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Polyetheretherketone as an alternative to titanium alloys in the additive manufacturing of orthopedic implants

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INTRODUCTION & AIM

The development of additive manufacturing technologies, including Selective Laser Melting (SLM), Direct Metal Laser Sintering (DMLS), and Powder Bed Fusion (PBF), has enabled the production of patient-specific orthopedic implants with complex geometries. Titanium alloys, particularly Ti6Al4V, Ti6Al7Nb, and Ti13Nb13Zr, are widely utilized due to their high mechanical strength and excellent corrosion resistance. However, increasing attention is being directed toward both the modification of existing titanium alloys and the exploration of alternative materials. In this context, high-performance polymers are emerging as promising alternative for metallic biomaterials in orthopedic applications.

The aim of the study was to demonstrate the potential of polymeric materials for orthopedic applications, in particular their suitability as structural materials for the fabrication of medical implants.

Table 1. Mechanical properties of selected metal biomaterials

Material	R_m [MPa]	$R_{p0,2}$[MPa]	A [%]	E [MPa]
Ti6Al4V	860	795	10	112.000
Ti6Al7Nb	900	800	10	110.000
Ti13Nb13Zr	973	836	10	79.000
Cortical bone	200	*	1.4	17.700

RESULTS & DISCUSSION

PEEK is a homopolymer with a linear structure, characterized by high molecular weight.

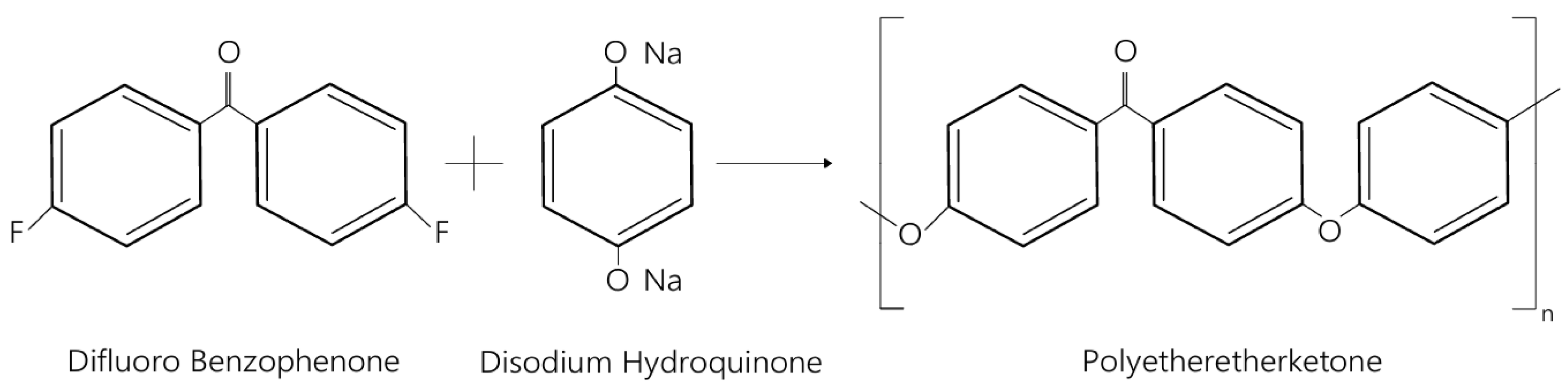

Figure 2. Structure of polyetheretherketone [own elaboration]

This material exhibits excellent mechanical properties, high chemical resistance and biocompatibility, which makes it widely used in medicine, particularly in biomedical engineering. PEEK implants are manufactured, such as skull implants and orthopedic implants including: bone plates, spinal, knee and hip implants.

Figure 3. PEEK orthopedic implants

CONCLUSIONS

The findings indicate that PEEK constitutes a promising alternative to titanium alloys in the additive manufacturing of orthopedic implants.

METHOD

This study is based on analysis of current literature concerning the application of PEEK in additive manufacturing technologies, with particular emphasis on Fused Filament Fabrication (FFF). The physicochemical and mechanical properties of PEEK were evaluated in the context of its suitability for orthopedic implants. Based on a review of scientific articles published between 2017 and 2026, a literature review was conducted on the use of PEEK in orthopedic implants manufactured using 3D printing technology. Attention was paid to the selection of additive manufacturing process parameters and the effect of sample orientation during printing on the mechanical properties of the resulting structures.

Figure 1. Layout of print samples

Table 2. Strength test results of samples produced using different printing Parameters [2]

Strength Tests		Tensile [MPa]	Bending [MPa]
Orientation of Test Samples	0°	67.14	122.53
	90°	66.97	156.84
Angle Fills	±10°	69.35	144.16
	±30° or ±20°	56.65	122.53
Extrusion Speed	0.8x	31.78	56.48
	1x 1.2x	69.35	160.88

Table 3. Effect of heat treatment and time on strength properties [2]

Strength Tests		Tensile [MPa]	Bending [MPa]
Temperature	150 °C	70.84	157.37
	300°	74.24	167.13
Time	30 min	74.24	167.13
	2 h	77.26	172.98

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

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1. doi.org/10.3390/polym15092209
2. doi.org/10.3390/polym15092209
3. doi.org/10.1016/j.cegh.2019.01.003