Intellectual Output_O2:
EMERALD e-toolkit manual for digital learning in producing biomimetic mechatronic systems

Toolkit 3
3D Printing

Diana BĂILĂ,

Polytechnic University of Bucharest | UPB

diana.baila@cont-edu.pub.ro

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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS

E-toolkit – 3D Printing

Project Title	**European network for 3D printing of biomimetic mechatronic systems** **21-COP-0019**
Output	**IO2 - EMERALD e-toolkit manual for digital learning in producing biomimetic manufacturing method**
Module	**3D Printing**
Date of Delivery	**January 2023**
Authors	**Diana BĂILĂ**
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1. 3D Printing toolkit for medical applications

Product 1: Personalized Orthosis – SLDPRT. file Poznan University of Technology Partner

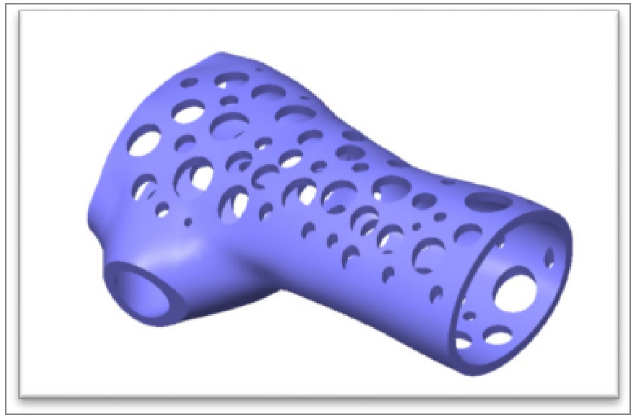

Fig.1. Personalised orthosis

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1.1. CAD Modeling

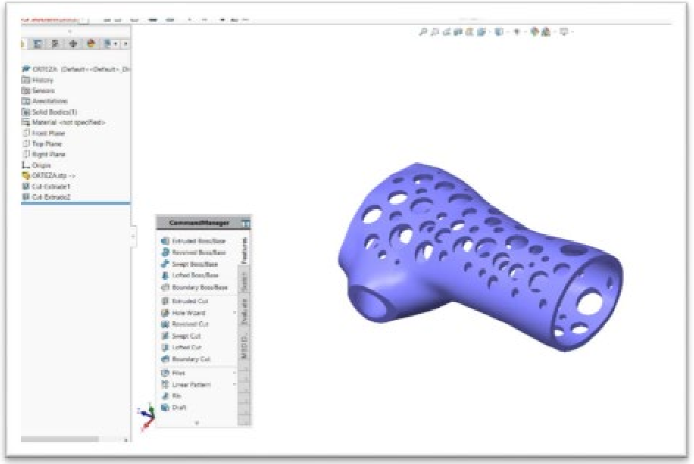

Fig.2. SolidWorks – SLDPRT. file

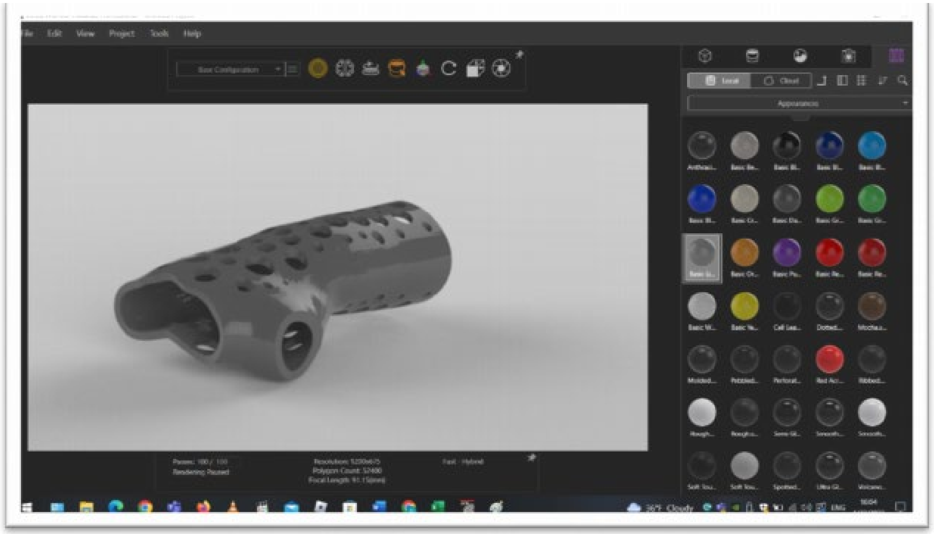

Fig.3. SolidWorks Visualize 2019 – orthosis with different texture mapping

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1.2. STL File

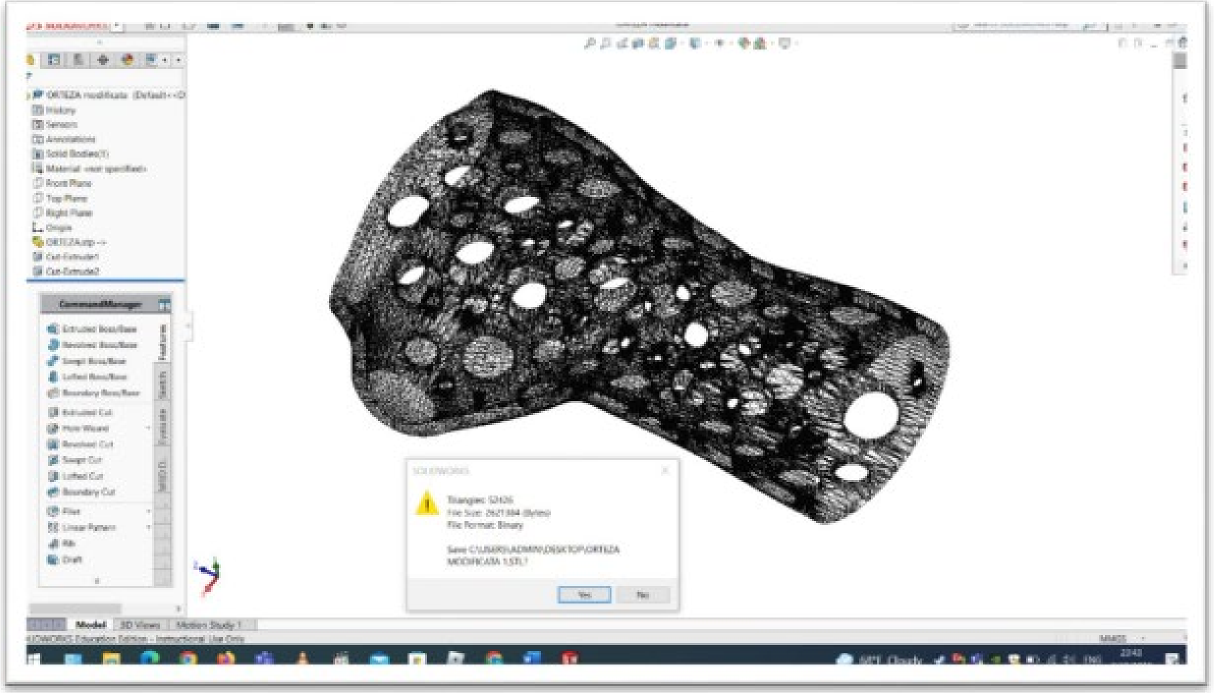

Fig.4.Orthosis meshing – STL. file

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1.3. 3D Printing software's

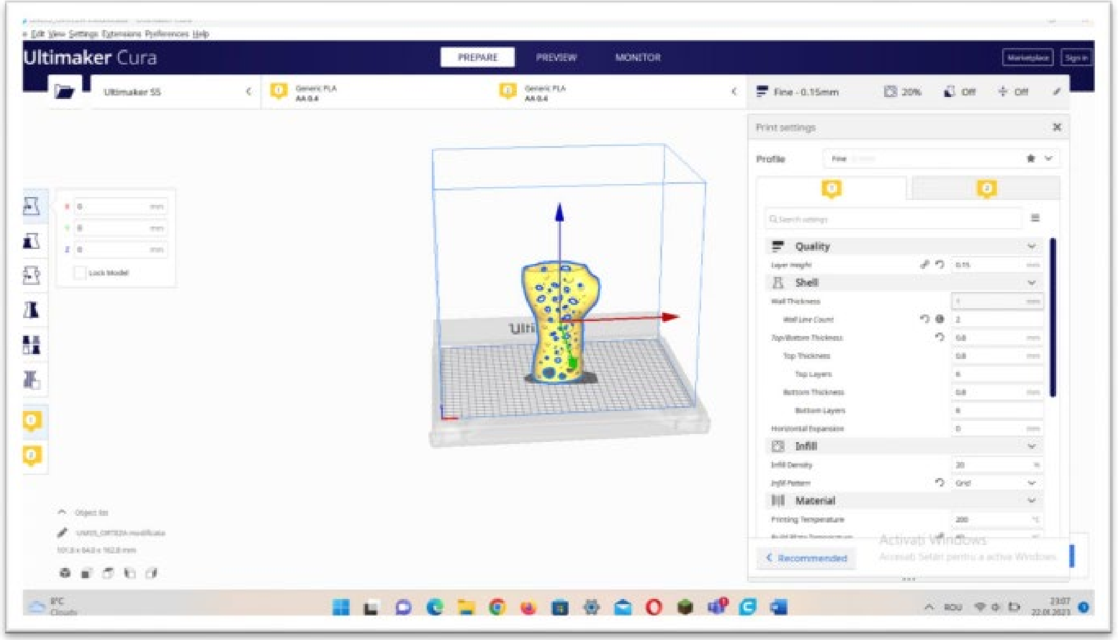

Fig.5. Open Ultimaker Cura software and introduce the STL. file of part

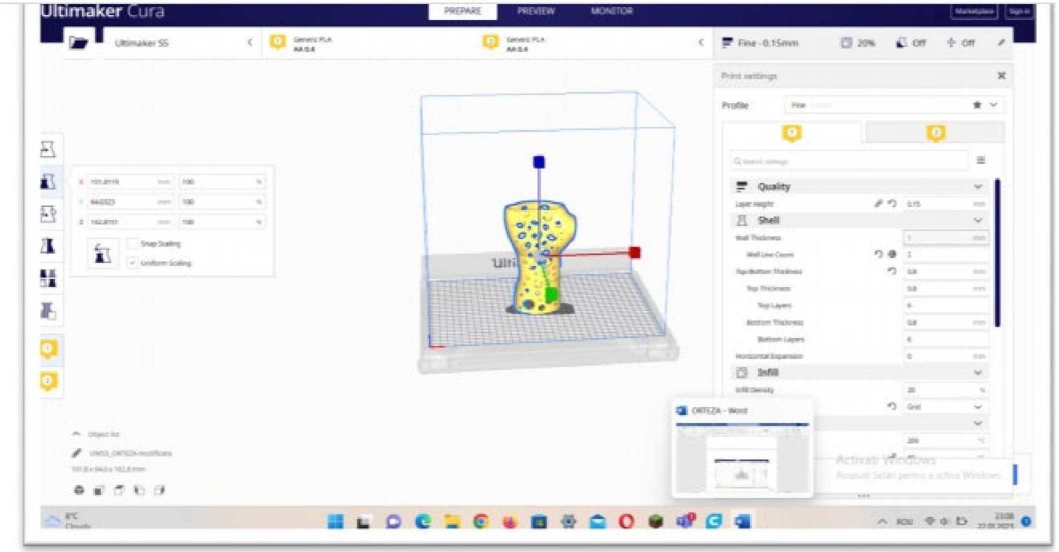

Fig.6. Change the part scale, after X, Y, Z axis

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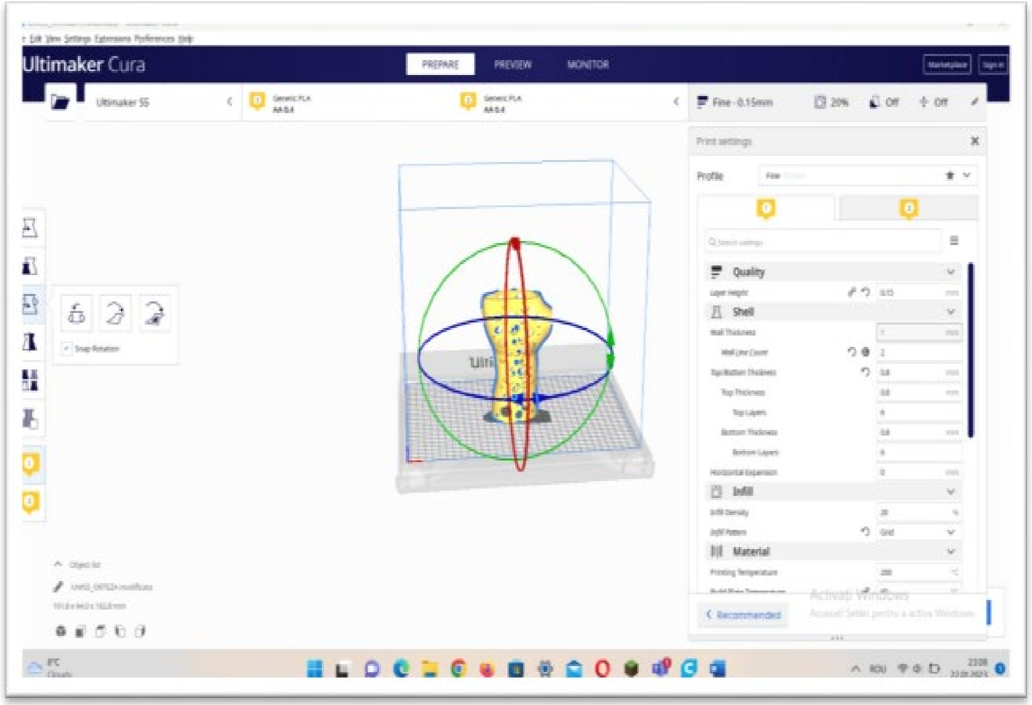

Fig.7. Rotation of the part after X, Y, Z axis

Table 1. The mechanical properties of Acrylonitrile Butadiene Styrene (ABS)

Properties	Values	Units
Density	1.0-1.4	g/cm3
Poisson's Ratio	0.35	-
Shear Modulus G	1,03-1,07	GPa
Melting Temperature	200	ºC
Glass transition temperature	105	ºC
Thermal Conductivity	0,25	W/m-K
Extruded Temperature	200-230	ºC
Heat Deflection Temperature, 1,81 MPa	81	ºC
Young's modulus	1,79-3,2	GPa
Tensile Strength	29,8-43	MPa
Compressive Strength	76-78	MPa
Elongation at Break	10-50	%
Flexural modulus	2,1-7,6	GPa
Hardness Shore D	100	
Izod Impact Strength	58	kJ/m2
Yield Strength	28-120	MPa
Standard Tolerance	+/-0.05	mm
Biodegradable	-	-
Melt flow	12-23	g/10min
Rockwell Hardness	R102-R104	

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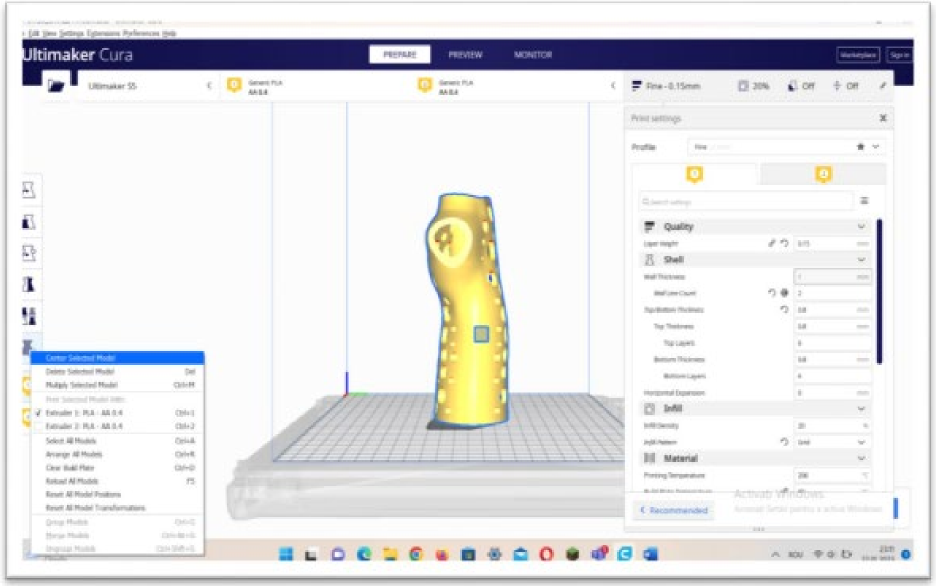

Fig 8. 3D Printing Extruder chosen

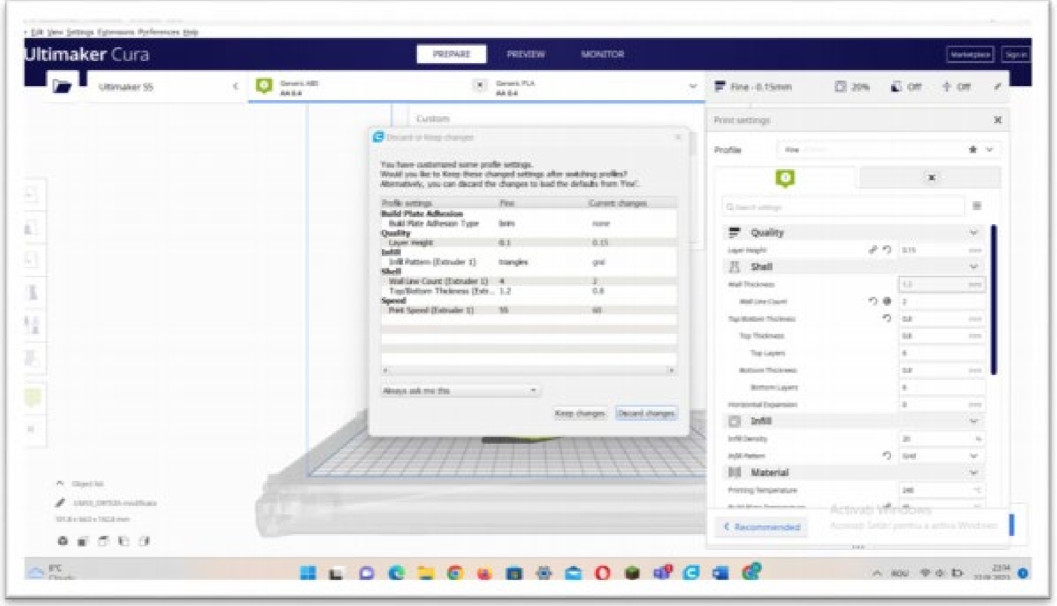

Fig.9. Choosing the ABS filament for 3D Printing

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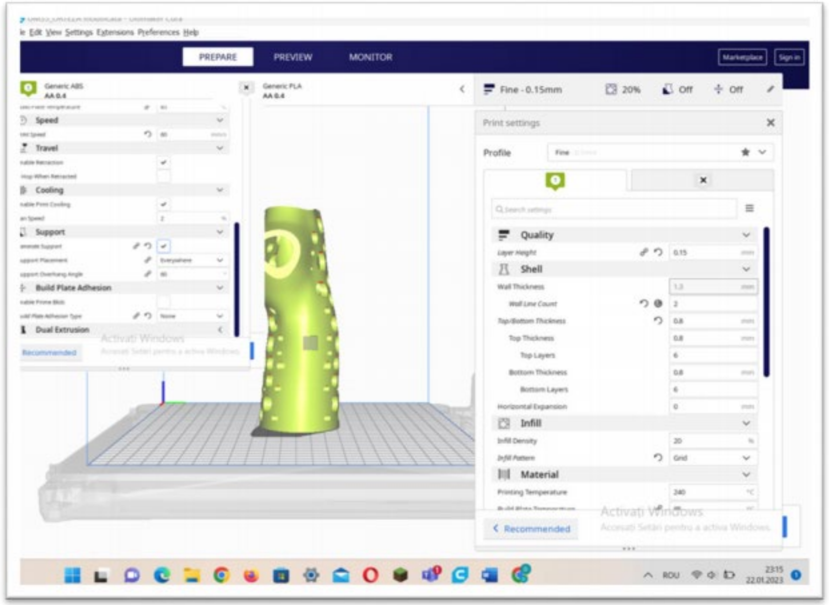

Fig.10b. Manufacturing parameters for custom 3D Printing without supports

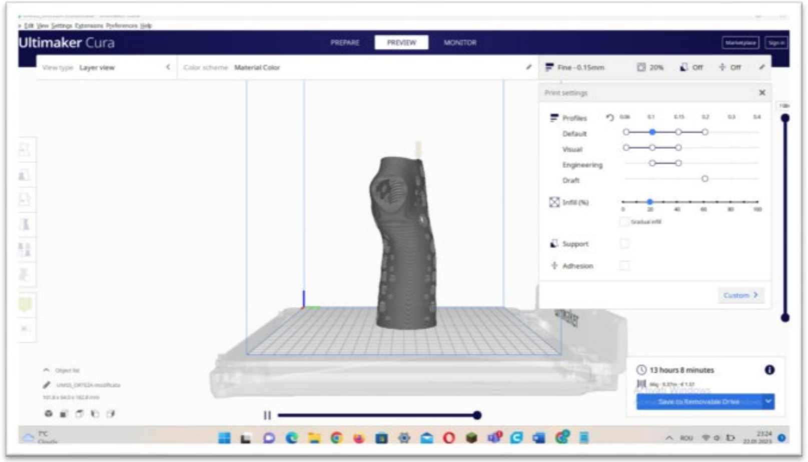

Fig.11. Recommended manufacturing parameters for the part by the software

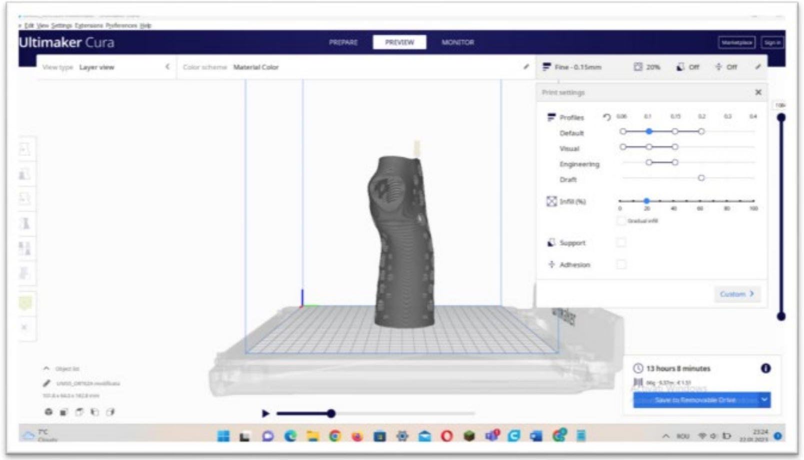

Fig.12. Preview the manufacturing 3D Printing process

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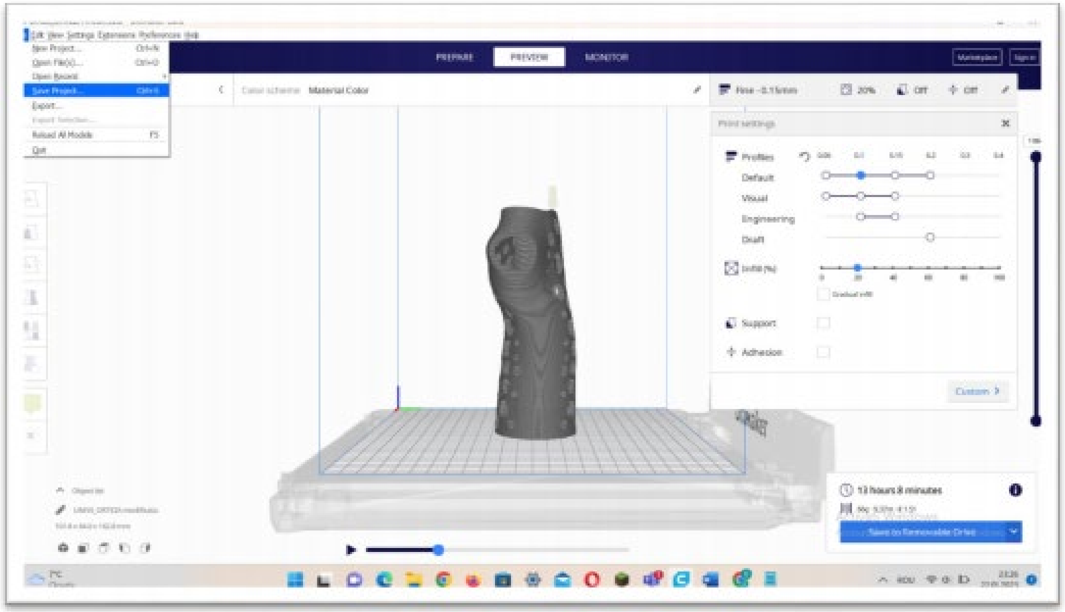

Fig.13. Save Project

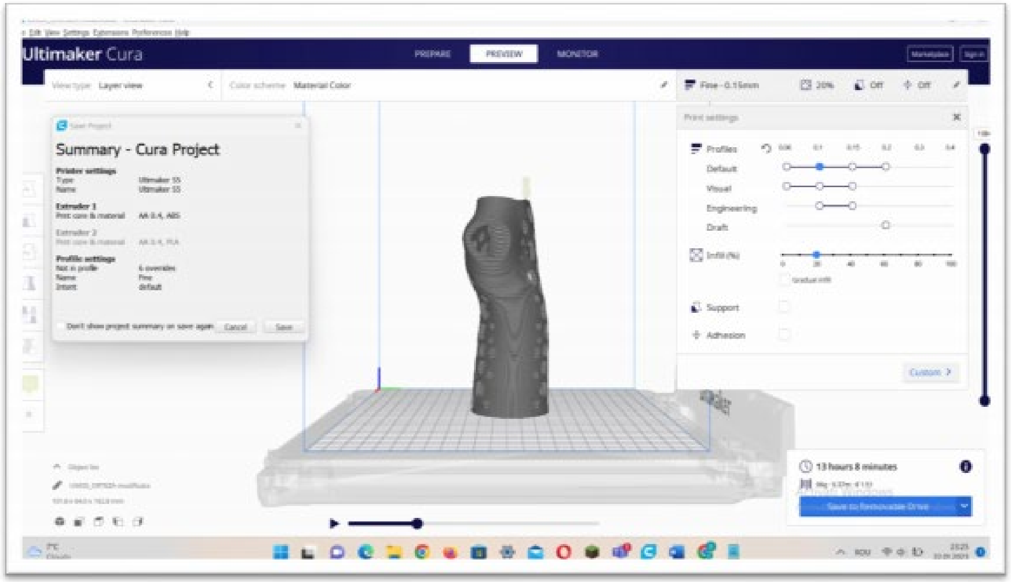

Fig.14. Summary- Cura Project

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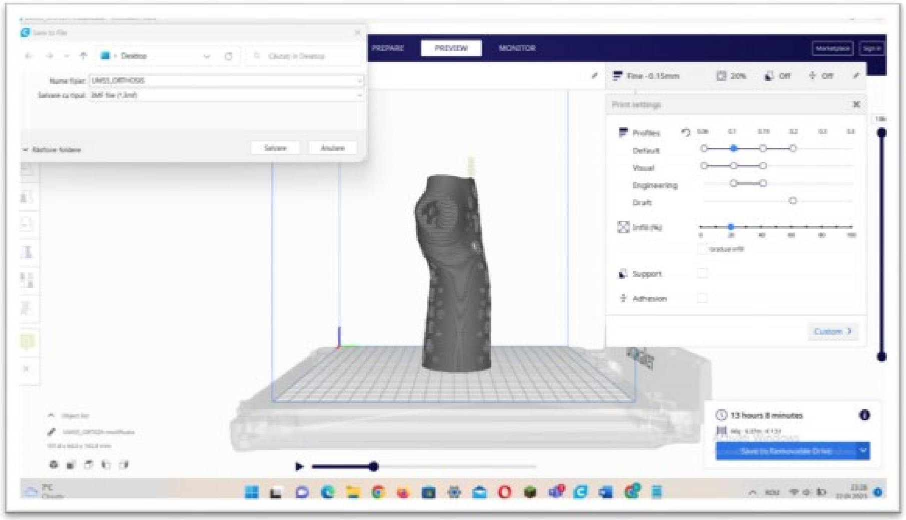

Fig.15. Save project as 3mf. file

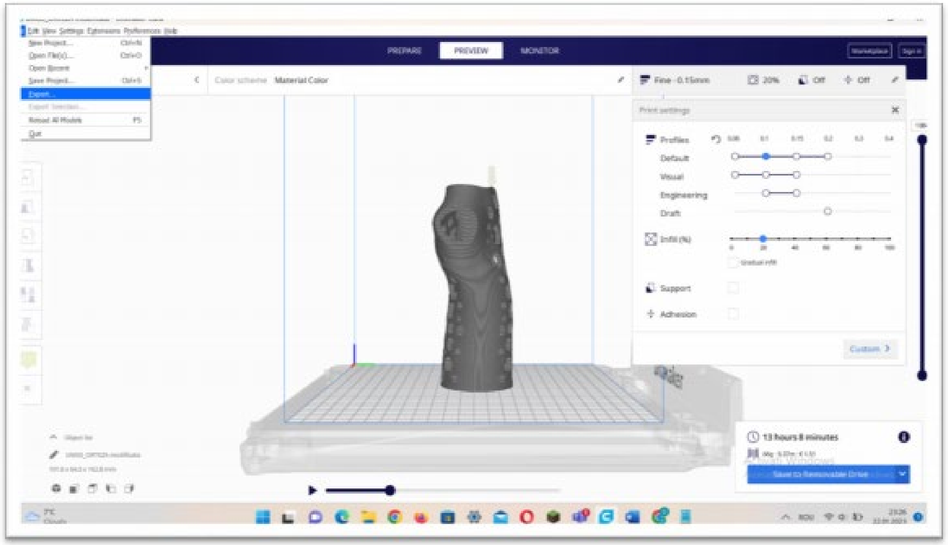

Fig.16. Export file

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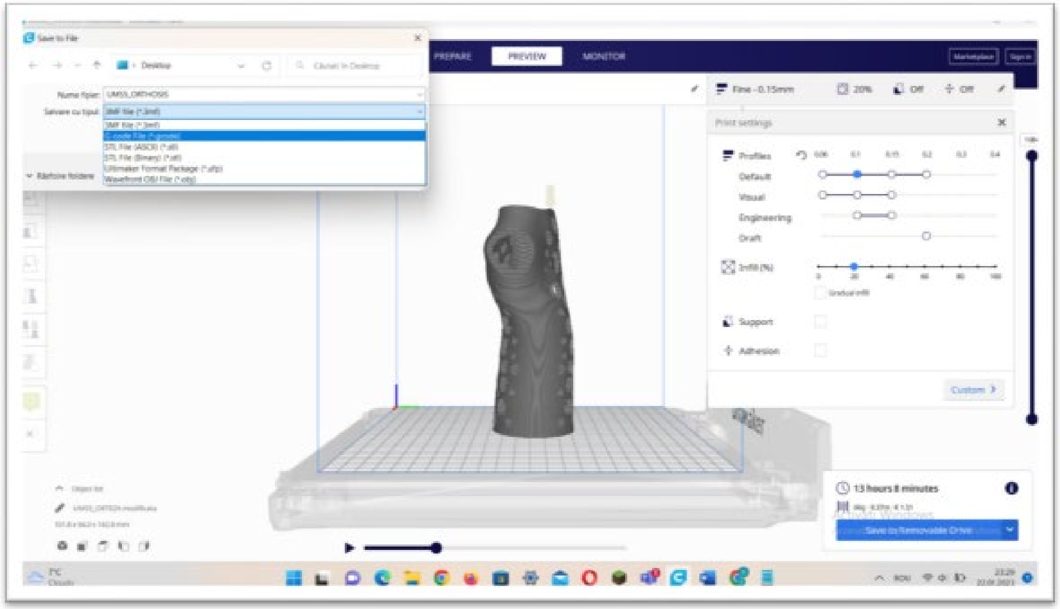

Fig.17. Different extension for file export

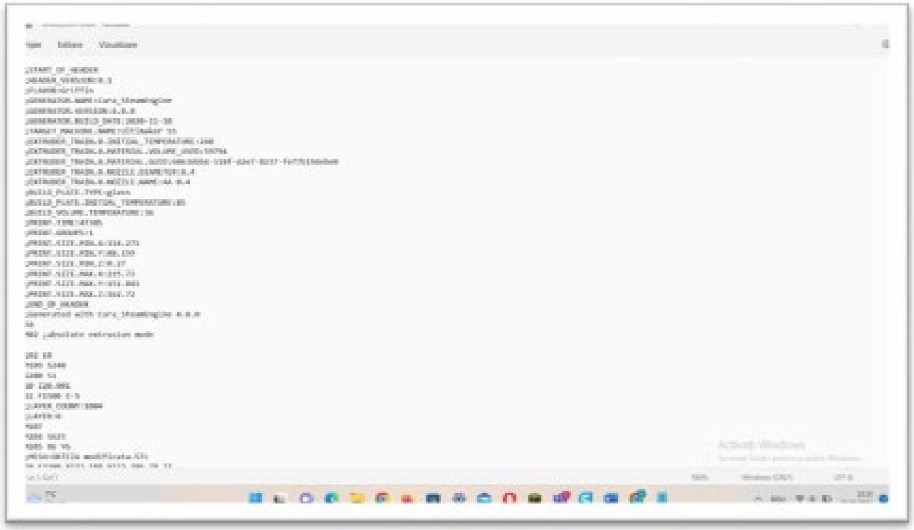

Fig.18. G-code file for personalized orthosis part

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Fig.19. Personalized Orthosis printed by FDM technology

Product 2: Robotic Arm – ASM, SLDASM. file Poznan University of Technology Partner

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2.1 CAD Modeling

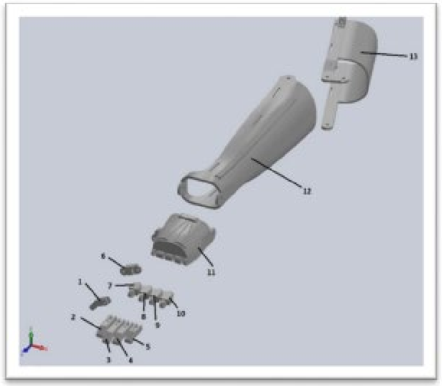

Fig.20. Exploded View – Robotic Arm

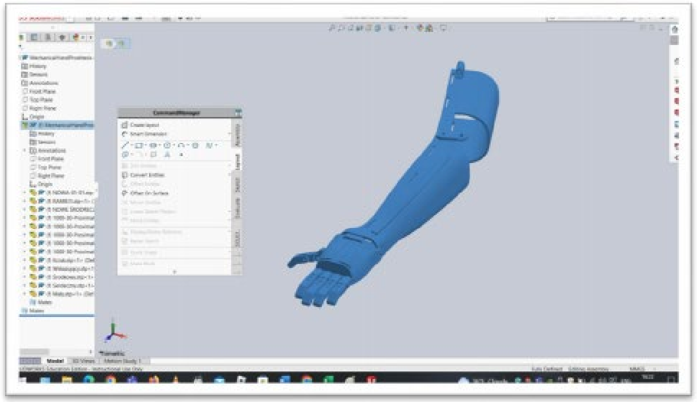

Fig.21. Robotic arm assembly – ASM, SLDASM. File

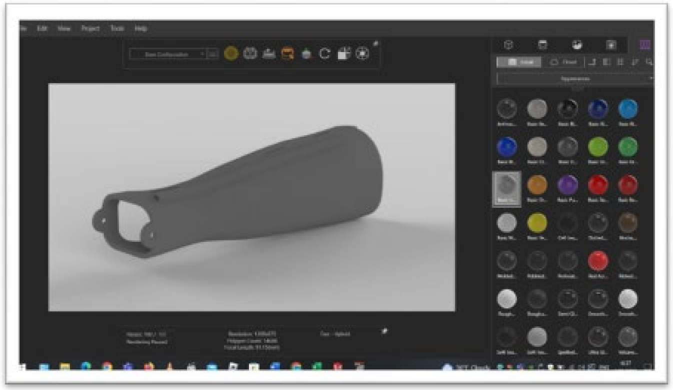

Fig.22. SolidWorks Visualize 2019 – robotic arm with different texture mapping

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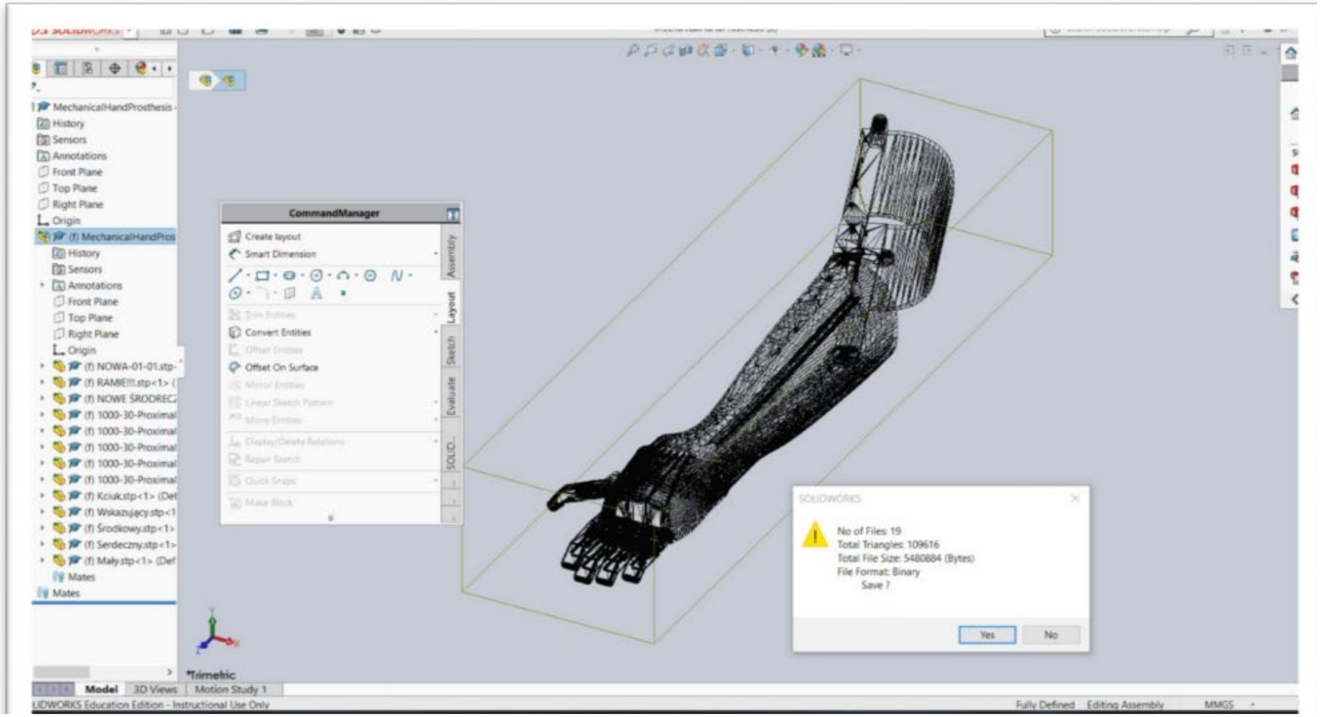
2.2. STL file



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2.3. 3D Printing software’s

Table 2. The mechanical properties of PLA (Polylactic Acid)

Properties	Values	Units
Density	1.25	g/cm3
Poisson’s Ratio	0.36	-
Shear Modulus G	2.4	GPa
Melting Temperature	173	°C
Glass transition temperature	60	°C
Thermal Conductivity	0.13	W/m-K
Extruded Temperature	160-220	°C
Heat Resistance	110	°C
Young’s modulus	3.5	GPa
Tensile Strength	61.5	MPa
Compressive Strength	93.8	MPa
Elongation at Break	6	%
Flexural strength	88.8	MPa
Hardness Shore D	85	A
Impact Strength	30.8	kJ/m2
Yield Strength	60	MPa
Standard Tolerance	+/-0.05	mm
Biodegradable	yes	-

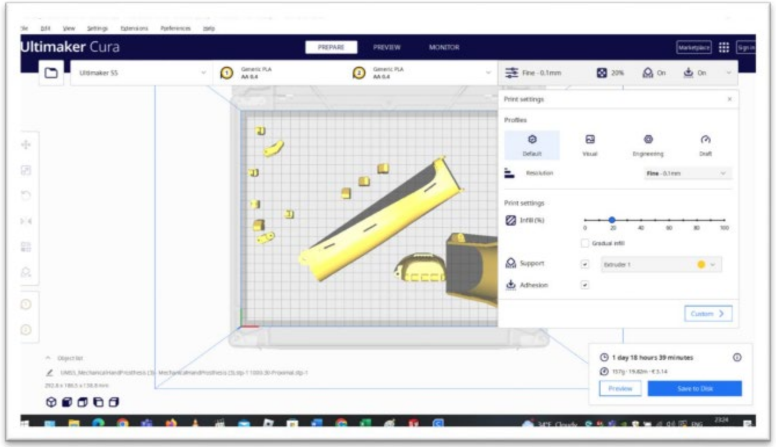

Fig.28. Recommended manufacturing parameters for the part by the software

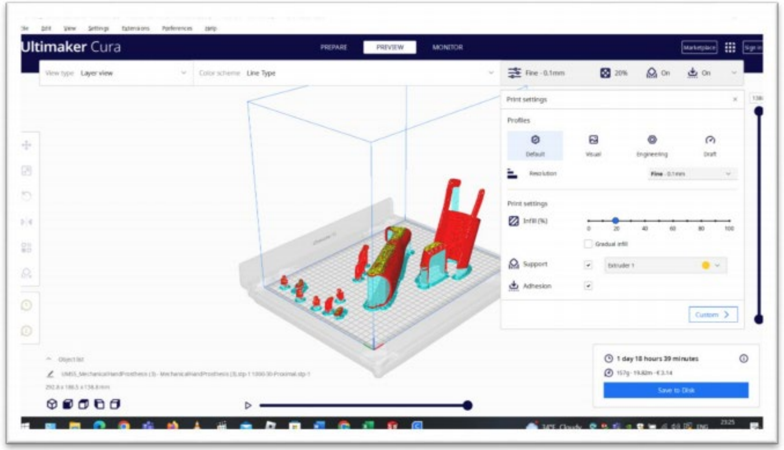

Fig.29. Preview the manufacturing 3D Printing process

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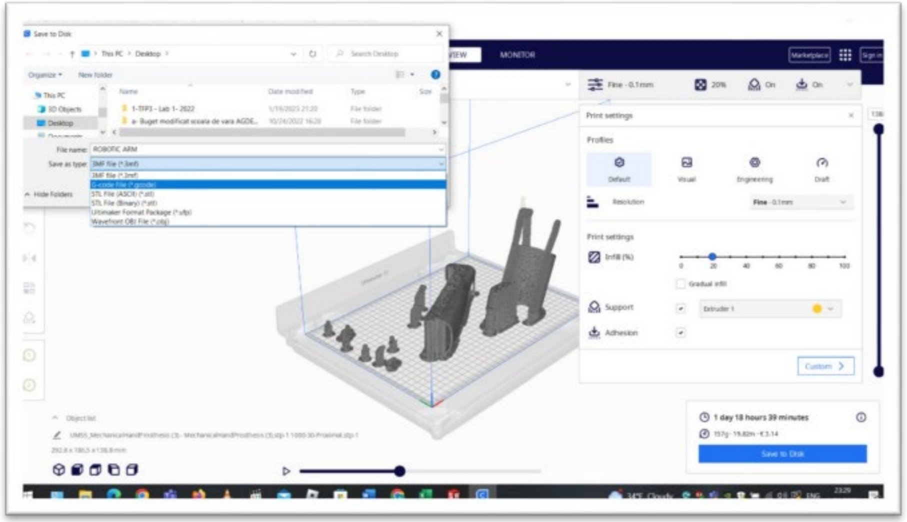

Fig.32. Different extensions for file export

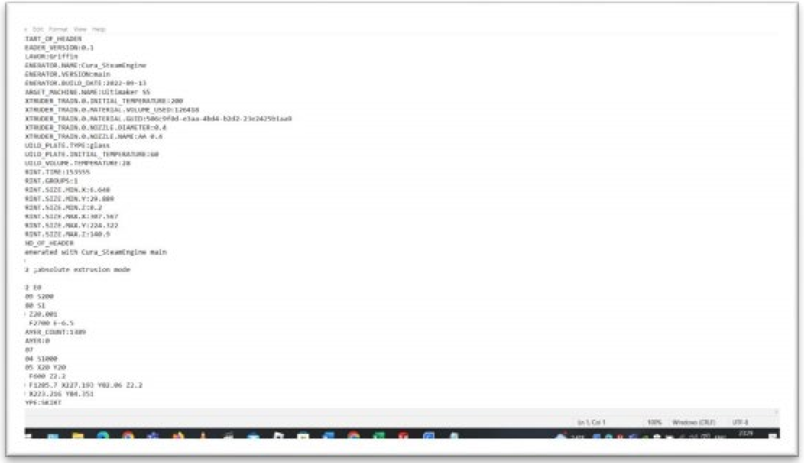

Fig.33. G-code file for Robotic Arm

Fig.34. Robotic Arm printed by FDM technology and assembled

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Product 3: 3D Fresh Printing of organ phantom for surgical applications – site https://www.embodi3d.com/

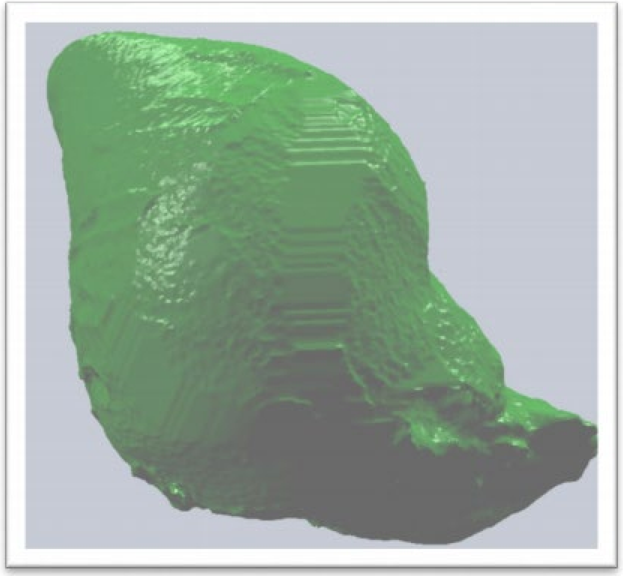

Fig.35. Liver model for printing

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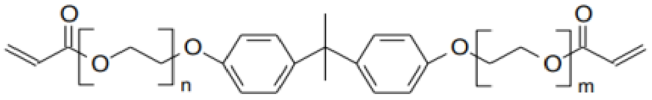
Table 3. The mechanical properties of Bisphenol A Ethoxylate Diacrylate

Bisphenol A Ethoxylate Diacrylate



n + m ~ 4

INTRODUCTION

EBECRYL 150 is an ethoxylated bisphenol A diacrylate commonly used as reactive diluent in UV/EB cure applications. EBECRYL 150 can improve the cure response, hardness, and chemical resistance of UV/EB curable coatings and inks while maintaining good adhesion, and without imparting brittleness.

PERFORMANCE HIGHLIGHTS

EBECRYL 150 is characterized by:

- High reactivity
- Moderate viscosity
- High refractive index

UV/EB curable formulated products containing EBECRYL 150 are characterized by:

- Hardness
- Chemical resistance
- Good adhesion
- Improved wetting

The actual properties of UV/EB cured products also depend on the selection of other formulation components such as oligomers, additives and photoinitiators.

SPECIFICATIONS[1]	VALUE
Acid value, mg KOH/g, max.	5
Appearance	Clear liquid
Color, Gardner scale, max.	2
Viscosity, 25°C, cP/mPa·s	1150-1650

TYPICAL PHYSICAL PROPERTIES	
Density, g/ml at 25°C	1.14
Flash point, Setaflash, °C	>100
Functionality, theoretical	2
Refractive index (n_D at 20°C)	1.5294
Vapor pressure, mm Hg at 20°C	<0.01

TYPICAL CURED PROPERTIES[2]	
Tensile strength, psi (MPa)	6300 (43)
Elongation at break, %	9
Young's modulus, psi (MPa)	180000 (1241)
Glass transition temperature, °C[3]	41

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3.1. CAD Modeling

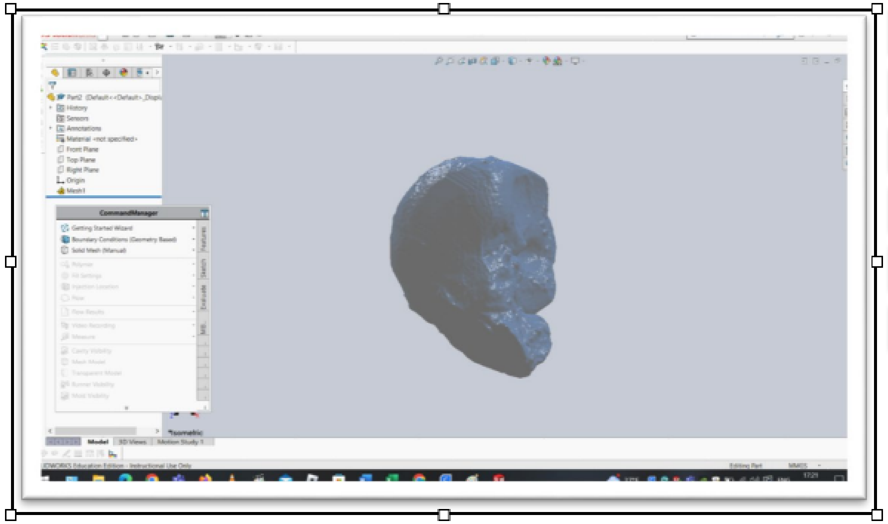

Fig.36. STL. file – liver phantom

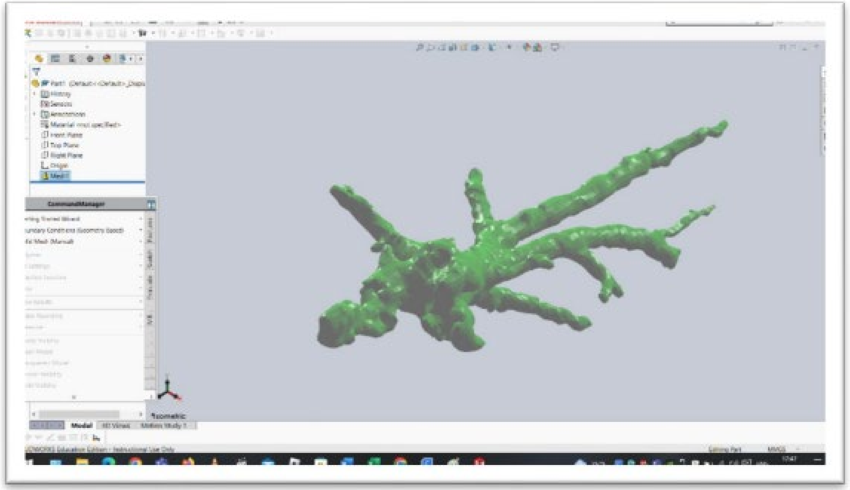

Fig.37. STL. file – blood vessel

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3.2. STL file

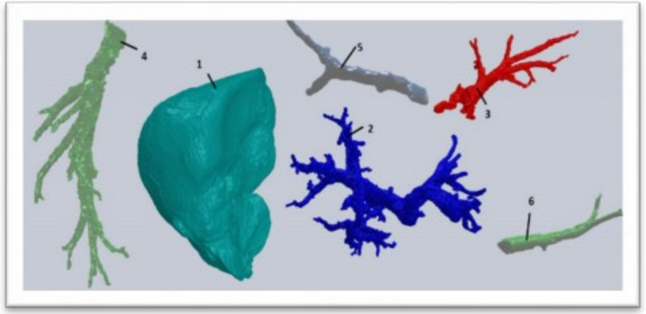

Fig.38. Exploded View – Liver phantom

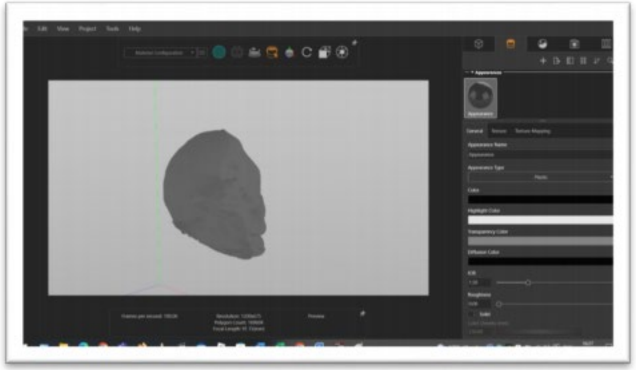

Fig.39. SolidWorks Visualize 2019 – Liver phantom with different texture mapping

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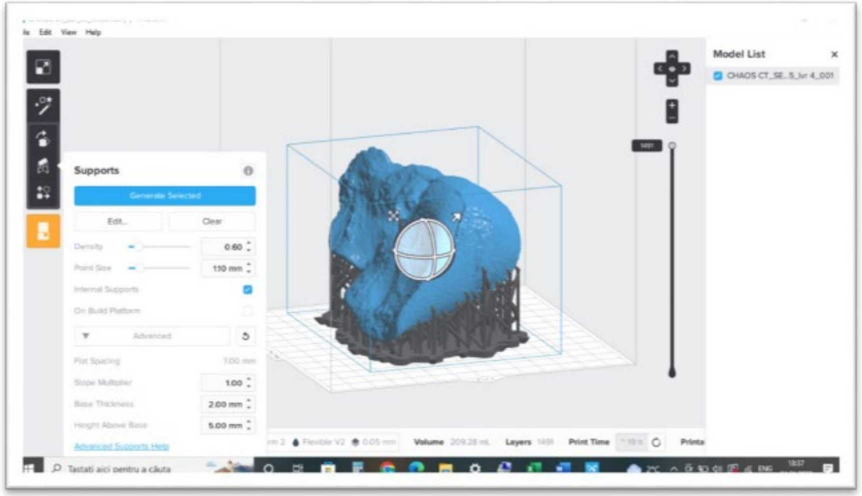
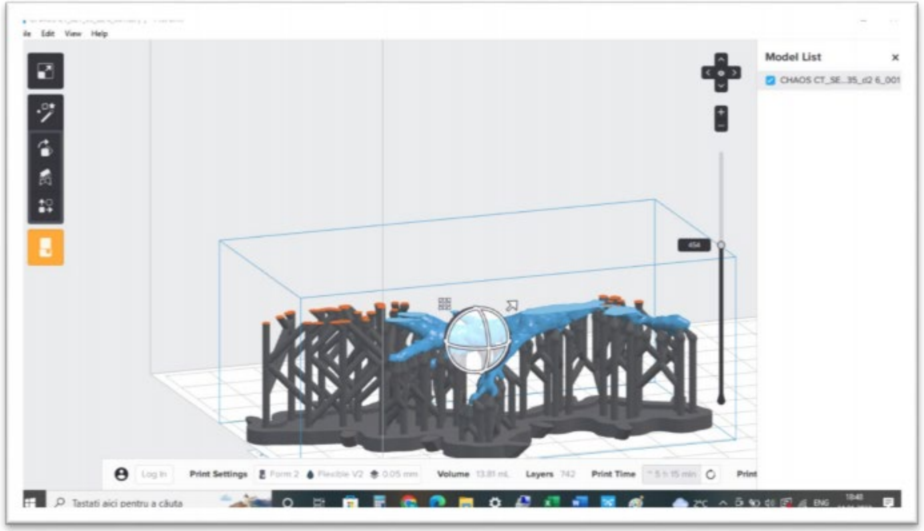
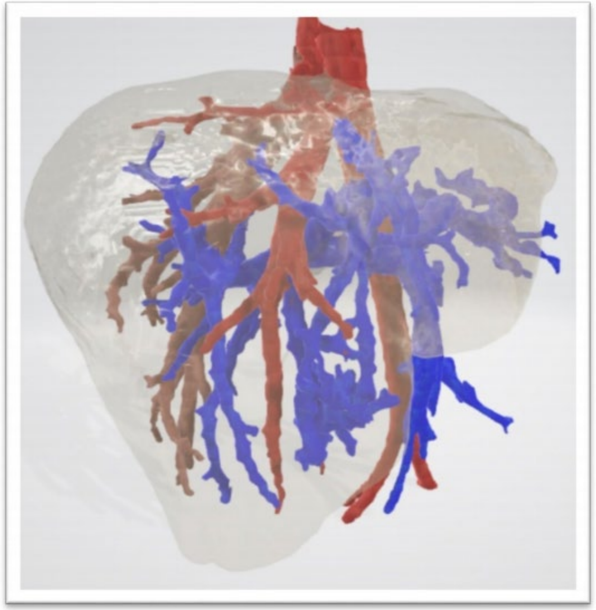
3.3. 3D Printing software’s







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4. Conclusions

In the future, further research on both multi-material and multi-colour prototypes could be performed, focusing on additive manufacturing technologies based on different silicones and plastic materials with different colours, necessary for different medical prothesis and devices.

The use of different silicones would be interesting in order to manufacture more complex phantoms, in which not only the desired organ is 3D printed, but also the surrounding anatomical structures. For example, the tumour or blood vessels by changing the component ratios.

The implications of the present research would be interesting for the manufacture of phantoms to be used in research and industry: medical imaging, preoperative surgical planning in hospitals, etc.

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