

***Intellectual Output_02:
EMERALD e-toolkit manual for digital learning in producing biomimetic
mechatronic systems***

Toolkit 4 Materials

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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS - EMERALD

EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC
MECHATRONIC SYSTEMS

<https://project-emerald.eu>

**E-toolkit – New materials used
for the developed biomimetic mechatronic
systems**

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Total Materia used for determination of the materials properties

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Total Materia used for determination of the materials properties.

Total Materia is the world's most comprehensive materials database, having more than 20,000,000 property records for over 450,000 metallic and non-metallic materials presented in 26 languages.

This database is world class quality, service and support, being trusted in over 160 countries, the smallest companies to global industry leaders all receive our complete specialist technical support.

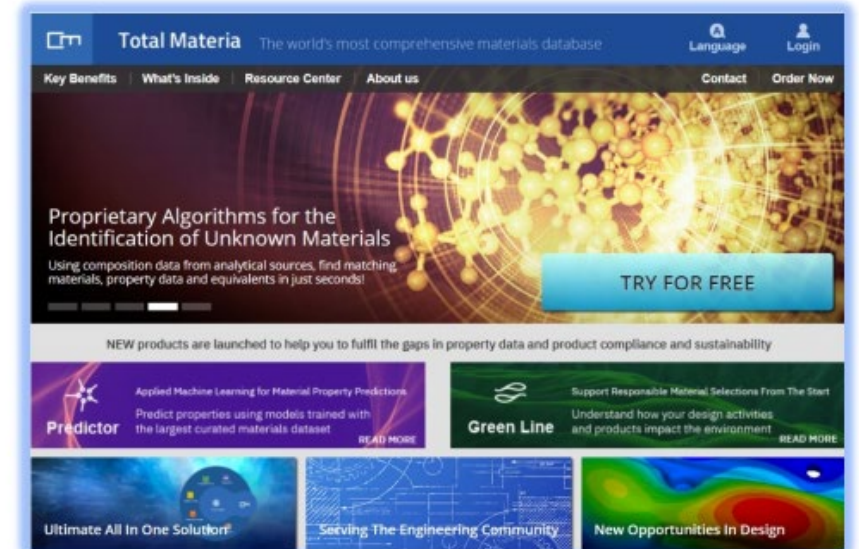


Fig.1. Total Materia database

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Total Materia used for determination of the materials properties.

Total Materia database help solve diverse engineering challenges from the simplest to the complex, being used in: medicine industry, aerospace industry, energy industry, automotive industry, machinery industry, engineering industry, diversified. By example, for the alloy Ti6Al4 V, we want to know the chemical composition and the mechanical properties, and we click on Advanced Search, as in the Figure 2.

Fig.2. Advanced Search

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In the figure 3, it is presented the choice of the standard in function of the country and group of materials.

It was choosing the alloy Ti6Al4V, making part of Titanium materials and was choose European Union standard, as in Figure 3. It must specify the material type, as example Bulk Materials, in Figure 4.

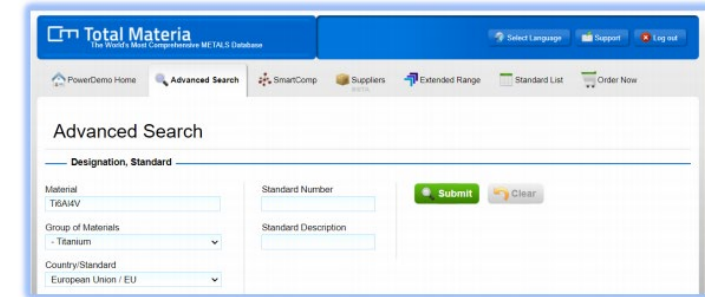


Fig.3. European Union standard choice

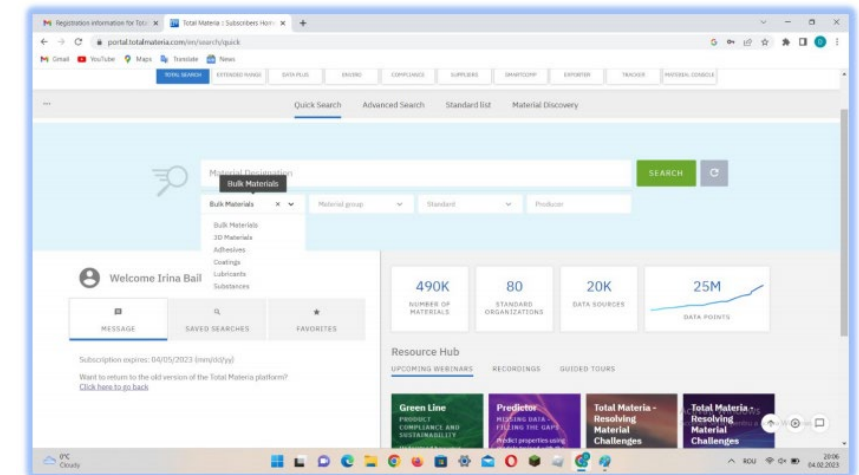


Fig.4. Material type

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In figure 5, it is specifying the material group and in this case, nonferrous alloys and European standard choice, as in figure 6.

When we give a quick search, as in figure 7, are presented different Ti6Al4V producers from different countries and using different standards.

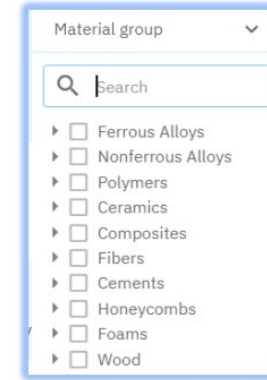


Fig.5. Material group

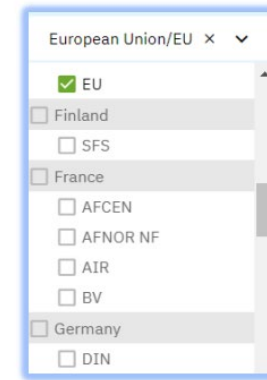


Fig.6. European standard choice

#	MATERIAL	STANDARD	COUNTRY / PRODUCER	CLASSIFICATION
1	MIM-Ti6Al4V-600	AFNOR NF	France	Ferrous Alloys / Sintered powdered metals
2	MIM-Ti6Al4V-600	ASIS	Romania	Ferrous Alloys / Sintered powdered metals
3	MIM-Ti6Al4V-600	B.S.	United Kingdom	Ferrous Alloys / Sintered powdered metals
4	MIM-Ti6Al4V-600	BOS	Bulgaria	Ferrous Alloys / Sintered powdered metals
5	MIM-Ti6Al4V-600	CEN	Czech Republic	Ferrous Alloys / Sintered powdered metals
6	MIM-Ti6Al4V-600	DIN	Germany	Ferrous Alloys / Sintered powdered metals
7	MIM-Ti6Al4V-600	EN	European Union	Ferrous Alloys / Sintered powdered metals
8	MIM-Ti6Al4V-600	ISO	International	Ferrous Alloys / Sintered powdered metals

Fig.7. Different Ti6Al4V producers

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The results it is the mechanical properties of the alloy Ti6Al4V, conforming of FR AFNOR NF standard, as in figure 8 and figure 9.

In figure 9, the database gives us all information about the mechanical properties of the alloy Ti6Al4V in function of the temperature used in the process where it is used this material.

In figure 10, the database shows us the chemical composition of the alloy Ti6Al4V.



Fig.9. Mechanical properties Ti6Al4V at the temperature between 0-30°C

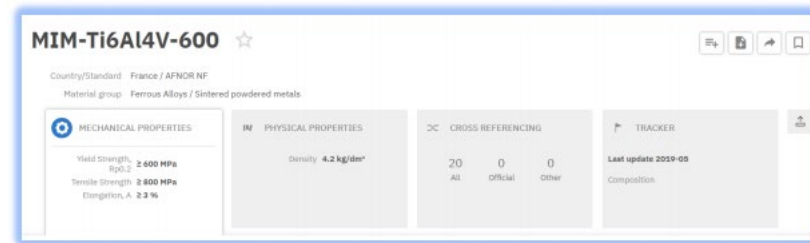


Fig.8. Ti6Al4V standard Fr AFNOR NF-Mechanical properties

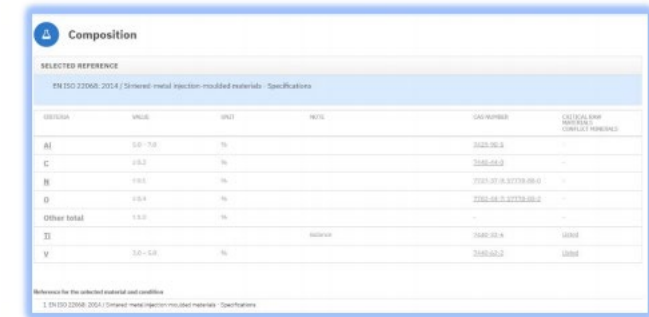


Fig.10. Chemical composition of Ti6Al4V

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2. Total Materia database – Advanced Research for alloys

In the case of Advanced Research, by example for the Ti6Al4V, producer Vday Additive Manufacturing Technology Co., it is given the classification of different Ti alloys producers, as in figure 11.

#	MATERIAL	STANDARD	COUNTRY / PRODUCER	CLASSIFICATION
1	Ti6Al4V	PROPRIETARY	Vday Additive Manufacturing Technology Co., Ltd. 21 Additive Ma	Nonferrous Alloys / Titanium 30-Materials
2	Ti-6Al-4V	AFNOR NP	France	Nonferrous Alloys / Titanium
3	Ti-6Al-4V	AS	Australia	Nonferrous Alloys / Titanium
4	Ti-6Al-4V	ASPO	HongKong	Nonferrous Alloys / Titanium
5	Ti-6Al-4V	B.S.	United Kingdom	Nonferrous Alloys / Titanium
6	Ti-6Al-4V	EOS	Bulgaria	Nonferrous Alloys / Titanium
7	Ti-6Al-4V	CSN	Czech Republic	Nonferrous Alloys / Titanium
8	Ti-6Al-4V	DSN	Germany	Nonferrous Alloys / Titanium
9	Ti-6Al-4V	EN	European Union	Nonferrous Alloys / Titanium
10	Ti-6Al-4V	GB	China	Nonferrous Alloys / Titanium

Fig.11. Ti6Al4V alloy used in Additive Manufacturing

In the figure 12, are presented the mechanical properties of Ti6Al4V used in Additive Manufacturing, for different temperature domains.

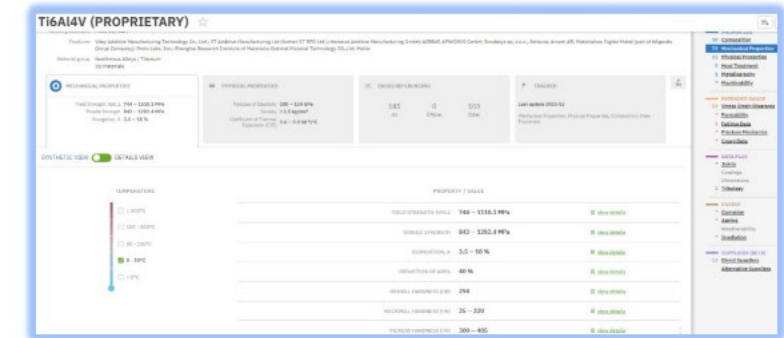


Fig.12. Mechanical properties of Ti6Al4V used in Additive Manufacturing

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2. Total Materia database – Advanced Research for alloys

The chemical composition of Ti6Al4V used in Additive Manufacturing is given in the figure 13. In the figure 14, the physical properties of Ti6Al4V used in Additive Manufacturing, for different temperature domains.

Ti6Al4V (PROPRIETARY) ☆

REFERENCES

- 3T Additive Manufacturing Ltd, Product Data Sheets / Available at: www.3t-am.com, visited 2019
- Arcon AB, Product Data Sheets / Available at: www.arcon.com, visited 2015
- Digital Metal, Product Data Sheets / Available at: www.digitalmetal.com, visited 2021
- Heraeus Additive Manufacturing GmbH, Product Data Sheets / Available at: www.heraeus.com, visited 2020
- Meltis, Product Data Sheets / Available at: https://meltis3d.com/, visited 2022
- Shanghai Research Institute of Material, Product Data Sheet / Available at: www.srim.com.cn, visited 2022

SELECTED REFERENCE

3T Additive Manufacturing Ltd, Product Data Sheets / Available at: www.3t-am.com, visited 2019

CRITERIA	VALUE	UNIT	NOTE	GAS NUMBER	CRITICAL MAP MATERIALS CONNECT MATERIALS
Al	6.00 - 6.75	%		3540-00.0	-
C	< 0.05	%		3540-44.0	-
Fe	< 0.3	%		3540-05.0	-
H	< 0.005	%		3480-24.0	-
N	< 0.05	%		3727-37.0-377709-00.0	-
O	< 0.3	%		3780-84.0-372709-00.0	-
Ti			Balance	3540-32.0	listed
V	3.50 - 4.50	%		3540-42.0	listed

Fig.13. Chemical composition of Ti6Al4V used in Additive Manufacturing

TEMPERATURE	PROPERTY / VALUE
<input type="checkbox"/> > 300°C	MODULUS OF ELASTICITY 100 – 124 GPa
<input type="checkbox"/> 100 - 300°C	DENSITY ≥ 2.5 kg/dm³
<input type="checkbox"/> 30 - 100°C	COEFFICIENT OF THERMAL EXPANSION (CTE) 7.6 – 7.9 10⁻⁶/°C
<input checked="" type="checkbox"/> 0 - 30°C	MELTING TEMPERATURE 1600 – 1750 °C
<input type="checkbox"/> < 0°C	

Fig.14. Physical properties of Ti6Al4V used in Additive Manufacturing

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2. Total Materia database – Advanced Research for alloys

The database gives us details concerning the heat treatment used for the alloy Ti6Al4V used in Additive Manufacturing.

Heat Treatment	
Reference	Descriptions
Arcam AB, Product Data Sheets / Available at: www.arcam.com , visited 2019	Hot Isostatic Pressing (HIP) at 920°C for 120 minutes, 100 MPa.
3T Additive Manufacturing Ltd, Product Data Sheets / Available at: www.3t-am.com , visited 2019	Stress relieved at 800°C for 2 hours in a vacuum furnace with specimens on build plate.
Meltio, Product Data Sheets / Available at: https://meltio3d.com/ , visited 2022	Stress Relief - Heat up to 730°C in 2 h - Hold at 730°C during 2 h - Cool down to Ambient T° in 1 h 50 min

All references for the selected material:

- 1 3T Additive Manufacturing Ltd, Product Data Sheets / Available at: www.3t-am.com, visited 2019
- 2 Arcam AB, Product Data Sheets / Available at: www.arcam.com, visited 2019
- 3 Meltio, Product Data Sheets / Available at: <https://meltio3d.com/>, visited 2022

Fig.15. Heat treatment used for the alloy Ti6Al4V used in Additive Manufacturing

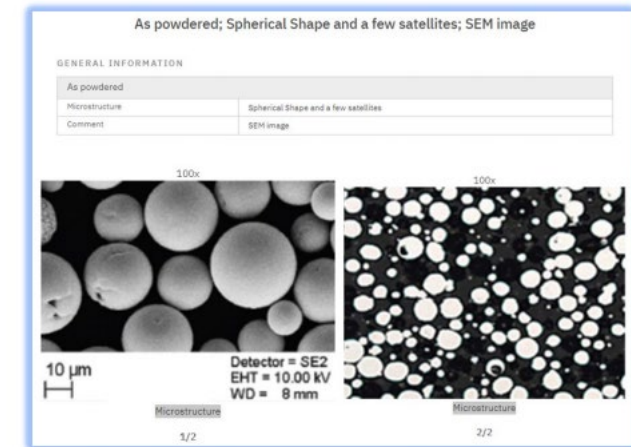


Fig.16. Metallography details for Ti6Al4V powders used in Additive Manufacturing

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2. Total Materia database – Advanced Research for alloys

The material does not have direct properties. Similar materials that have these properties are listed in the table below. Click on the material to view properties.

#	MATERIAL	STANDARD	COUNTRY / PRODUCTION	EQUIVALENCE CATEGORY
1	YTAW 640 E	KS	Korea	Other sources
2	AB-5	SAC	United States	Other sources
3	B 265 Grade S	ASTM	United States	Other sources
4	B 265 Grade TI-6Al-4V	ASTM	United States	Other sources
5	ERTI-S	AMS	United States	Other sources
6	S TI 6402	ONORM	Austria	Other sources
7	S TI 6402	BN	Belgium	Other sources
8	S TI 6402	BS	Bulgaria	Other sources
9	S TI 6402	CSN	Czech Republic	Other sources
10	S TI 6402	EN	European Union	Other sources

Fig.19. Different variants similar alloy of Ti, used in welding and in brazing

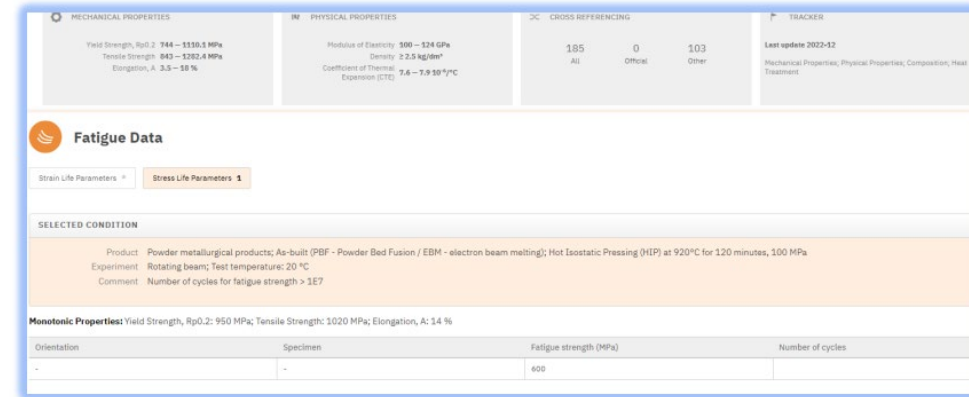


Fig.21. Fatigue data given for Ti6Al4V used in Electron Beam Melting (EBM)

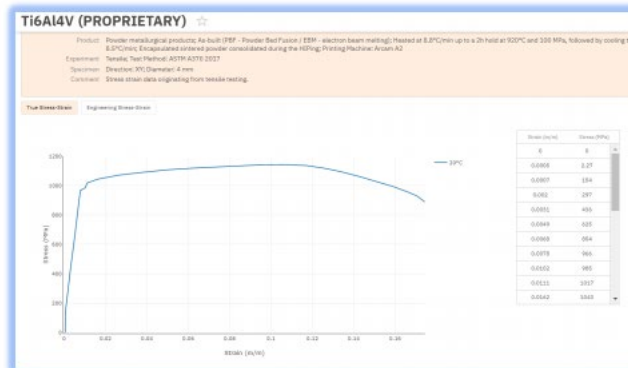


Fig.20. Stress strain diagram for Ti6Al4V used in Electron Beam Melting (EBM)

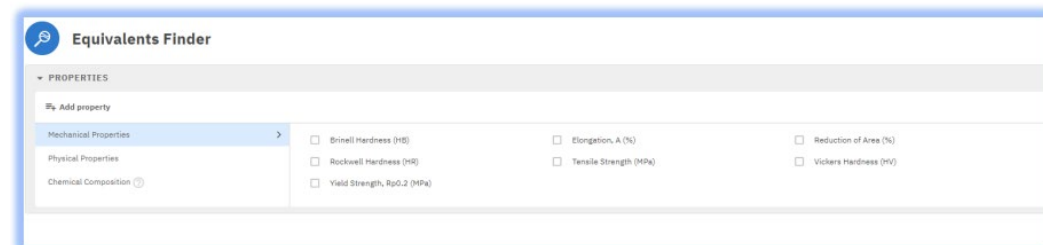


Fig.22. Equivalents finder

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3. Total Materia database – Search algorithms used for identification the unknown metallic materials

For the chemical composition Co 54,31 %, Cr 23,08 %, Mo 11,12 %, W 7,85 %, Si 3,35 % and Mn, Fe < 0,1, using the algorithms of the Total Materia database, it will identify the material with this chemical composition.

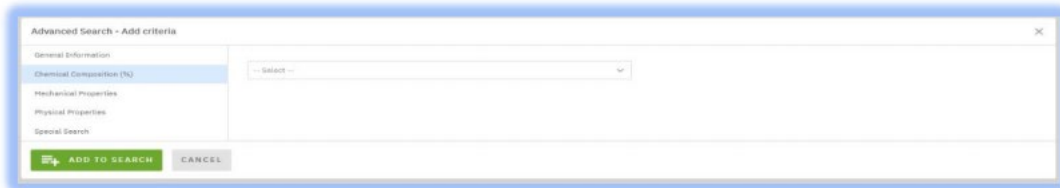


Fig.26. Algorithms used for identification the unknown materials

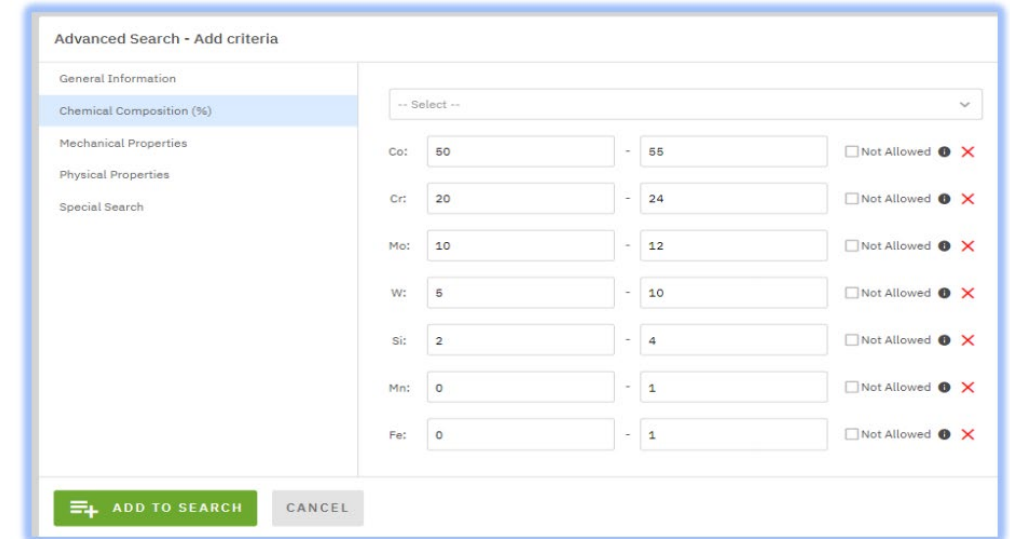


Fig.27. Chemical composition selection

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4. Total Materia database – polymers, ceramics and composite materials

Total Materia database is used too for the polymers (Fig.31), ceramics and composite materials.

The database given 125 results of PLA types, as in the figure 32.

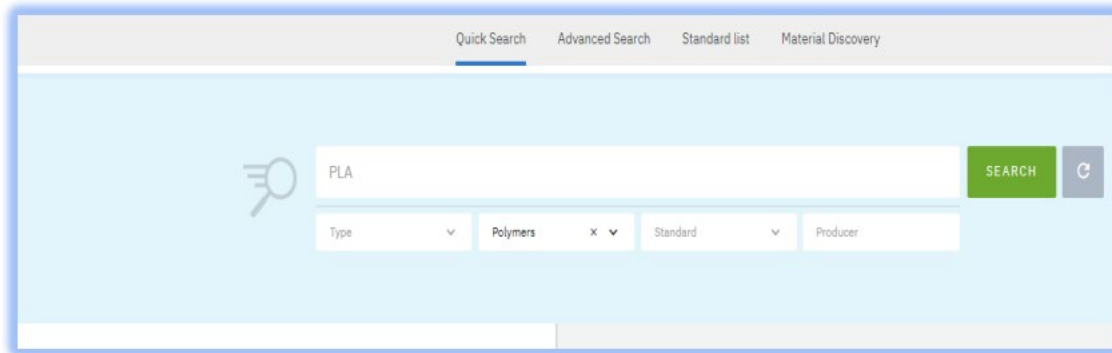


Fig.31. Total Materia database for the polymers

#	MATERIAL	STANDARD	COUNTRY / PRODUCER	CLASSIFICATION
1	PLA	GENERIC		Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
2	PLA++	PROPRIETARY	Breathe-3DP	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
3	PLA Crystal Clear	PROPRIETARY	Filamentum	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
4	PLA Extrafill	PROPRIETARY	Filamentum	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
5	PLA Filament	PROPRIETARY	Filament PH	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
6	PLA Plus ProSpeed	PROPRIETARY	Rosa 3D	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
7	PLA Premium Filament	PROPRIETARY	Arvofil 3D	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials
8	PLA Prografon color	PROPRIETARY	Advanced Graphene Products	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials

Fig.32. 125 results of PLA types existing on the database

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4. Total Materia database – polymers, ceramics and composite materials

In figure 33, are presented the mechanical properties of PLA crystal clear.

Database give us the manufacturing processes of PLA crystal clear, such as 3D Printing and temperature used in the manufacturing processes, as in figure 34.

Manufacturing Processes		
PROPERTY	VALUE	UNIT
3D printing machine settings		
Reference: Fillamentum, Product Data Sheets / Available at: www.fillamentum.com, visited 2021		
Heated Bed Temperature	50 – 60	°C
Printing Temperature	210 – 230	°C
Reference for the selected material and condition		
1 Fillamentum, Product Data Sheets / Available at: www.fillamentum.com, visited 2021		

Fig.34. Manufacturing processes of PLA crystal clear

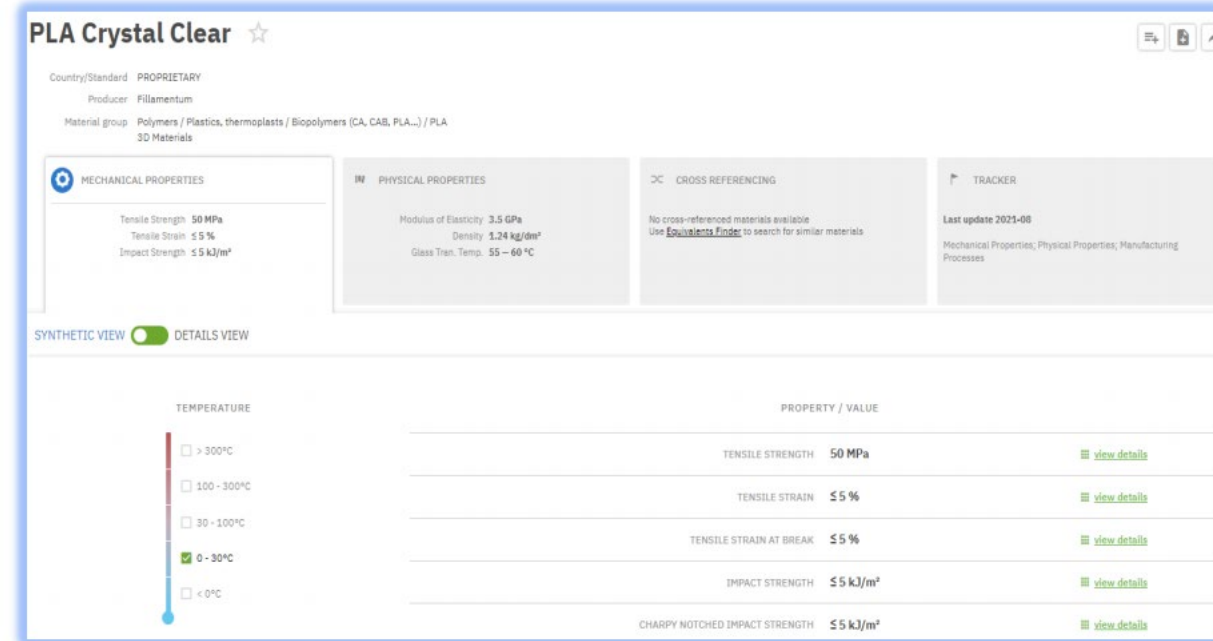


Fig.33. Mechanical properties of PLA crystal clear

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5. Conclusions

In the last years, the materials developed very much, appeared different news materials with very interesting properties realized by different world companies, that can be used in Additive Manufacturing and in other manufacturing domain to realize medical parts or for industrial domain and grace to this database, all materials developed are introduced in this platform, giving us the possibility to choose, the chemical composition, the mechanical properties, or using the search algorithms, finding the unknown material, in function of the chemical or mechanical properties.

The implications of the present research would be interesting for the manufacture by Additive Manufacturing different medical parts, using different materials using the database Total Materia, or others to know the mechanical and chemical properties that are very important to establish the manufacturing parameters and manufacturing systems and tools.