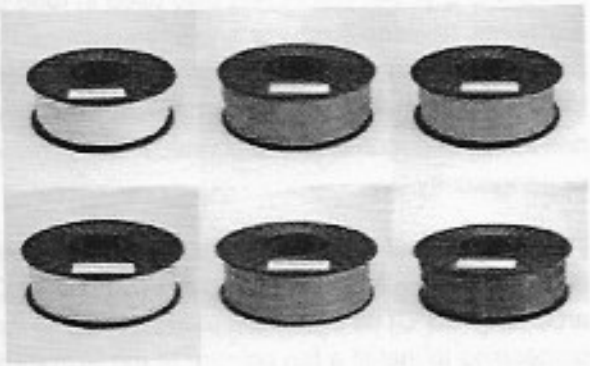
What Material Should I Use For 3D Printing?



This article will give you a quick overview of the current consumables used in 3D printing and will explain the main differences in terms easily understood by beginners. As explained in our previous article *"What is 3D printing?"*, there are mainly two sorts of 3D printers, the industrial-type printers and the consumer-oriented 3D printers, a.k.a. desktop 3D printers.

The present article will only focus on the most common consumables used in consumer 3D printers using the FDM (fused deposition modeling) technology. A traditional inkjet printer needs ink cartridges in order to be able to print – the situation is similar for 3D printers, except that 3D desktop-type printers need plastic filament. These consumables are mostly available online in a variety of types of material (ABS, PLA, PVA, etc.), colors, diameters and lengths.

What Material? – ABS vs PLA vs PVA

Note: the more exotic printing plastics like polycarbonate (PC), high-density polyethylene (HDPE) or nylon are not discussed in this article.

ABS (Acrylonitrile butadiene styrene)

ABS is used in a very large variety of applications in the industry nowadays. Examples include, among many others, the manufacturing of pipes (like drain, waste or vent pipes), automotive components, electronic assemblies, protective headgear (ABS has good shock absorbance), kitchen appliances, music instruments, protective carrying cases and toys, among which the most notable are the famous Lego bricks.

ABS is generally very durable and strong, slightly flexible and quite resistant to heat. Printers able to process ABS plastics normally operate with a hot end (the heated part melting the plastic, before it's forced through the print nozzle) at a temperature around 210-250°C. Therefore, a 3D printer able to process ABS is necessarily equipped with a heated printbed (the surface that the 3D prints are built on), in order to prevent warping or cracking of the printed materials.

Considering cost, ABS is the cheapest plastic of the three filament types analysed and until recently was the favourite material of the 3D printing communities. The material is suitable for a very large variety of purposes, especially as it can easily be sanded (to smoothen the printed objects and removed jagged edges) and painted. Printed or broken parts can simply be glued together with ABS glue and it is easily dissolvable in acetone (i.e. nail polish remover). ABS is generally available in white, black, red, blue yellow and green colors or transparent and has a matte appearance.

But ABS also has some drawbacks. First of all, it is a petroleum-based non-biodegradable plastic, but which fortunately can be recycled. Another problem is that ABS does create (mild) fumes which may irritate more sensitive persons – an installation of the printer in a well ventilated area or even a specific fume hood may be necessary. ABS can also deteriorate by prolonged exposition to sunlight.

PLA (Polylactic Acid)

Filament Diameter and Filament Sources

Once you have chosen the appropriate material, you should check whether the filament diameter is compatible with your printer before ordering. The two standard diameter sizes for filament are 1,75mm or 3mm. Only some printer models can accept both of these and you should always check what diameter your printer can use. Filament is generally sold at its weight price. Spools of 1kg or 2,5kg are standard sizes, although some materials are sold by the meter or in loose coils (especially the more exotic filament colors or plastic types). As to quality, some people argue to only buy from reputable suppliers, but these filaments may come with a certain price tag. Others have made great experiences with relatively cheap filament. In the end, it probably comes down to experimenting with filaments from various sources, before finding the one suiting your needs best. A list with sources will be added to this post in time.

Comparison Table

	ABS	PLA	PVA
Scientific designation	Acrylonitrile butadiene styrene	Polylactic acid or polylactide	Polyvinyl alcohol
Produced from	Petroleum	Plant starch	Petroleum
Properties	Durable Strong Slightly flexible Heat resistant	Tough Strong	Water-soluble Excellent film formation High bonding power Good barrier properties
Extruder temp	210-250°C	160-220°C	190-210°C
Price	14-60$ / kg	19-75$ / kg	80-120$ / kg
Post-processing	Easy sanding Easy glueing Easily dissolvable in acetone	Sanding possible Limited glueing	Dissolvable in water
Positive points	Great plastic properties Smooth finish Solidifies quickly Durable and difficult to break Ideal for mechanical parts	Bioplastic – good environmental properties Good smell when heated Nontoxic No heated printbed necessary High print speed and resolution Less warping or shrinking issues Ideal for small parts Hard or soft/flexible variants	Biodegradable Recyclable Non toxic
Negative points	Petroleum-based Non-biodegradable Heated printbed necessary Fumes Deterioration through sunlight	Slow cooling down Low heat resistance Easier to break then ABS Needs thicker walls then ABS	Expensive Deterioration due to air moisture Special storage necessary

PLA is a biodegradable thermoplastic which is derived from renewable resources, such as cornstarch, sugar cane, tapioca roots or even potato starch. This makes of PLA the most environmentally friendly solution in the domain of 3D printing, compared to all the other petrochemical-based plastics like ABS or PVA. PLA is used for example in medical suturing as well as surgical implants, as it possesses the ability to degrade into inoffensive lactic acid in the body. Surgically implanted screws, pins, rods or mesh simply break down in the body within 6 months to 2 years. But PLA is also used in food packaging, bags, disposable tableware, upholstery, disposable garments, hygiene products and even diapers. PLA is therefore considered as pretty safe. For those wanting to print PLA drinking cups or other recipients destined for food or drink, a word of caution though: do not forget that the coloring pigments in the filament may not be as harmless as the PLA itself. Unfortunately, the notice of use nearly never documents the chemical composition of those pigments in order to inform about their harmlessness or dangerosity.

PLA is tough, but a little brittle, once it has cooled down. Its temperature threshold is lower than the one of ABS, as PLA is normally extruded around 160°C-220°C. A heated printbed is not mandatory, but it may (at temperatures around 50-60°C) be beneficial to the quality of the printed object. PLA is quite slow to cool – experts recommend sometimes to install a fan pointed at the extruded material in order to speed up the cooling process. Once it is heated, PLA does emit a slight odor, best described as sweet corn, pancakes or maple syrup – but it does not emit fumes like heated ABS. No fume hood will be necessary and you may safely print with PLA in-house.

PLA can be sanded down and may be painted over with acrylic paint, but some people recommend using a primer Glueing PLA is however not as easy as glueing ABS. Most people seem to get some results with cyanoacrylate (i.e. super glue), but this does have some disadvantages of its own (use of safety glasses and gloves, extreme stickiness to fingers and other body parts, very quick hardening, etc.).

PLA has been becoming a very popular choice in the 3D printing communities, considering its low toxicity and its better environmental friendliness, compared to all the petroleum-based plastics. Its main drawbacks are that it cannot stand too much heat, as standard PLA becomes soft around 50°C (i.e. you can re-heat your printed object with a hot air gun, for example). On the other hand, one may consider this an advantage in order to easily repair, bend or weld printed parts.

But PLA is generally considered the easiest material to work with, when you first start printing. It has been becoming more and more readily available and probably will overtake ABS as the preferred choice. PLA is available in most colors and may be translucent or solid. When it comes to colors, this article by Flashgamer gives you a pretty good idea what is currently available. Most notable colors are the translucent (a.k.a. transparent) one, as well as the "glow in the dark" PLA.
Soft PLA is also available – this very interesting variant permits the printing of flexible materials, but is more complicated to use. Sourcing soft PLA may also prove difficult.

PVA (Polyvinyl Alcohol)

PVA is a special plastic that is water-soluble. It is most commonly used as paper adhesive, as thickener, as packaging film, in feminine hygiene and adult incontinence products, as mold release agent or in children's play putty or slime. Another wide use is in freshwater sport fishing, where PVA bags filled with bait are thrown into the water. The bag rapidly dissolves, releasing the bait, in order to attract the fish.

In 3D printing, PVA is sometimes used in printers with dual or multiple-extruders, in order to provide a support structure to an object with overhang issues. Some complex prints involving lots of overhangs (areas where there is no support under the upper layers) can be realised only by printing such a support structure. Otherwise, the printed structure would warp or simply collapse. The finished object can be put into water until the PVA has completely dissolved, freeing the object of the support structure, without the need of any pesky manual post-printing curing.
PVA is normally extruded a temperature of 190°C, but is not very easy to use, as it attracts water so much. Ambient air moisture will deteriorate the filament very quickly. PVA needs to be stored in a sealed box or container and may need to be dried before use. Another disadvantages of PVA include its high price and quite difficult sourcing.