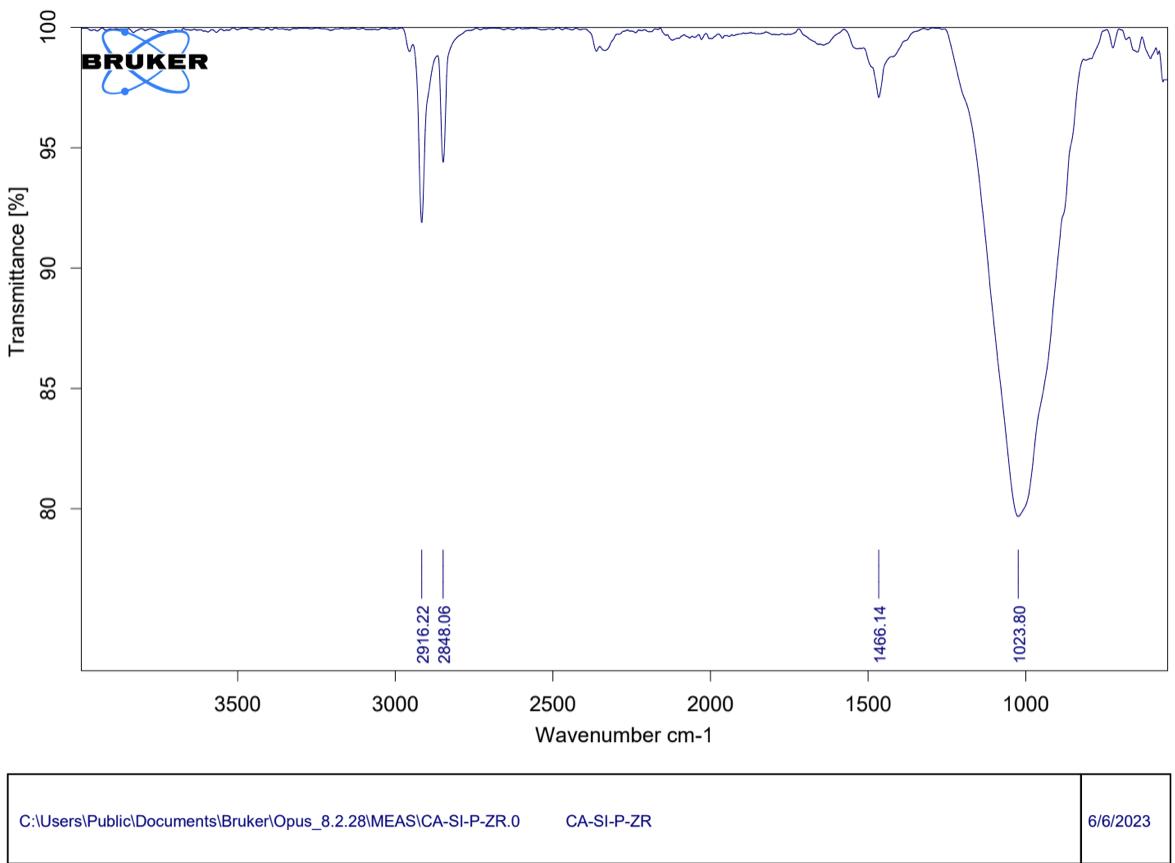
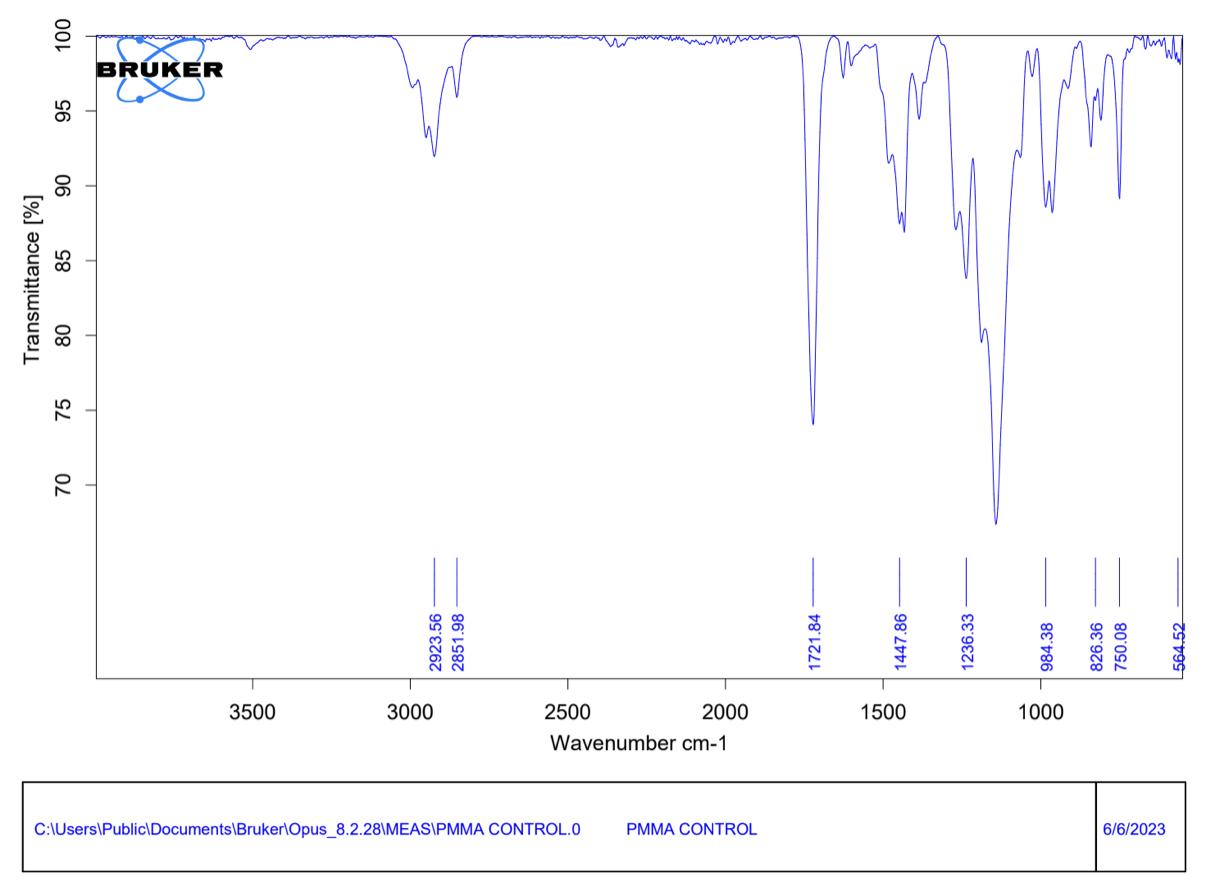


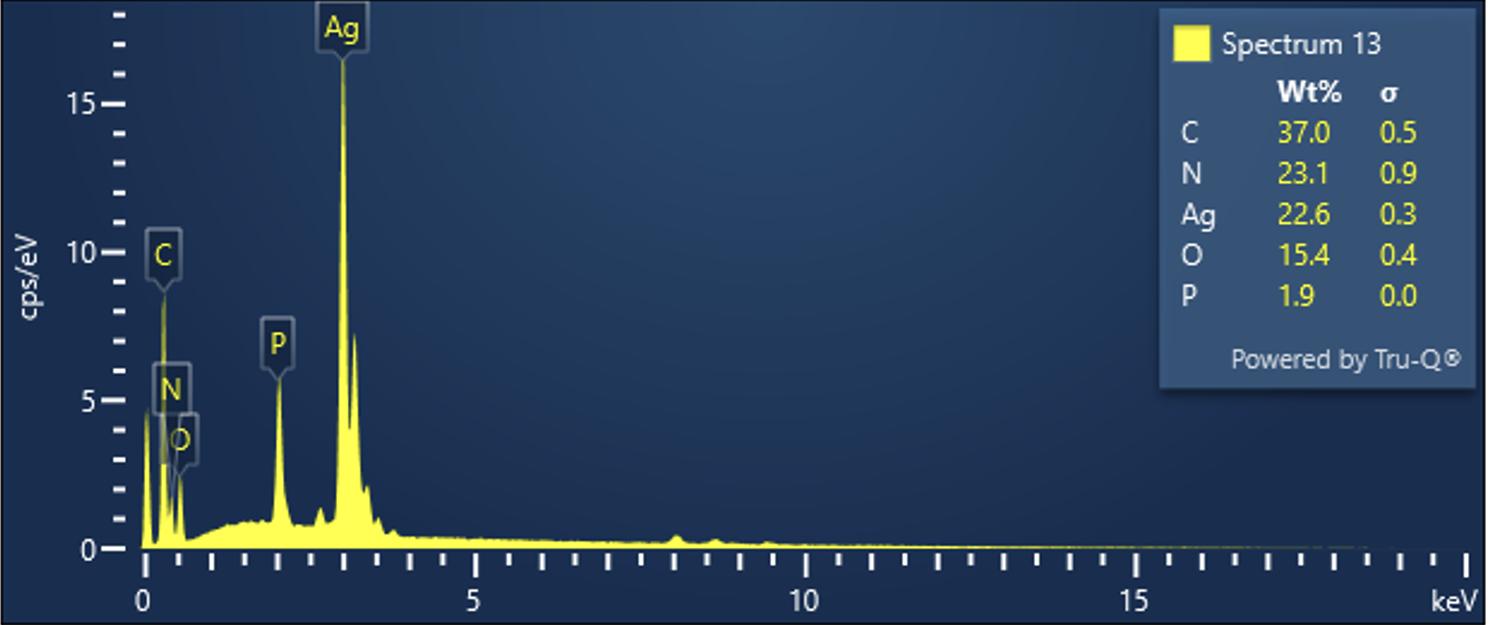
Figure 2: CHEMICAL COMPOSITION



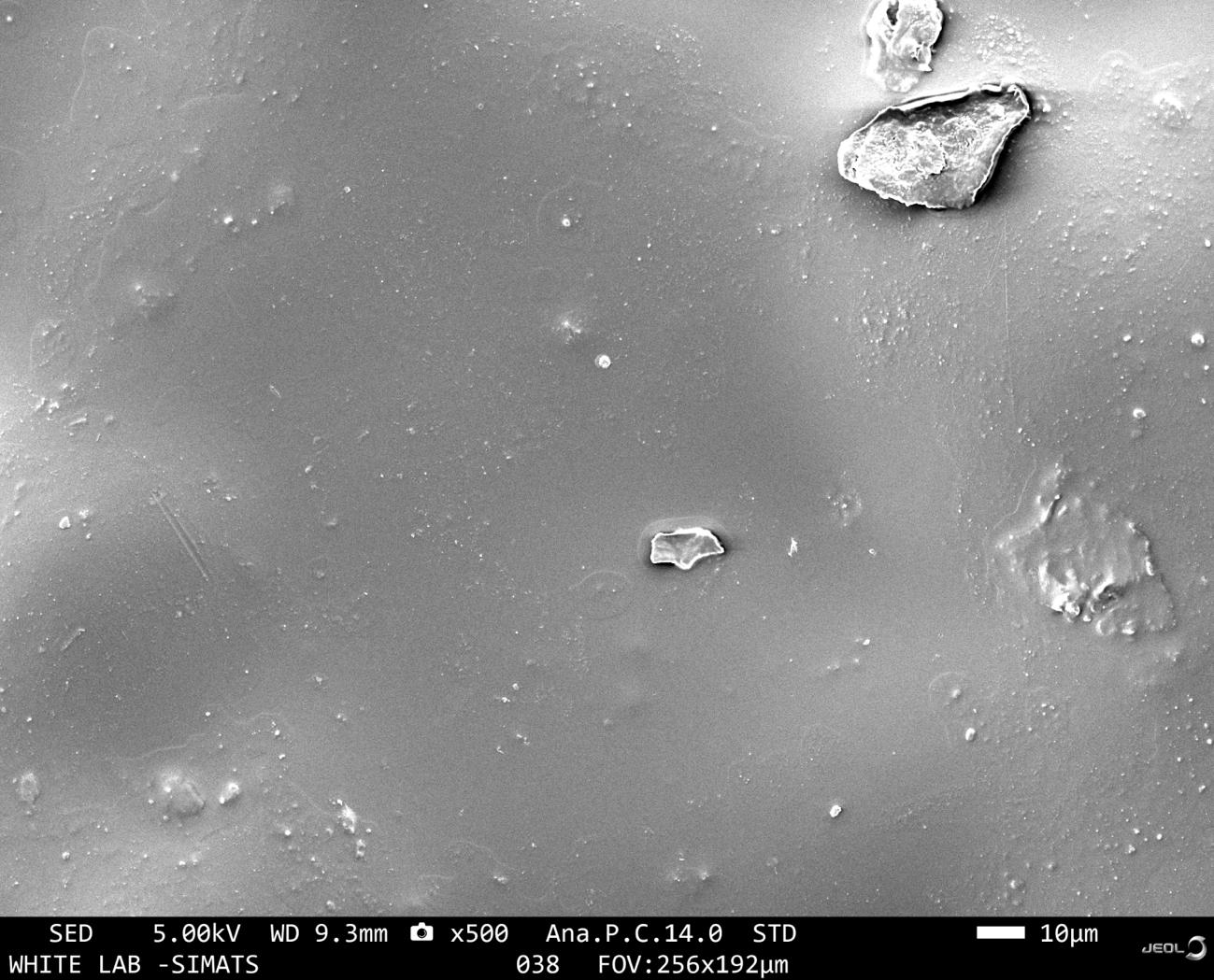
**Fig 1** a) FTIR of bioglass



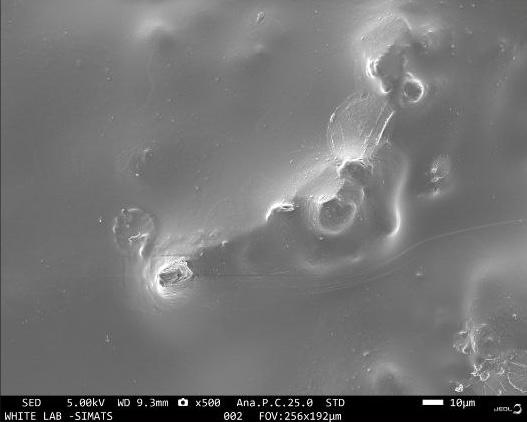
**Fig b** 1) PMMA scaffold



**Fig 2** EDAX of bioglass



**Fig 3** Pristine PMMA



**Fig 4**  PMMA Scaffold

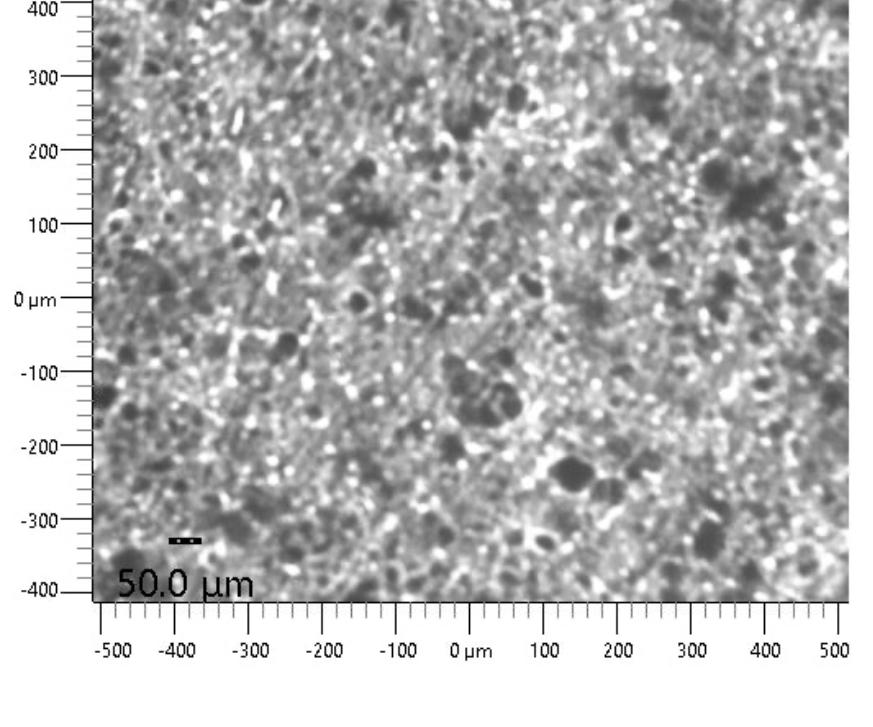
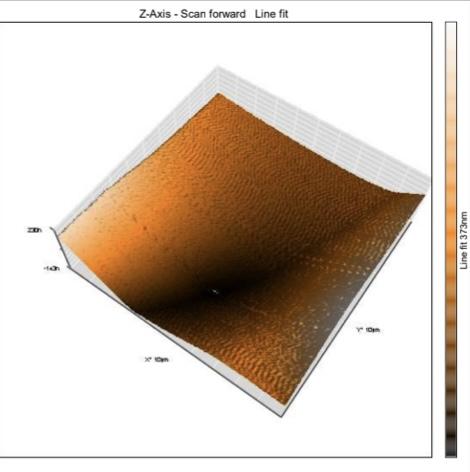
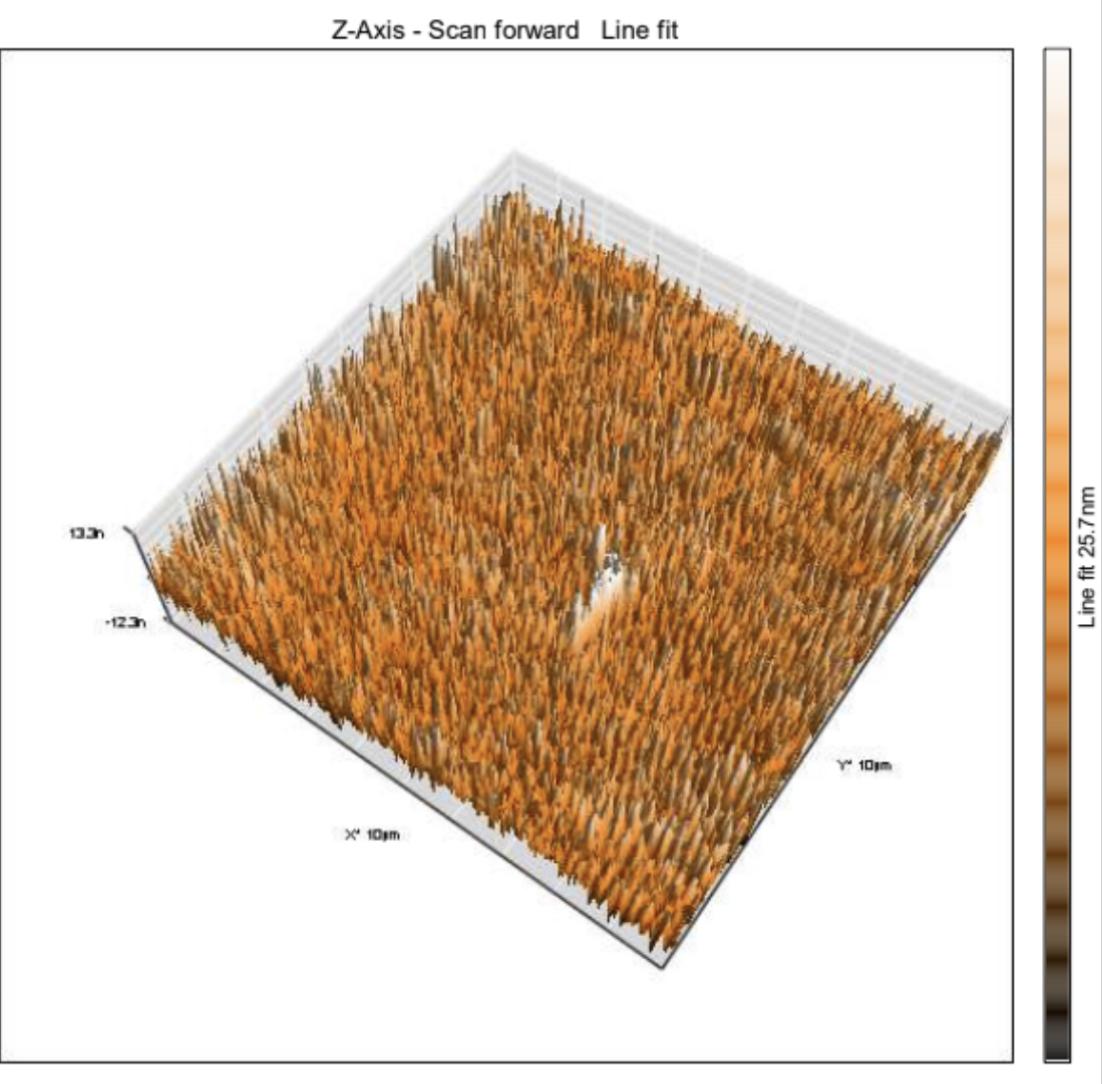


Figure 5: Light microscopy scaffold

## surface roughness



**Fig 6** A)PMMA SCAFFOLD



**Fig 7** Pristine PMMA

# CONTACT ANGLE

# Haemocompatability

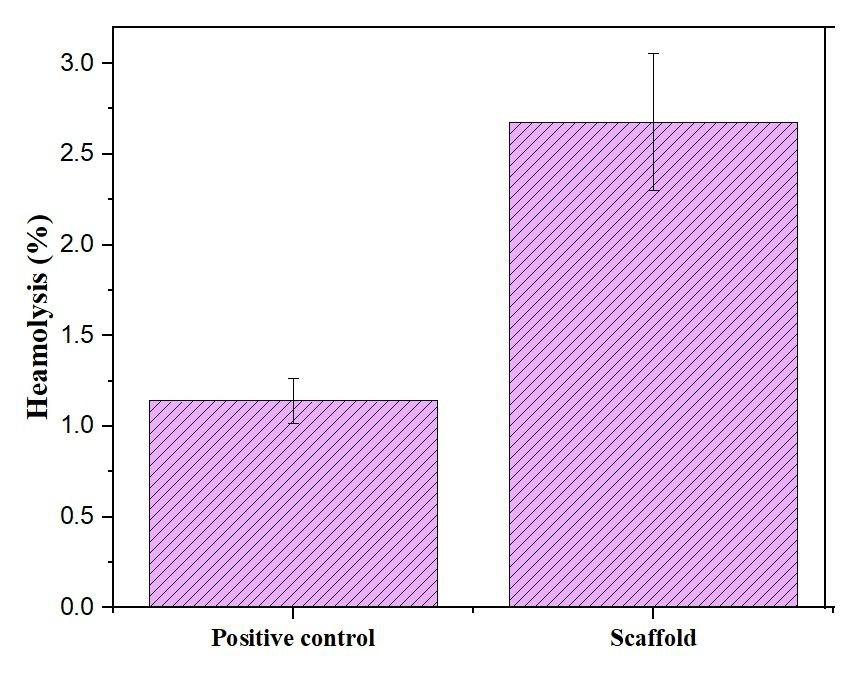


Figure 8: Haemocompatability

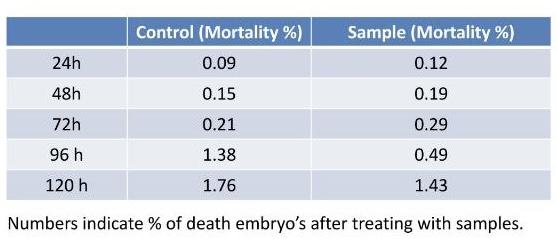


Figure 9: Table

The zirconium modified bio glass is synthesised successfully and it is confirmed by EDX,FTIR analysis.Bioglass has been modified with the help of polymer it is confirmed by FDR analysis.Surface morphology of PMMA modified bio glass also visualised and it confirms that bio glass attached on the surface of PMMA matrix.so,it is also evidenced by the AFM results scaffold surface roughness was increased. Further fabricated bioglass loaded PMMA was evaluated by two methods hemocompatibility and zebrafish analysis both the result revealed that synthesised scaffolds are biocompatible.

# DISCUSSION

The morphology of the Bioglass show’s crystalline appears in the SEM image, the elemental composition of it is confirmed by EDXA which shows Ca,Si,P,Mg . The polymer PMMA has a plane morphology and the SEM image of Bioglass with PMMA shows that Bioglass is bonded to the surface and has higher surface roughness than the pristine PMMA which is given by AFM analysis. To test the biocompatibility of the scaffold we used hemocompatibility,zebrafish toxicology assay and contact angle[(Hollinger et al., 2017; Ramalingam et al., 2012)](https://paperpile.com/c/QAwU8E/rwpA+gRQ3b).While our investigation aligns with many findings from existing studies on bioactive nanostructure scaffolds, it is essential to recognize that variations in experimental setups, materials, and specific research goals can lead to differences in outcomes. These differences contribute to the richness of knowledge in the field and emphasise the need for careful consideration of context when interpreting and applying research findings. Collectively, these studies contribute to the growing body of evidence supporting the use of bioactive scaffolds in tissue engineering and regenerative medicine, offering the potential for transformative clinical applications [(Lemos et al., 2021; Narayan, 2017)](https://paperpile.com/c/QAwU8E/1Rj93+TWpje).

# CONCLUSION

These scaffolds exhibit favourable biocompatibility, mechanical strength, and bioactivity, making them promising candidates for promoting tissue regeneration and repair. As we continue to refine their design and conduct further studies, bioactive nanostructure scaffolds hold the promise of revolutionising clinical treatments for various medical conditions. Future research and clinical trials will be instrumental in realising their full potential in healthcare.

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