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

***Intellectual Output_O2:***
***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

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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS

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

| | |
|---|---|
| **Project Title** | **European network for 3D printing of biomimetic mechatronic systems**<br>**21-COP-0019** |
| **Output** | **IO2 - EMERALD e-toolkit manual for digital learning in producing biomimetic manufacturing method** |
| **Module** | **Database used for the smart (intelligent) materials properties** |
| **Date of Delivery** | **January 2023** |
| **Authors** | **Diana BĂILĂ, PUB** |
| **Version** | **FINAL VARIANT, *27.01.2023*** |

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.

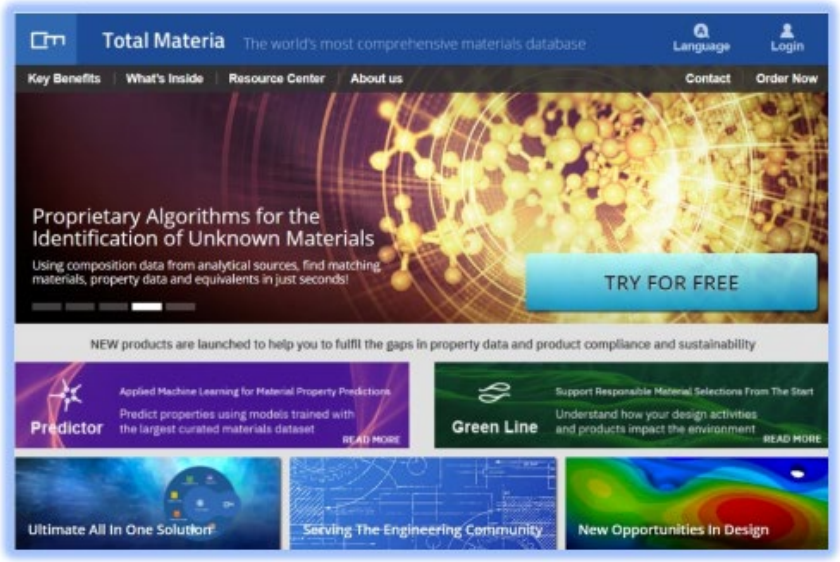


**Fig.1. Total Materia database**

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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.

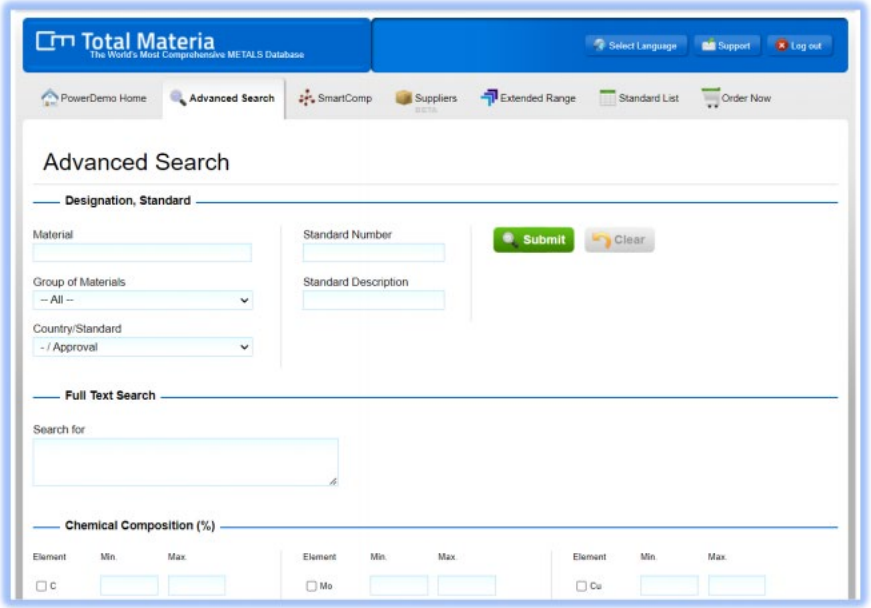


**Fig.2. Advanced Search**

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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.

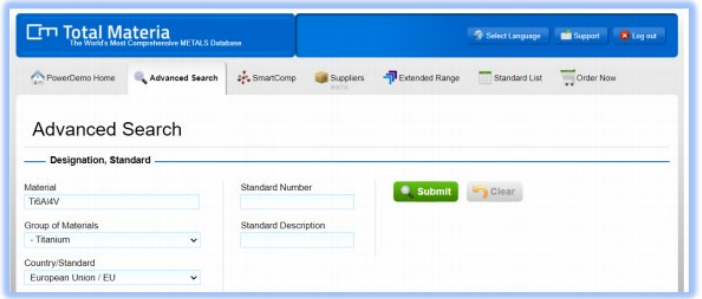


Fig.3. European Union standard choice

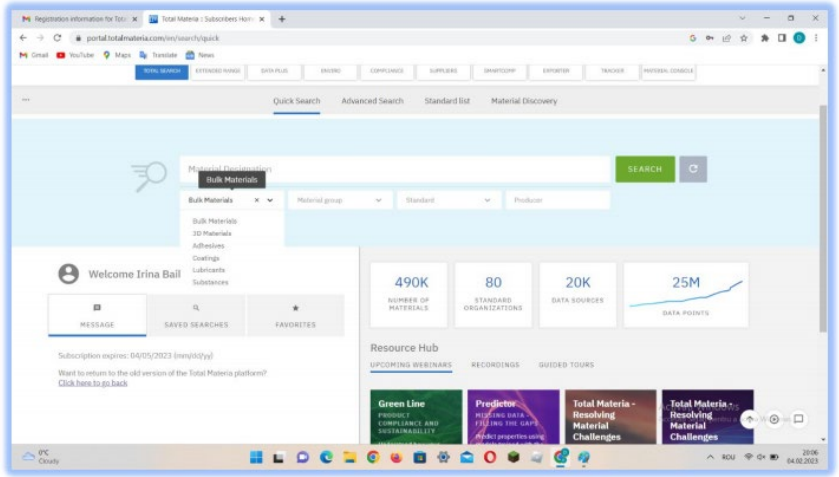


Fig.4. Material type

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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.

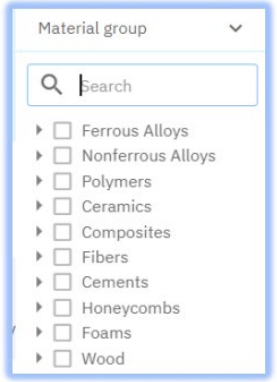


Fig.5. Material group

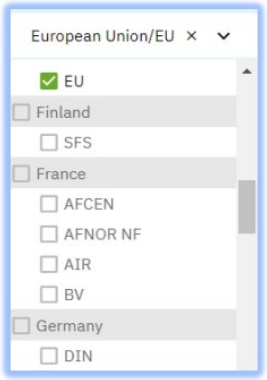


Fig.6. European standard choice

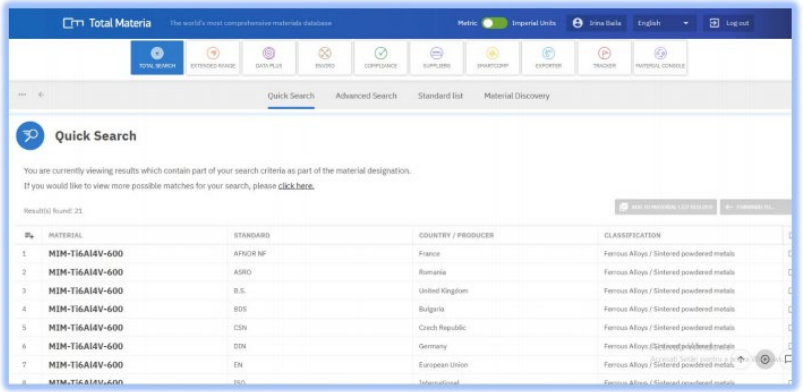


Fig.7. Different Ti6Al4V producers

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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.

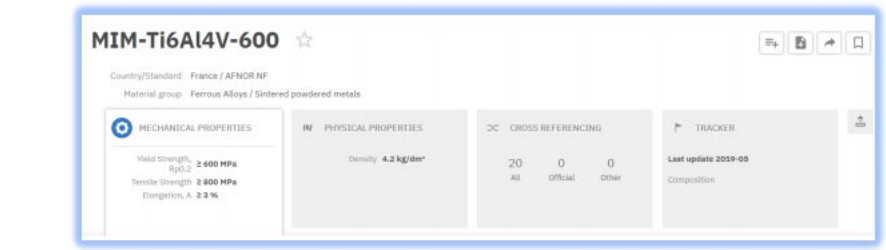


Fig.8. Ti6Al4V standard Fr AFNOR NF-Mechanical properties


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

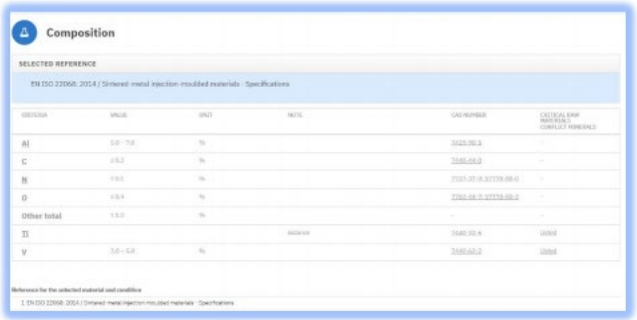


Fig.10. Chemical composition of Ti6Al4V

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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.

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

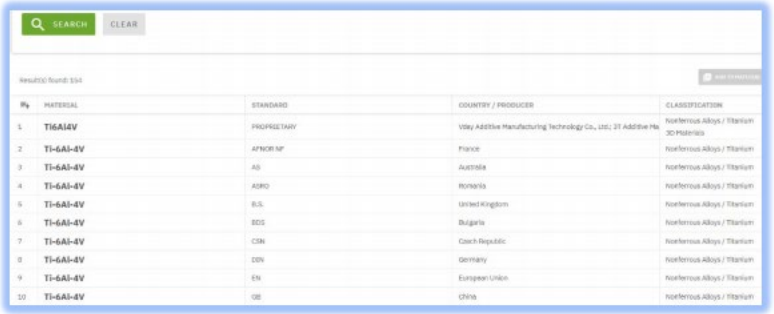


Fig.11. Ti6Al4V alloy used in Additive Manufacturing

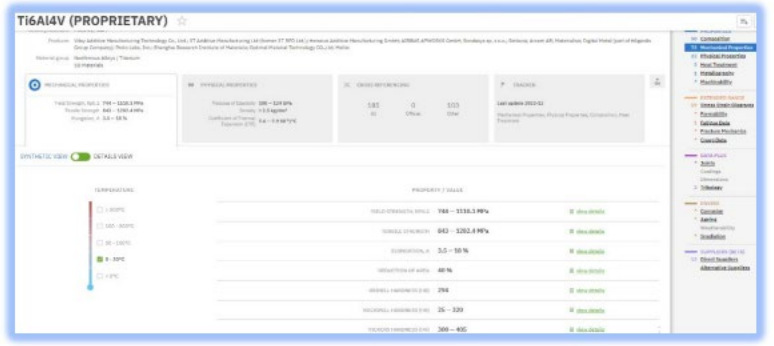


Fig.12. Mechanical properties of Ti6Al4V used in Additive Manufacturing

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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.

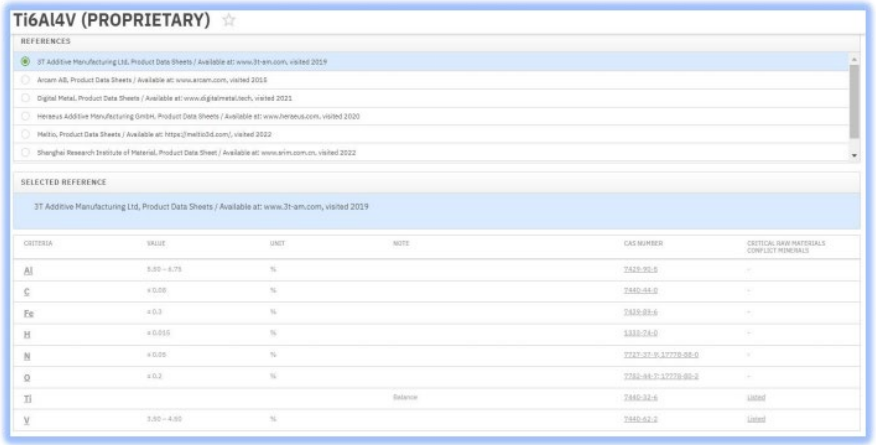


**Fig.13. Chemical composition of Ti6Al4V used in Additive Manufacturing**

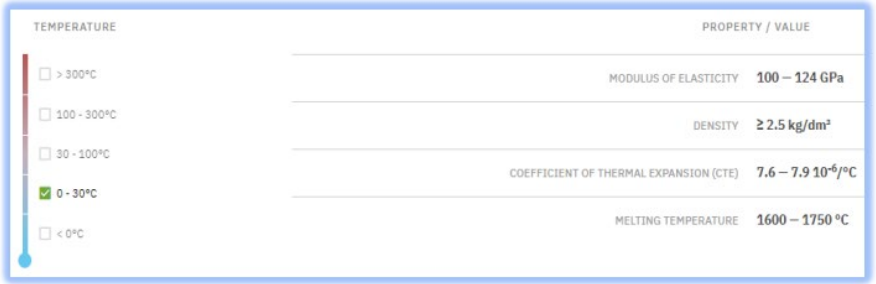


**Fig.14. Physical properties of Ti6Al4V used in Additive Manufacturing**

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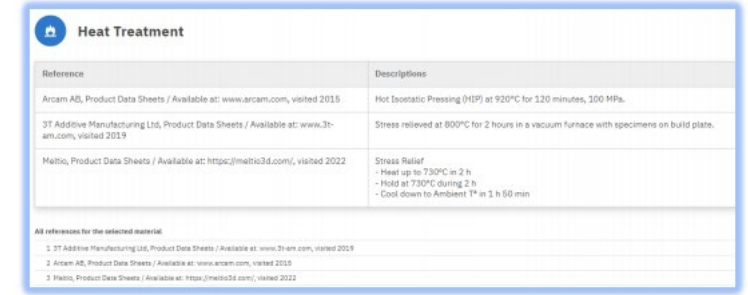
## 2. Total Materia database – Advanced Research for alloys

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 2015 | 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<br>- Heat up to 730°C in 2 h<br>- Hold at 730°C during 2 h<br>- 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 2015
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**

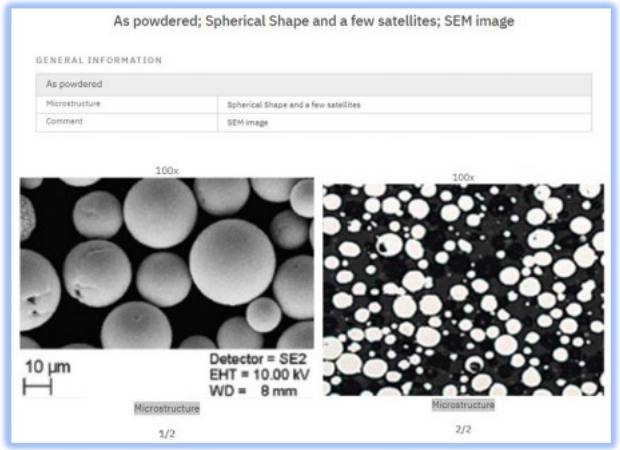



**Fig.16. Metallography details for Ti6Al4V powders used in Additive Manufacturing**

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## 2. Total Materia database – Advanced Research for alloys

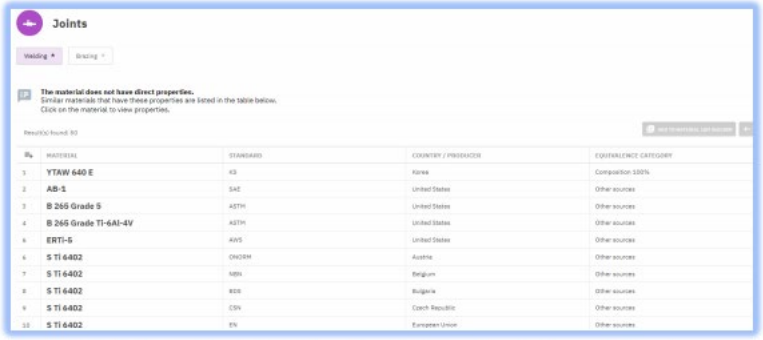


Fig.19. Different variants similar alloy of Ti, used in welding and in brazing

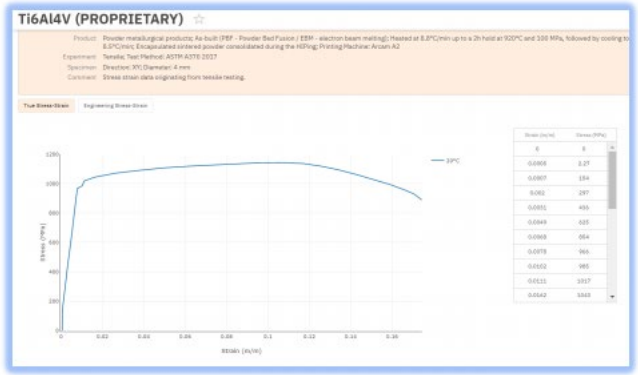


Fig.20. Stress strain diagram for Ti6Al4V used in Electron Beam Melting (EBM)

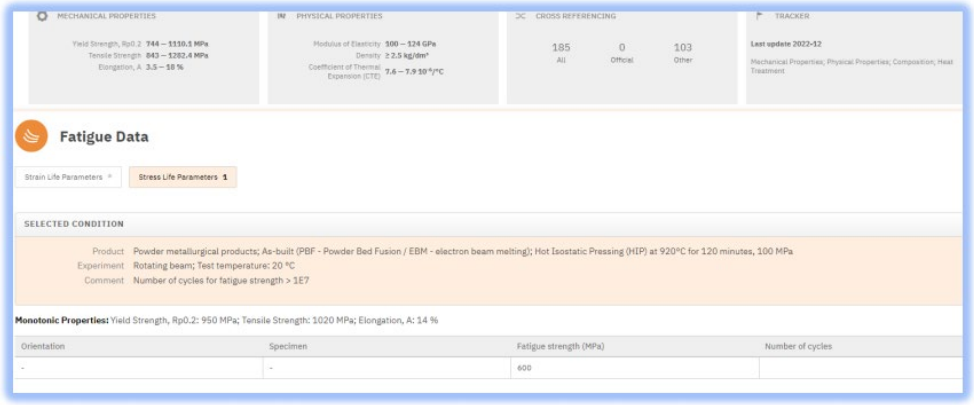


Fig.21. Fatigue data given for Ti6Al4V used in Electron Beam Melting (EBM)


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.

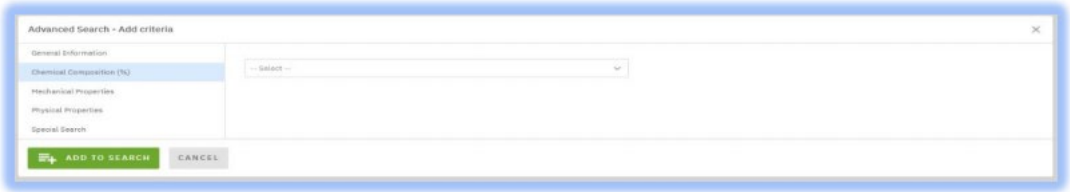


Fig.26. Algorithms used for identification the unknown materials

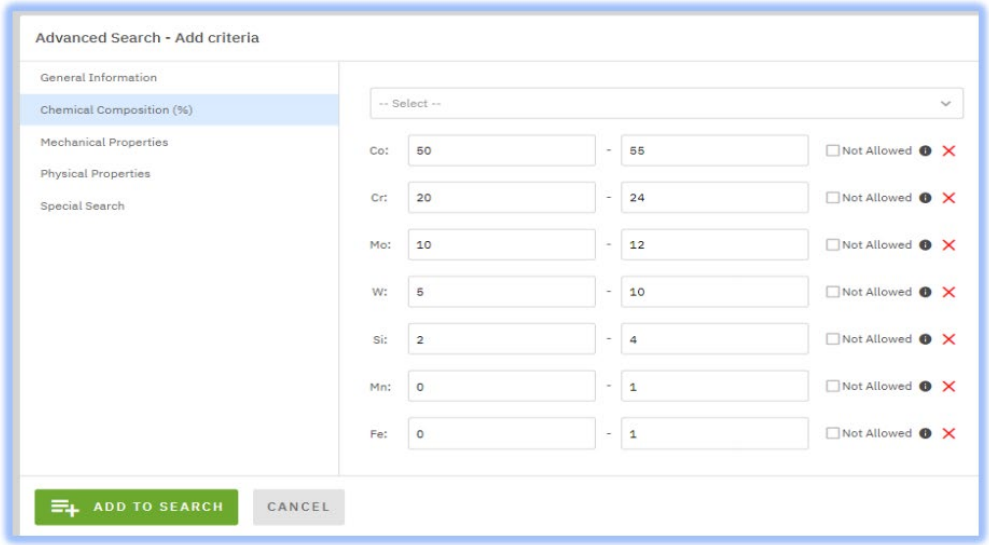


Fig.27. Chemical composition selection

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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.

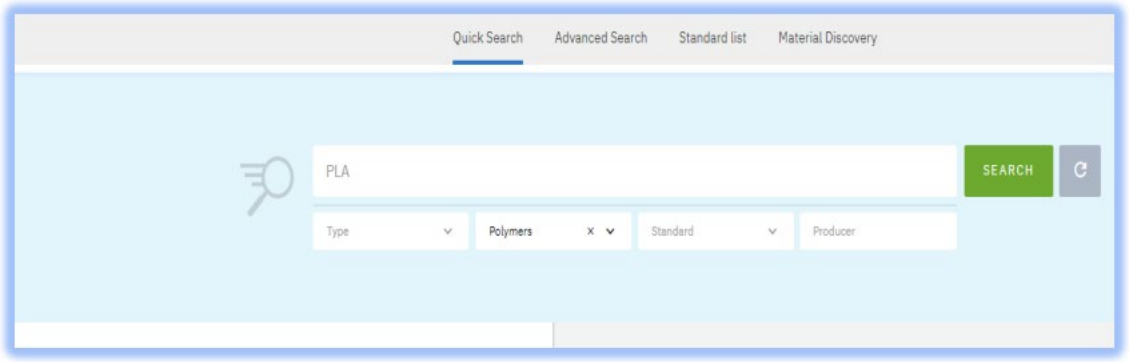
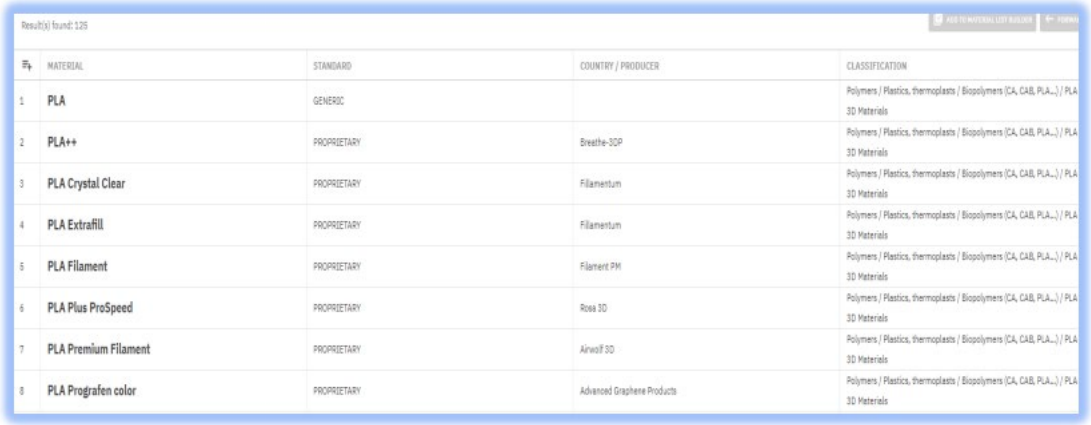



Fig.31. Total Materia database for the polymers



Result(s) found: 125

| | 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 PM | 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 | AirwolF 3D | Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA...) / PLA 3D Materials |
| 8 | PLA Prografen 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.

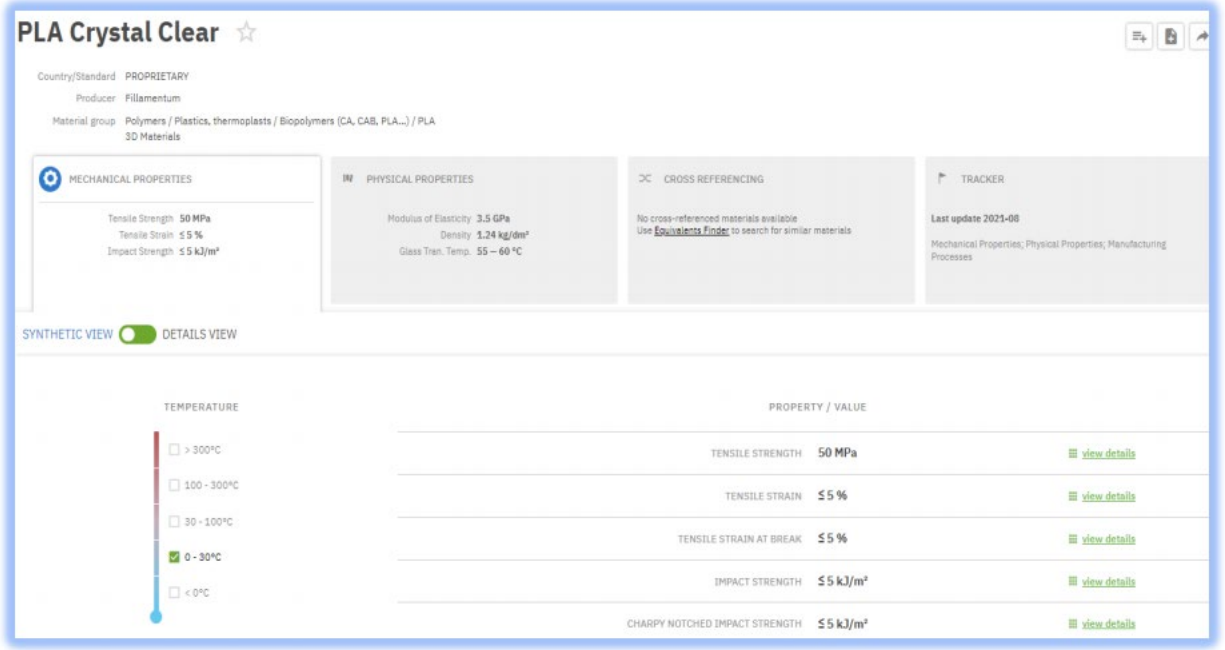


**Fig.33. Mechanical properties of PLA crystal clear**

**Manufacturing Processes**

| PROPERTY | VALUE | UNIT |
|---|---|---|
| 3D printing machine settings<br>**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**

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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.

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