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ANALYSIS OF THE MATERIALS USED IN SOME RAPID PROTOTYPING TECHNOLOGIES, FROM THE POINT OF VIEW OF MICROHARDNESS AND SURFACE QUALITY

Beatrice TUDOR, Claudiu GRIGORAS
"Dunarea de Jos" University of Galati, Romania
e-mail: beatrice.tudor@ugal.ro

ABSTRACT

The paper presents a comparative study, from the point of view of microhardness and surface quality, of samples made from materials used in rapid prototyping technologies, namely photopolymer resin and PLA. Microhardness determinations were made for both materials, with Micro-Vickers HDT-VS1D INSIZE digital automatic hardness tester, and the surface of the samples was analysed, from a qualitative point of view, with the optical microscope, OLYMPUS BX51M.

KEYWORDS: microhardness, surface, photopolymer resin, PLA, hydrogels

1. Introduction

Rapid prototyping, along with computerization and automation technologies, have favoured mass production of customized models for the medical field. These designs have a low cost, it is made in a relatively short time and reduce the risk of errors.

Synthetic polymers are also known as artificial polymers, being structured into three large classes: thermoplastics, elastomers and synthetic fibres. These synthetic polymers have applications in biomedicine, diagnostics and tissue engineering. They form an important category of materials also used for 3D printing, not only for biomedical applications. They have very good mechanical properties and a low price. The most imported synthetic polymers that are 3D printed are: Poly (lactic acid - PLA), Poly (caprolactone- PCL), Poly (D, L-lactic-co-glycolic acid - PLGA), (PEEK) etc. [1, 3].

The most used materials for 3D printing are non-toxic hydrogels. The use of FDM extrusion printing and SLA rapid prototyping technology are essential in the 3D printing of hydrogels.

Other materials used in 3D printing, in addition to the mentioned materials, can be: silk, fibrin, decellularized ECM, matrigel of natural origin, elastin, etc. [2].

2. Experimental determinations

In the study, the microhardness of the samples made from photopolymer resin and PLA was determined.

To compare the strength of these two materials, used in dental bridges, we used the Micro-Vickers HDT-VS1D INSIZE digital automatic hardness tester.

Were made three different determinations, for each material, for make an average of the determinations.

The determinations were made on samples from PLA material, and

photopolymer resin.

Both samples were analyzed with the same specification of the, respectively:

- load (kg) - 0.5;
- replacement time (s)-10;
- the objective at 40x;
- brightness of 4 lx.

The stages through which the hardness on the device determinations were made are:

For both samples of PLA material and photopolymer resin, we performed the following steps:

- placing the sample on the support of the microhardness measuring device (Fig. 1);
- fixing the specifications of the device (Fig. 2);
- focusing on the area, by marking the length and width (Fig. 3);
- generating data by turning on the device.

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Fig. 1. *Placing the sample on the holder of the hardness measuring device*

Fig. 2. *Fixing the specifications of the device*

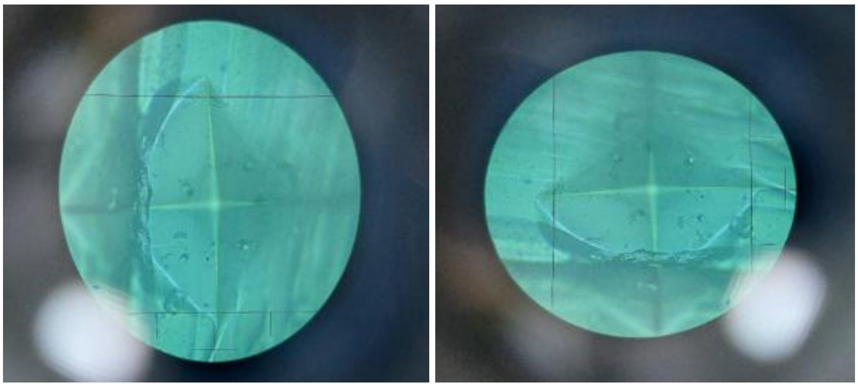


Fig. 3. *Marking the length and width of the sample from PLA material*

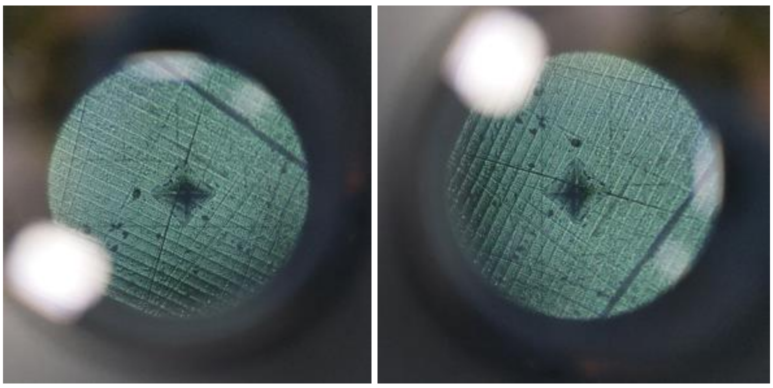


Fig. 4. *Marking the length and width of the sample from photopolymer resin*

Table 1. *Results from hardness results*

Material	No. of determinations	D1 (Distance 1)	D2 (Distance 2)	HV Hardness
PLA	1	169.89	194.57	27.9
	2	160.15	203.05	28.1
	3	201.30	158.87	28.5
Average value		**177.11**	**185.49**	**28.2**
Photopolymer resin	1	101.37	108.53	84.1
	2	119.57	143.06	53.7
	3	114.55	99.35	81
Average value		**111.83**	**116.98**	**72.9**

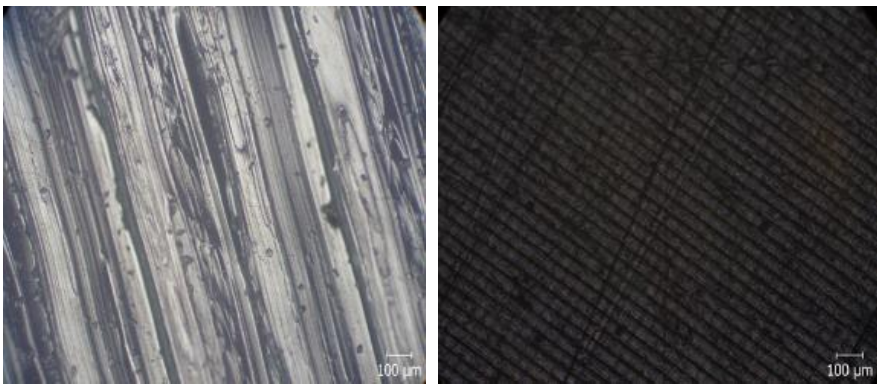
Following the determinations, we notice that the photopolymer resin sample has a higher hardness than the PLA material sample. This is also due to the action of UV light, which increased the resistance of the sample. This determination of hardness recommends the use of photopolymer resin in the creation of models for maxillo-facial surgery [4, 7].

Following the results obtained after determining the microhardness, we notice that the photopolymer resin sample has a higher hardness than the PLA material sample. This is also due to the action of UV light, which increased the resistance of the sample. This results recommend the use of photopolymer resin in making models for maxillofacial surgery [4, 7].

The samples were analysed with the optical microscope OLYMPUS BX51M, from the metallography laboratory, in order to visualize the appearance of the surfaces as precisely as possible (Fig. 5).

The optical images obtained for the surfaces of PLA samples and photopolymer resin are presented in Fig. 6.

Fig. 5. *OLYMPUS BX51M optical microscope*



PLA material   Photopolymer resin

Fig. 6. *Optical images for sample surfaces (100 µm)*

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After visualizing the quality of the sample surfaces, it is observed that the sample made of photopolymer resin has a much lower roughness than the sample from PLA.

This study may be useful in choosing the optimal material in various simulations and medical applications.

3. Conclusions

The photopolymer resin sample has a higher hardness than the PLA material sample.

In terms of surface quality, the photopolymer resin sample has a much lower roughness than the PLA sample.

The higher hardness of the photopolymer resin and the quality of the surface, recommend the use of this type of material, in making models for maxillo-facial surgery.

References

[1]. Cernica D., Márton E., Mester A., Chițu M., Benedek I., *Tehnica imprimării 3D în imagistică și aplicațiile medicale*, 2021.

[2]. Tayebi L., Masaeli R., Zandsalimi K., *3D Printing in Oral & Maxillofacial Surgery*.

[3]. Tsoulfas G., Bangeas P. I., Suri J. S., *3D printing: applications in medicine and surgery*, Volume 1.

[4]. Tappa K., Jammalamadaka U., *Novel biomaterials used in medical 3D printing techniques*, J. Funct. Biomater., vol. 9, no. 1, doi: 10.3390/jfb9010017, 2018.

[5]. Meneghello R., Savio G., Raffaeli R., Cerardi A., Turchetto M., Planchenstainer L., *An integrated methodology for the functional design of dental prosthesis,* Int. J. Interact. Des. Manuf., vol. 7, no. 2, p. 103-114, doi: 10.1007/s12008-012-0169-5, 2013.

[6]. Budak I., Kosec B., Sokovic M., *Application of contemporary engineering techniques and technologies in the field of dental prosthetics Analysis and modelling*, J. Achiev. Mater. Manuf. Eng., vol. 54, no. 2, p. 233-241, 2012.

[7]. Strub J. R., Rekow E. D., Witkowski S., Strub J. R., Rekow E. D., Witkowski S., *Computer aided design and fabrication of dental restorations: current systems and future possibilities*, J Am Dent Assoc,137:1289-96., vol. 137, 2006.

[8]. Tian Y. *et al.*, *A Review of 3D Printing in Dentistry: Technologies, Affecting Factors, and Applications*, Scanning, vol. 2021, doi: 10.1155/2021/9950131, 2021.