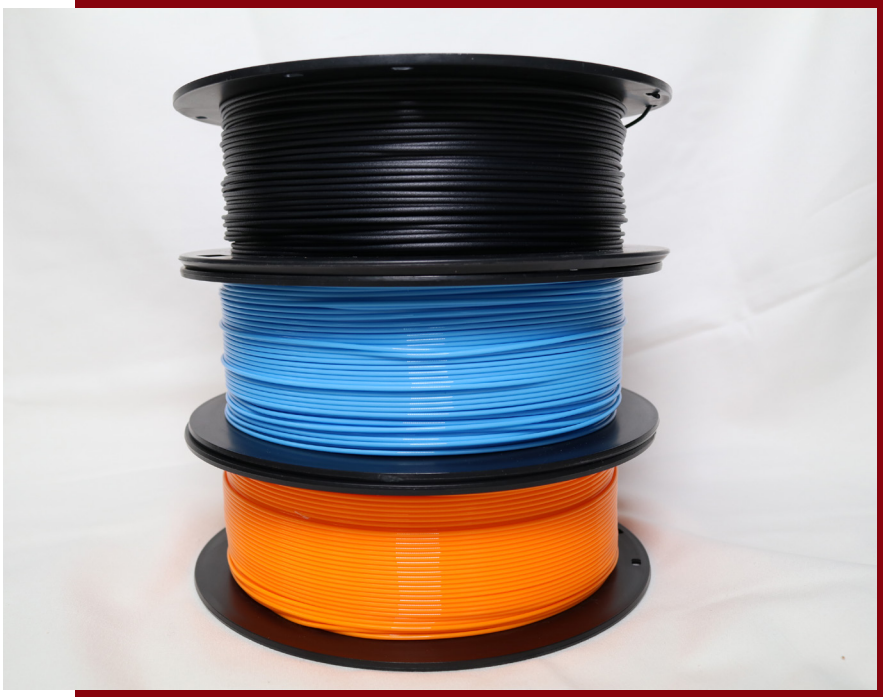
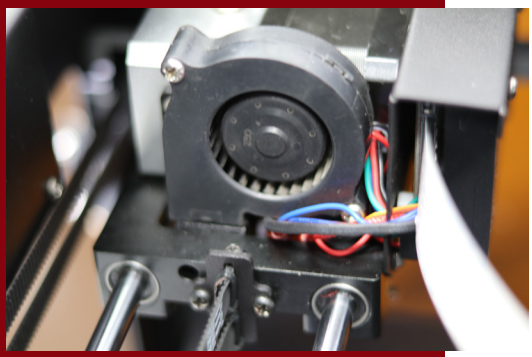
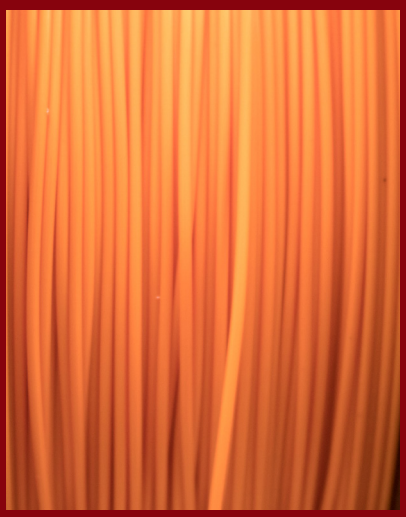
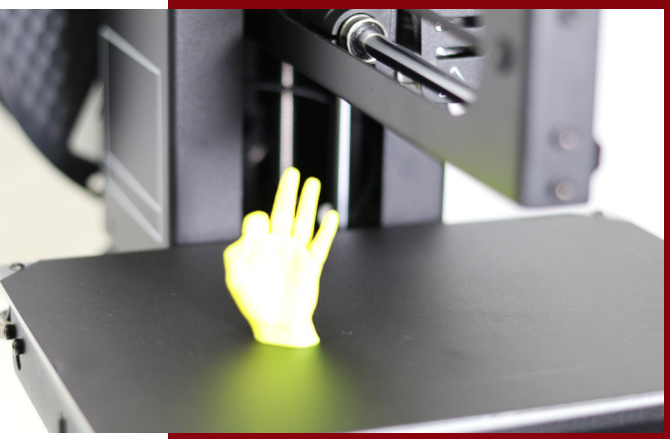
The Comprehensive Guide to

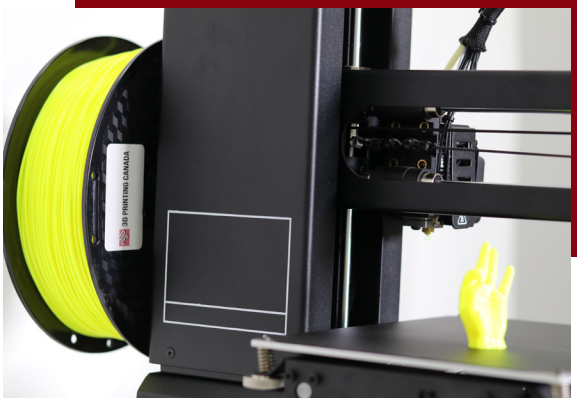
Comparing 3D Filament











3D PRINTING CANADA

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The Comprehensive Guide to Comparing 3D Filaments

In the fourth Industrial age, the 3D printer is quickly cementing its place as the ultimate manufacturing and DIY tool with the ability to completely revolutionize how 3D objects or physical items are produced. This is why the 3D printer can now be found in almost every manufacturing plant, co-creation hubs, and even domestically in many homes!

The 3D printer is surely here to stay but while many an article has been written on the prowess of 3D printing devices, the materials that aid its ability to create have largely been ignored. And the drive to remedy this situation, serves as the back-bone for creating this comprehensive guide on 3D filaments that every hobbyist can take advantage of.

Now is probably the time to mention that, most of the 3D printers you have come across or printed with make use of the Fused Deposit Modelling (FDM) process to print your favourite objects. This, in turn, means that the filaments you are probably more familiar with fall under the category of thermoplastics such as the PLA and ABS filaments but it is important to note that there is much more than the PLA /ABS options available to you. Read on as we review the different 3D filament types you can use to create art!

The Categories for Reviewing 3D Filaments

In order to eliminate any confusion during the review process, some categorization will be put used in order to help you easily access the sections in this guide directed at your 3D printing/filament needs. These categories include:

- **Common 3D Printing Filaments**—these are the standard 3D filament types that are commonly used to print 3D objects in a domestic setting.
- **Decorative 3D Printing Filaments**—these are 3D filaments types imbibed with features that provide completed 3D prints with distinct surface finishes.
- **Industrial 3D Printing Filaments**—industrial manufacturing firms make use of 3D filaments according to the material needs, weight and tensile strength of products relevant to particular industries.

Here you have the three categories that form the basis for the 3D filaments included in this guide.

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Common 3D Printing Filaments

In this category, 6 options will be reviewed and do not be surprised if you have some knowledge of the highlighted filament types for as the category suggests, they are quite common to the 3D printing community. It is also worth stating that the common 3D filaments are generally thermoplastics and this review will touch on their:

- **Properties**—this covers the base material they are made from and other technical features
- **Pros and Uses**—this touches on when and where these common filaments should be used.
- **Cons**—this covers the difficulties associated with using a particular 3D filament

Polylactic Acid (PLA) Filament

PLA takes the crown as the most popular 3D printing filament type currently being used. It is the 'Apple device' of the 3D printing community and it's highly likely that you must have encountered this biodegradable thermoplastic no matter how recent your introduction to 3D printing is.

Its popularity is due to its low melting point—lower than ABS—which makes it quite easy to 3D print without straining the capacity of your printer. PLA which is made predominantly form starch; exudes no odour and is totally recyclable therefore makes it a great choice for anyone who's invested in green living. Using our review criteria, here are its:

PLA takes the crown as the most popular 3D printing filament type currently being used

PLA Properties:

1. **Tensile Strength**—Considerable strength which ensures 3D prints are solid
2. **Print Temperature**—it becomes molten at 180 – 230 °C
3. **Solubility**—No, it does not dissolve in water
4. **Warping Susceptibility**—Minimal
5. **Colour:** Comes in multiple colours

When to Use PLA:

- When printing domestic items, toys etc.
- As base material to support other filament types
- For rapid prototyping
- If in need of a cheap filament to learn with

Cons:

- PLA is brittle and not overtly durable
- PLA wilts under temperatures above 60 degrees.

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Acrylonitrile Butadiene Styrene (ABS) Filament

ABS is also another thermoplastic polymer made from the fusion of the three monomers contained in its name. Therefore, it integrates the strength of Acrylonitrile, the toughness of Butadiene and the rigidity of Styrene which makes it tougher than PLA.

ABS is quite as popular as PLA which means it is one of the plastic filaments you can consider using for your domestic projects but unlike PLA, it exudes a distinct scent while 3D printing with it. It is also worth noting that ABS is relatively costly to produce when compared to PLA. Reviewing with our criteria:

ABS Properties:

1. **Tensile Strength:** Considerably high
2. **Print Temperature:** It becomes molten at 210 – 250 degrees.
3. **Print Bed:** printing on a heated print bed of temperature 80 – 110 degrees is recommended
4. **Solubility:** No
5. **Warping Susceptibility:** relatively high due to its printing temperatures
6. **Colour:** Comes in multiple colours

When to Use ABS:

- If making domestic items; toys, phone cases LEGOS etc.
- To 3D print durable objects; hard plastics, Helmets, Shin/elbow guard
- For rapid prototyping

Cons:

- Susceptible to warping when cooled
- Relatively more expensive

Nylon Filament

Nylon's popularity as an all-purpose manufacturing material is also extended to the 3D printing community. And for many hobbyists, it provides a well-balanced mixture of strength, flexibility and durability which is generally sought after by hobbyists working with thermoplastics.

Although not as popular as PLA and ABS, its strength and durability is something that can give your 3D printed objects and added edge. 3D printing with Nylon comes with exuded scents and fumes which are not quite offensive but still requires a well-ventilated workspace to dissipate. Looking at the properties of Nylon filaments, we have:

Properties:

1. **Strength:** Considerable strength and flexibility
2. **Print Temperature:** Nylon prints at 240 – 260 degrees.
3. **Print Bed:** Heat beds set at 70 – 100 °C is recommended to eliminate warping
4. **Solubility:** No
5. **Warping Susceptibility:** High
6. **Colour:** Multiple filament colours

When To Use Nylon:

- When durability is sought i.e. 3D printing engineering components
- To 3D print hard plastic objects like LEGOs, helmets etc.

Cons:

- Susceptible to warping during cooling
- Quite expensive if compared to PLA
- Exudes fumes when 3D printed.

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Thermoplastic Elastomers (TPE) Filaments

As the name suggests, TPE is a mixture of thermoplastics and rubber which gives it the high flexibility the automotive and clothing accessories industries thrive on. Its strength and flexibility make it a favourite for 3D printing items that must withstand wear and tear due to regular use.

When compared to PLA and ABS filaments, TPE takes the lead in terms of strength and flexibility. 3D printing with TPE produces some odour and fumes which may be nauseating to the user. Therefore, using TPE in well-ventilated areas is recommended.

When compared to PLA and ABS filaments, TPE takes the lead in terms of strength and flexibility

Properties:

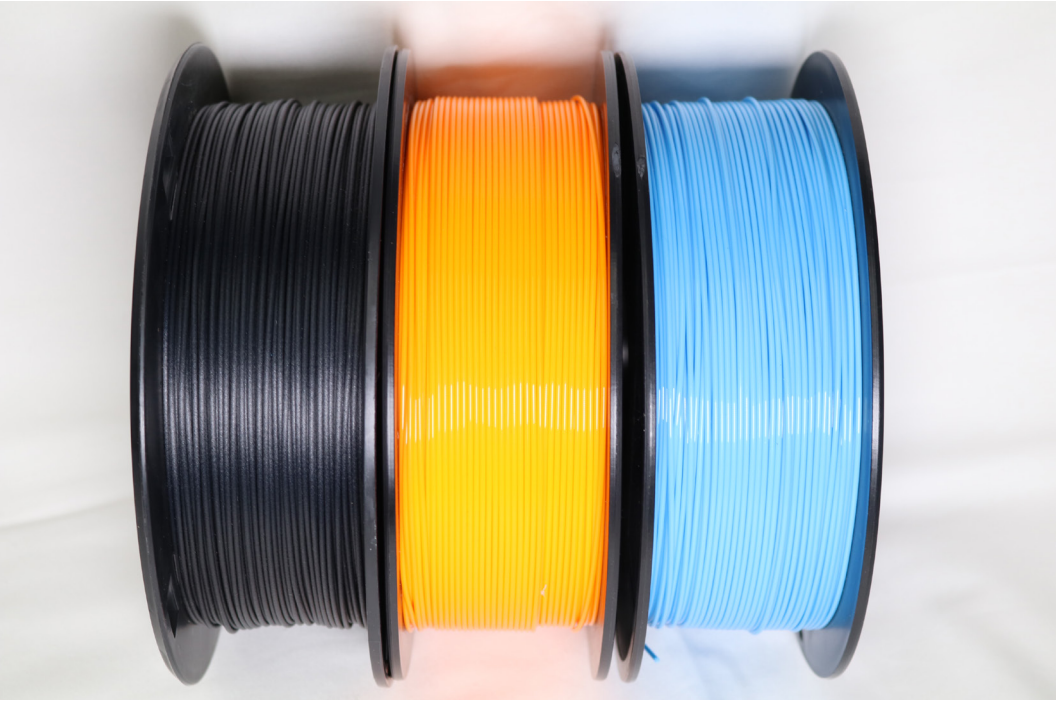
1. **Tensile Strength:** Considerable strong with very high flexibility
2. **Print temperature:** TPE prints at 210 – 230 °C.
3. **Print Bed:** A heated bed set at 30 – 60 degrees is recommended
4. **Solubility:** Not soluble in water
5. **Warping Susceptibility:** Relatively minimal when compared to nylon, PLA and ABS
6. **Colour:** Filament comes in different colours

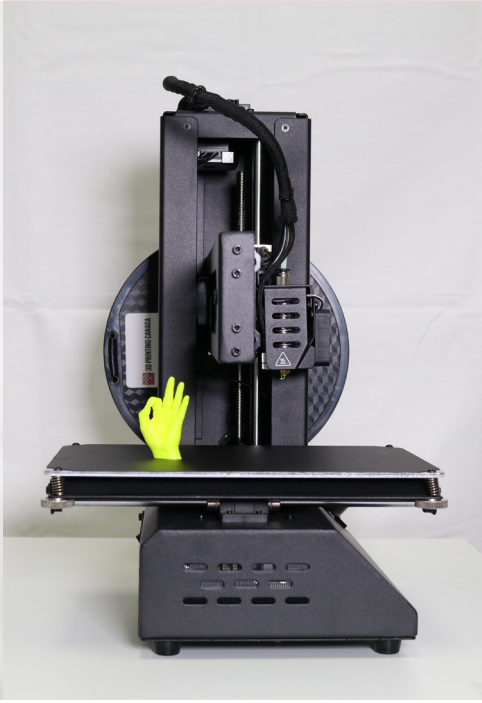
When to Use TPE:

- If developing plastic components for the automotive, medical instrumentation and ornament industry.
- When working on projects with elastic/ flexible components.
- If 3D printing plastic products for outdoor use.

Cons:

- TPE is relatively more expensive to use than PLA and ABS
- Its printing temperature is also relatively high





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Polyethylene coTrimethylene Terephthalate (PETT)

It may come as a surprise for you to know that you hold processed forms of PETT every other day for it is the material generally used in the manufacturing of water bottles and plastic food containers. In its unprocessed form, PETT provides the 3D printing community with a transparent plastic material to 3D print with.

PETT is used in developing domestic items where a translucent surface is required. It is also quite durable and can serve as a great substitute to PLA and ABS filament types. Reviewing the PETT with our chosen criteria, we have:

Properties:

1. **Tensile Strength:** PETT is considerable strong and a bit flexible
2. **Print Temperature:** PETT prints at approximately 220 – 250 degrees.
3. **Print Bed:** A heated bed set at 50 – 70 degrees provides heated support for its base
4. **Solubility:** Not soluble
5. **Warping Susceptibility:** Relatively minimal when compared to PLA and ABS
6. **Colour:** comes in multiple colour

When to Use PETT:

- When 3D printing objects with a transparent finish
- For 3D printing domestic toys and tools

Cons:

- PETT is hygroscopic—which mean it absorbs moisture—and must be kept in a dry place.
- Due to its transparent surface, it is susceptible to scratching

Polyethylene Terephthalate Glycol-modified (PETG) Filament

This is a modified version of the PET material which was enhanced with the aim of developing a clearer, less brittle filament. PETG can also be used on its own to 3D print translucent domestic and commercial items when needed.

Like PETT, PETG is also more durable and flexible than the popular PLA and ABS options. Therefore, it can serve as a good substitute for both when 3D printing toys and domestic objects. In terms of its properties, PETG shares many similarities with PETT.

Properties:

1. **Tensile Strength:** quite high, durable and more flexible than PLA/ABS
2. **Print Temperature:** prints at approximately 220 – 250 degrees.
3. **Print Bed:** A heated bed set at 30 – 60 degrees is recommended
4. **Warping Susceptibility:** Relatively minimal when compared to PLA and ABS

When to Use PETG:

- PETG should be used when a clearer and more durable material is needed
- PETG can be used to 3D print domestic items and some industrial components
- It can also serve as an alternative to other filament types

Cons:

- PETG also absorbs moisture and must be stored in waterproofed surroundings
- PETG is quite sticky when in molten form. This makes it a good adhesive to eliminate warping but a poor supporting material.

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Polycarbonate (PC) Filaments

The strongest group of thermoplastics are the Polycarbonates which you can use to 3D prints consigned for really rugged work or use. PC filaments are more likely to be used in an industrial/commercial setting than to 3D print domestic items except you are interested in 3D printing bulletproof glass and unbreakable screen guards for your smartphones. Its properties include:

The strongest group of thermoplastics are the Polycarbonates which you can use to 3D prints consigned for really rugged work or use

Properties:

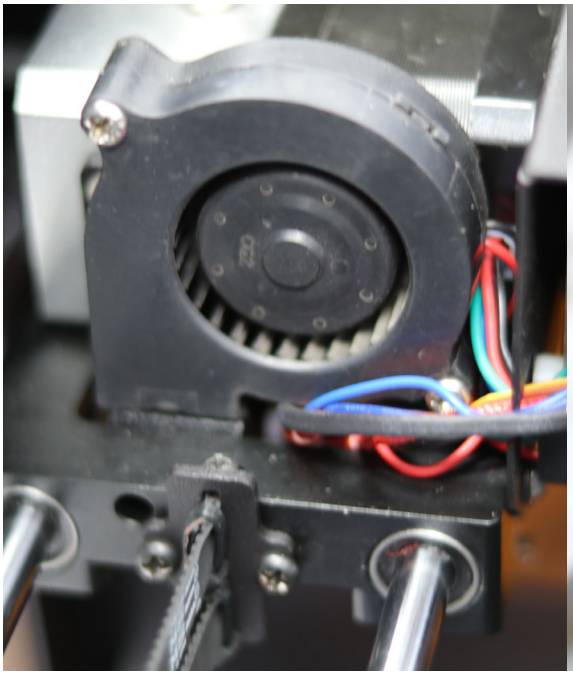
1. **Tensile Strength:** PC is the strongest thermoplastic filament you can use. It is also very durable and moderately flexible.
2. **Print Temperature:** PC prints at 270 – 310 degrees
3. **Print Bed:** Using a heated bed with temperatures at 90 – 110 °C is recommended.
4. **Solubility:** Not soluble in water
5. **Warping Susceptibility:** Quite high
6. **Colour:** Comes in multiple colours.

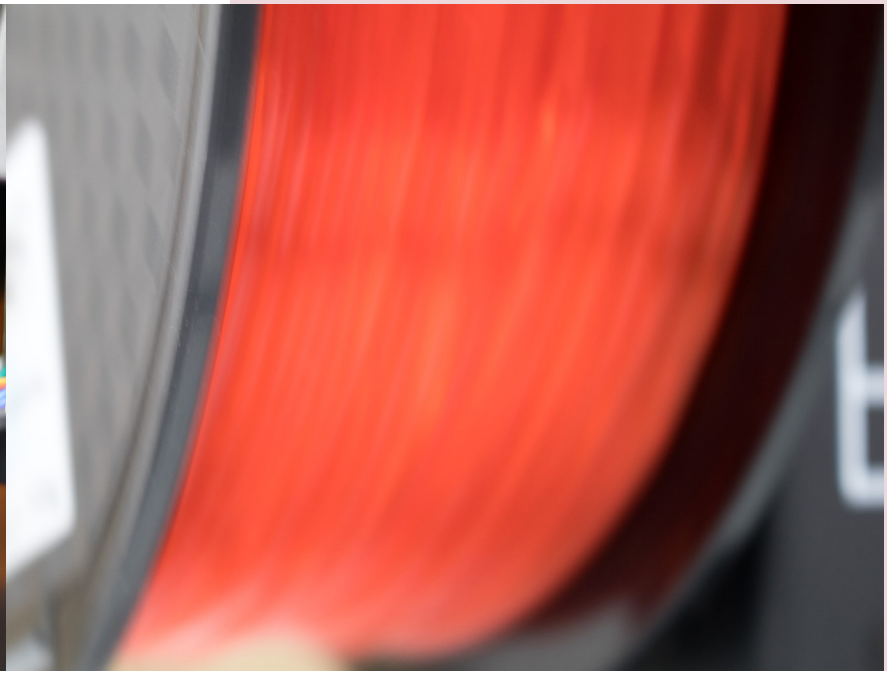
When to Use PC:

- PC should be used to 3D print very durable materials such as unbreakable screens, LED lighting fixtures, automotive and mechanical components. Note that PC isn't Plexi-glass for it is more flexible than it.
- To 3D print durable instruments and machine parts that are put to regular use and susceptible to wear and tear.

Cons:

- PC is hygroscopic and must be stored away from moisture
- PC is more expensive to purchase when compared to most thermoplastics
- PC produces fumes during the 3D printing process.





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Plasticized Copolyamide Thermoplastic Elastomer (PCTPE)

PCTPE is another combination that involves thermoplastics and rubber with the aim of creating a durable and highly flexible material for the 3D printing community. It is basically a hybrid version of TPE which includes Nylon. Due to its durability and flexible nature, PCTPE is mostly used as a material for 3D printing prosthesis and other elastic components.

As a hobbyist, you should view PCTPE as a more durable version of Nylon for they share certain similarities such as texture and flexibility. Reviewing its properties, we have:

Properties:

1. **Tensile Strength:** Considerably strong, high durability and high flexibility.
2. **Print Temperature:** It prints at 210 – 230 °C.#
3. **Print Bed:** A heat bed set at 40 degrees is recommended.
4. **Solubility:** Not soluble in water.
5. **Warping Susceptibility:** Minimal
6. **Colour:** Multiple coloured spools

When to Use PCTPE:

- PCTPE is great for 3D printing prosthetics and other aids for the human body
- It can also be used to 3D print wearable objects and clothing accessories

Cons:

- A bit more expensive than PLA and ABS
- Produces fumes when been 3D printed

Polycaprolactone (PCL)

PCL is one of those polymers that are not quite popular within the 3D printing community but still have their practical uses and the development of training accessories for sports is where it shines brightest. It is a durable material that brings strength and a measure of flexibility to your 3D printing workshop. Reviewing PCL we have:

Properties:

1. **Tensile Strength:** PCL is considerably strong and quite durable.
2. **Print Temperature:** PC has a really low melting point and can be printed at 60 -100 °C
3. **Print Bed:** It doesn't need a heat bed and adheres well to your printing platform.
4. **Solubility:** Not soluble in water
5. **Warping Susceptibility:** Very minimal
6. **Colour:** Comes in multiple colours.

When to Use PCL:

- PCL should be used when the goal is to 3D print a durable yet flexible model i.e. knee braces and orthotics.
- PCL can also be used to 3D print wrist bands and other domestic items.

Cons:

- A low melting point means if exposed to heat, 3D printed models can be distorted.
- PCL is quite expensive when compared to other thermoplastics and this may be due to its limited use by the 3D printing community.

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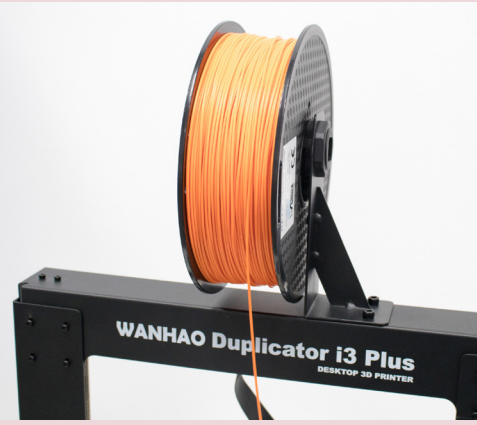
Decorative 3D Printing Filaments

Here, we will take a look at the extraordinary, the 3D filaments that bring some 'pizzazz' to your printing table! Decorative 3D filaments are materials that integrate certain features that enhance the overall look of your project.

The 3D filaments under this category generally do not need any finishing techniques—colouring, painting, shining etc.—applied on them to look cool. This is because their very presence is generally a thing of beauty to the eyes of the beholder. So sit back, relax and learn more about the exotic 3D filaments you can use to create art!



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Wood

Through the years, Wood grain and well-polished wooden surfaces have been used as beautification materials to add an aesthetic appeal to physical objects. Wood as a decorative material can be seen on the dashboard of your cars as well as the wallpapers we use in our homes. Therefore, it should come as no surprise to you that wood is a 3D filament that is highly sought after by hobbyists.

Now, let's analyze wooded filaments! Here, we would like you to know that this filament is not 100% wood but is basically 60 – 70% PLA—which has been covered earlier—infused with 30 – 40% of wooden fibres and but when printed, looks and feels like wood. Its properties include:

Properties:

1. **Tensile Strength:** Wood is durable but with low flexibility due to the addition of wooden fibres
2. **Print Temperature:** Wood filaments print at 170 – 220 °C.
3. **Print Bed:** Yes, heat bed set at 30-40 degrees is recommended.
4. **Solubility:** Not Soluble in water
5. **Warping Susceptibility:** Minimal
6. **Colour:** PLA can be infused with different types of wooden fibres such as pine, cork, bamboo etc. which makes multiple colours available to you.

When to Use Wood:

- Wood should be used to 3D print figurines, bowls and other ornamental/decorative items
- It can also be used to 3D print engineering and architectural models for presentations

Cons:

- High temperatures darken the texture of your wooden 3D print. Therefore, caution must be taken when 3D printing with wood.
- It is a bit more expensive than PLA or ABS
- Printing with wood comes with fumes which you must prepare for.

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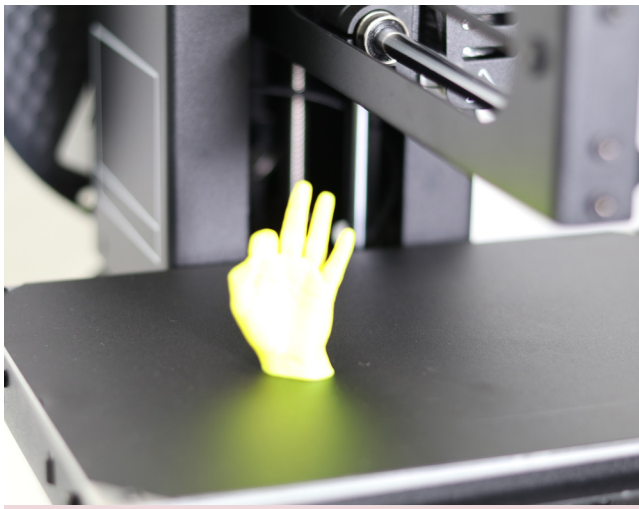
Metal Filaments



There are multiple techniques—airbrushing, painting etc.—you can explore to achieve a metal finish for your 3D print but using metal as your printing material is definitely the best option available to you. This is because using metal adds that bulk and metallic feel you can't achieve with any other finishing technique.

It is also important to note that metal filament is made up of PLA or ABS thermoplastics infused with powdered metals to make it possible to 3D print. The ratio of this mixture is generally 50% metal grains and 50% PLA or ABS. Reviewing metal filaments we have:

Properties:

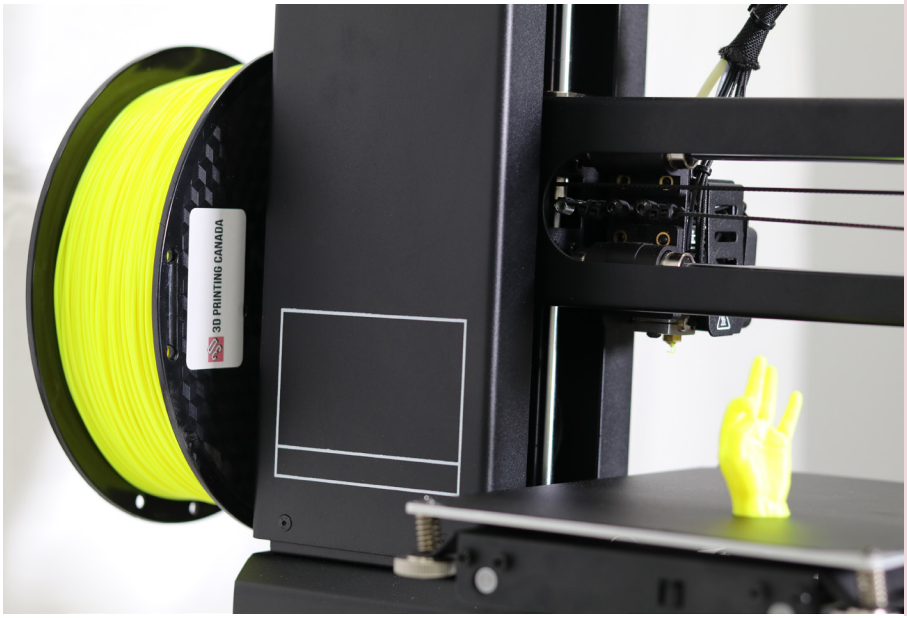
1. **Tensile Strength:** Metallic 3D prints are considerably strong with very low flexibility.
2. **Print Temperature:** It prints at 200 – 230 °C.
3. **Print Bed:** Yes, using a heat bed set at 40 -7-degrees is recommended to avoid warping.
4. **Solubility:** No
5. **Warping Susceptibility:** Average
6. **Colour:** PLA or ABS infused with bronze, aluminium etc. add their peculiar colours to your 3D prints.

When to Use Metal:

- Metal like wood should be used to 3d print ornament and decorative pieces that will not be put under too much use/stress.
- It should be used when you desire your 3D print to have a metallic finish and feel.

Cons:

- Metal filaments are not flexible
- Regularly 3D printing with metal wears down your 3d printer's nozzle
- Metal spools are more expensive than PLA or ABS



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Conductive Filaments

The field of 3D printing has been hailed as one of the emerging technologies—alongside Artificial Intelligence, the Internet of Things and Robotics—with the ability to disrupt the 21st century. And in many situations, these emerging technologies are expected to work hand-in-hand to achieve the said changes.

Conductive filaments are PLA and BAS filaments infused with conductive carbon particles that enable users, 3D print parts that can conduct electrical force. This makes it a great material for engineers and hobbyists interested in building IOT and robotic components.

Properties:

1. **Tensile Strength:** Quite durable and exhibits some level of flexibility.
2. **Print Temperature:** due to its PLA or ABS percentage, it prints at 180 – 210 degrees.
3. **Print Bed:** No real need for a heated bed.
4. **Solubility:** No
5. **Warping Susceptibility:** Average
6. **Colour:** Multiple colours

When to Use Conductive Filaments:

- For the development of low-voltage electrical circuits
- As a base for developing microprocessors
- To develop mechanical and engineering component that conduct electricity.

Cons:

- It is conducive and shouldn't be used to 3D print standard domestic items
- It is quite expensive when compared to most thermoplastics.

Industrial 3D Printing Filaments

The term 'industrial' goes to highlight that the 3D filaments under this category are basically used in industrial settings to manufacture items for commercial use. Therefore, you will hardly see the average 3D enthusiast working with them.

It is also important to state that although these filaments serve as materials for industrial 3D printers, they have secondary properties which they bring to the table. This can be structural support, heat resistance, increased solidity etc. The 3D filament s to be found here includes:

The term 'industrial' goes to highlight that the 3D filaments under this category are basically used in industrial settings to manufacture items for commercial use.

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Carbon Fiber

It is universally known that adding or infusing carbon fiber to any material strengthens it beyond its natural abilities. Therefore, adding carbon fiber to PLA or ABS filaments provide you with a hyper-rigid filament with little weight for the development of solid mechanical and engineering components.

Carbon fiber should be seen as a more enhanced filament type than Polycarbonates, which is quite similar to it. The major difference between both is that while Polycarbonates are moderately flexible, carbon fiber is a highly rigid material.

Properties:

1. **Tensile Strength:** Very strong, extremely stiff and rigid.
2. **Print Temperature:** Carbon fiber prints at 195 – 220 °C.
3. **Print Bed:** Yes, heated beds should be used and set at 30 – 40 °C.
4. **Solubility:** No
5. **Warping Susceptibility:** High
6. **Colour:** Comes in multiple colours

When to Use Carbon Fiber:

- Carbon fiber should be used in 3D printing mechanical/ engineering parts for automobiles, lathe machines, and other devices where extreme structural strength with low density is needed.
- It can also be used to provide a supporting base for models that need a solid bottom layer.

Cons:

- It distorts your nozzle head which ends up needing replacements.
- It causes a lot of wear and tear if used with a desktop 3D printer
- 3d printing with carbon fiber produces fumes and should be done in well-ventilated areas.
- It is also quite expensive for a 3D printing filament.

Polycarbonate ABS (PC-ABS) Filaments

Here again, we find a polymer infused with carbon fiber but tempered with ABS thermoplastics to reduce its rigidity. With PC-ABS, the limitations that come with using carbon fiber have been reduced a bit as ABS infuses some of the rigidity associated with Polycarbonates.

So when in search of a strong, heat resistant but somewhat flexible 3D filament to 3D print with, PC-ABS is your best bet. A review of its properties show:

Properties:

1. **Tensile Strength:** Really strong but shows more flexibility than Polycarbonate
2. **Print Temperature:** PC-ABS prints at a high temperature of 220 – 260 °C
3. **Print Bed:** Using a heated bed is recommended. And its temperature should hover at the 100 °C mark.
4. **Solubility:** No
5. **Warping Susceptibility:** High
6. **Colour:** Produced in multiple colours

When Should You Use PC-ABS:

- PC-ABS is a favourite of the hardware, electronics and telecommunications industry. It provides enough strength and flexibility for the components these industries thrive on.
- It can also be used to 3D print parts for automobiles and machines.

Cons:

- PC-ABS is hygroscopic—sucks in moisture—and most be stored in a dry place.
- It causes the wear and tear of nozzles on domestic 3D printers.
- It is more expensive than PLA, ABS and PC filament types.

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Acrylonitrile Styrene Acrylate (ASA) Filament

The limitations of ABS and PLA have been touched on to some extent in the paragraphs above and this affects its use in commercial and industrial circles. ASA serves as a great alternative to the most common thermoplastics because it is more resistant to the forces of nature—rain, cold, heat etc.—unlike ABS. It is also quite resistant to man-made forces—chemicals, heat etc.—which adds to its durability.

Properties:

1. **Tensile Strength:** Considerably strong and moderately flexible.
2. **Print Temperature:** ASA prints at 180 -220 °C
3. **Solubility:** Not soluble in water or limonene
4. **Warping Susceptibility:** It experiences minimal warping when compared to ABS
5. Colours: Available in multiple colours

When to Use ASA:

- ASA should be used to 3D print commercial items that are exposed to natural element on a regular basis e.g. outdoor sockets, bicycle seats etc.
- It can serve as a more enhanced version of ABS when 3D printing domestic items.

Cons:

- ASA is susceptible to cracking when 3D printed
- ASA is more expensive than ABS and PLA

High Impact Polystyrene (HIPS) Filament

HIPS is what you call a multi-purpose 3D filament due to the duties it carries out in the 3D printing process. It is made up of polystyrene and rubber which makes it quite hard but also elastic when 3D printed.

HIPs is basically used in manufacturing protective packages such as plastic boxes, CD cases etc. which are used to aesthetically box products. Alternatively, HIPS is commonly used as the supporting material for other filament types when 3D printing. This is due to its soluble nature as it dissolves when placed in limonene.

Properties:

1. **Tensile Strength:** Slightly strong but highly flexible
2. **Print Temperature:** It Prints at 150 – 200 °C.
3. **Solubility:** HIPS is soluble in limonene
4. **Colour:** Generally cream in colour

When to Use HIPS:

- HIPS is basically used in 3D printing as a support material to fill the spaces between printed parts
- It can also be used to support overhanging print models so they do not get malformed.

Cons:

- It serves more as a supporting cast than a 3D printing filament
- Limonene affect/distorts most filament types except ABS. therefore, it is recommended that you use HIPS to support ANS prints.

Polyvinyl Alcohol (PVA) Filament

PVA is one of the more popular supporting materials used in the 3D printing process due to its solubility. Unlike HIPS, PVA is actually soluble in water which makes it compatible for use with just about every 3D filament type on this guide. It serves basically the same functions as HIPS and using our review parameters you have:

Properties:

1. **Tensile Strength:** low strength but harder than HIPS
2. **Print Temperature:** Prints at 100 – 200 °C
3. **Solubility:** Soluble in water
4. **Colour:** Generally white or cream

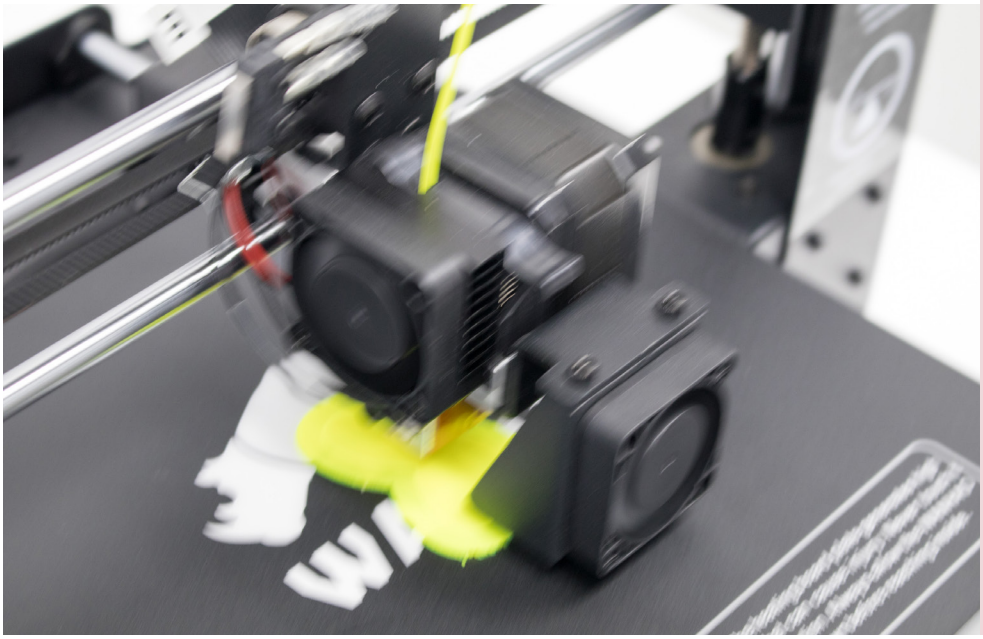
When to Use PVA:

- PVA is used to support overhanging or fragile structures during the 3D printing process.
- It is also use to fill up the space between 3d printed parts to limit stringing.
- PVA is compatible with PLA, ABS PC etc. because it dissolves in water which doesn't affect most 3D filament types.

Cons:

- It is basically a supporting material for the 3D printing process.

PVA is one of the more popular supporting materials used in the 3D printing process due to its solubility



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Thermoplastic Polyurethane (TPU)

Thermoplastic Polyurethane is another one of those enhanced thermoplastic built for industrial use. As its name suggests, it consists of thermoplastics and polyurethane which adds elasticity to the material.

TPU was built for commercial use and its considerable strength and elasticity makes it one of those filament types that can be used to 3D print both industrial components—where rigidity is valued—as well as sporting/medical devices or aids due to its elasticity.

Properties:

1. **Tensile Strength:** TPU brings considerable strength as well as flexibility to the table.
2. **Print Temperature:** It prints at 230 – 250 °C which is relatively high compared to other thermoplastics.
3. **Print Bed:** A heated bed set at 40 – 60 °C is recommended.
4. **Solubility:** Not Soluble in water
5. **Warping Susceptibility:** Moderate
6. **Colour:** Multiple colours are available

When to Use TPU:

- TPU can be used to 3D print tough industrial components and tools that experience constant use.
- TPU's flexibility also makes it a good filament type for 3D printing sport shoes, protective guards and medical devices such as knee braces.
- TPU can also be used to 3D print replacement parts for your 3d printer.

Cons:

- TPU has a high print temperature and constant use may wear down your 3D printer's mechanical parts
- TPU is a bit more expensive than ABS and PLA filament types.

Conclusion

Here you have the different types of 3D filaments you can exploit to 3D print your favourite digital 3D models. Do remember that these filaments are tailored for fusion deposition modelling (FDM) 3D printers and you can purchase the different 3D filament types in Canada from 3D Printing Canada's online store. For information, do not hesitate to contact us using our email addresses or via the phone.

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