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Filament comparison chart

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3D Insider is an ad-supported platform that generates revenue through clicks and commissions. Over the past decade, 3D printing has gained immense popularity, with desktop-scale models becoming increasingly accessible and affordable. Among various 3D printing technologies, Fused Deposition Modelling (FDM) stands out as the most popular option due to its affordability, ease of use, and versatility in handling a wide range of filament materials. With numerous filaments available, selecting the right one for your project can be overwhelming. In this article, we'll delve into the characteristics of common FDM filaments, highlighting their strengths and weaknesses, as well as discussing their best applications. We'll start with popular options and work our way down to lesser-known alternatives. To help you choose the ideal filament for your 3D printing project, consider the following questions: 1. What physical and chemical properties do I need my print to have? Different filaments offer distinct properties, such as ABS's strength and heat resistance or PLA's biodegradability. HIPS can be dissolved in limonene, while PVA can be dissolved in water. 2. Can my 3D printer handle the filament I'm planning to get? Some filaments are more demanding in terms of printer capabilities. Printing support materials with HIPS or PVA requires a dual extruder printer, while high-temperature filaments require temperatures beyond some printers' specifications. 3. What is my level of skill and experience? Some filaments are easy to work with, such as PLA, while others can be challenging due to warping and stringing issues, like Nylon. Beginners should start with simple filaments and gradually develop more advanced skills. 4. What is the look I want to achieve for my 3D print? Specialty filaments offer unique aesthetics, from wood-like appearances to metallic finishes. Even basic filaments like ABS can be finished in ways that achieve professional-grade aesthetics with minimal effort. Let's start by exploring the characteristics of ABS (Acetonitrile Butadiene Styrene), a high-temperature filament suitable for functional parts and outdoor items. Properties: * High-temperature printing * Heat-stable * Chemically stable * Durable * Rigid * Soluble in acetone * Emits fumes while printing Applications: * Functional parts (hinges, brackets, etc.) * Outdoor items Printing temperature: 220 to 250 °C ABS is a strong and heat-resistant material valued for its superior strength and chemical stability. It's a polymer made from three monomers: acrylonitrile, butadiene, and styrene. ABS requires high temperatures (220-250°C) for printing, which makes objects printed with it remarkably durable. However, this property can lead to warping due to rapid cooling. To overcome these challenges, use a heated bed with adhesive, control the bed temperature with an enclosure, or use a bed adhesion aid like Kapton tape. Finish your prints with an acetone vapor bath for a professional-grade finish. ABS has its pros and cons: it's heat-stable, chemically stable, good at impact strength, but non-biodegradable, produces noxious fumes, power-intensive due to high printing temperatures, and prone to warping. On the other hand, PLA (Polylactic acid) is a flexible material suitable for prototyping and display items. It's less prone to warping and doesn't emit fumes during printing. However, it has sub-par durability and heat stability. Print PLA at 150-160°C with a speed of 40-70 mm/s and a bed temperature not necessary but optional. Polylactic Acid (PLA) is rapidly becoming the go-to filament material for desktop 3D printing due to its affordability, ease of use, and complete biodegradability. Let's dive into what makes PLA tick and why it's an excellent choice for beginners. As a polymer made from lactic acid monomers, PLA breaks down into its building blocks when decomposing, which are naturally occurring in the environment and even within our bodies. This eco-friendly characteristic has earned PLA widespread adoption in industries like medicine for producing biodegradable sutures and stents. Additionally, PLA can be sourced from renewable materials like cornstarch, sugar cane, or potato starch. Another advantage of using PLA is its low printing temperature requirement, which minimizes warping and stringing issues common with high-temperature filaments. When heated, PLA emits a pleasant aroma reminiscent of pancakes. When printing with PLA, keep the following tips in mind: 1. Utilize a heated bed if possible to ensure proper adhesion. 2. Store your PLA in vacuum-sealed bags to prevent moisture absorption and potential clogging issues. 3. Finish your prints using sanding and polishing techniques, as acetone vapor baths are not applicable. Pros of using PLA include its ease of use, low power consumption due to low temperature, no warping or stringing issues, and 100% biodegradability and bioactivity. Cons include its tendency to melt easily, degrade quickly when exposed to sunlight, and absorb moisture easily. Nylon is a highly durable material that excels in mechanical parts and equipment applications. It has a low coefficient of friction and can withstand heavy wear and tear. In 3D printing, nylon prints are exceptionally robust due to excellent layer-to-layer adhesion. However, it also absorbs water easily, making it prone to moisture absorption. To get the best results when printing with nylon, it's essential to dry the filament before use and apply high-quality bed adhesion materials. An enclosure or heated chamber is also crucial for maintaining a consistent internal temperature during printing. Nylon has several pros, including its superior strength and durability, abrasion resistance, heat stability, and chemical stability. Additionally, it takes up coloring agents easily, making it an excellent choice for creating vibrant prints. However, it does have some cons, such as requiring high temperatures (260-280°C) during printing, which can lead to warping and stringing issues. Some tips for successfully printing with nylon include: 1. Drying the filament in an oven before use to remove excess moisture. 2. Using a high-quality bed adhesion material to prevent warping. 3. Printing in an enclosure or heated chamber to maintain a consistent internal temperature. 4. Adjusting your printer settings and using a heated build platform (if available) to ensure successful prints. High-Impact Polystyrene (HIPS) is a versatile plastic that excels in high-temperature printing, support structures, and moving parts with repeated impact. Its unique properties make it an ideal material for certain applications. **Printing Details** * Temperature: 230 to 240°C * Speed: 40 to 70 mm/s * Bed temperature: 90 to 110°C * Cooling: No cooling fan; print using an enclosure HIPS is often used as a support material when printing with ABS, thanks to its ability to dissolve in limonene. This solvent-based removal process eliminates the need for manual support structure removal. **Properties** * High impact strength and flexibility * Heat-stable and resistant to warping * Excellent physical properties make it suitable for various commercial and industrial applications **Tips and Considerations** 1. **Dissolve support structures**: Submerge your print in limonene for at least 24 hours to dissolve HIPS support materials. 2. **High-temperature printing techniques**: Use appropriate high-temperature printing techniques when working with HIPS as the main filament material, including a heated bed and adhesion aid. 3. **Cooling process**: Allow HIPS prints to cool completely before moving them to prevent warping. **Pros** * High impact strength * Tough but flexible * Heat-stable Support Material: PVA (Polyvinyl Alcohol) * Dissolves completely in limonene * Prints at high temperature (185-200°C) * Prone to warping and stringing when hot * Very soft when heated to high temperatures Properties: * Resistant to oils and solvents, but dissolves in water * 100% biodegradable * Applications: support structures for PLA prints, printing temperature, and cooling requirements. PVA printing requires patience and precision. To achieve successful prints, you should ensure that the previous layer has solidified before applying additional PVA layers. This necessitates slow printing speeds of approximately 30 mm/s or lower. Furthermore, utilizing a cooling fan can aid in accelerating the cooling process of the PVA material. PETG (Polyethylene Terephthalate) is an incredibly resilient filament with numerous advantages. Its high strength and impact resistance make it an excellent choice for printing components that require mechanical stability. Additionally, PETG exhibits exceptional chemical stability, clarity, and heat tolerance. This versatility renders it suitable for a wide range of applications, including food packaging, medical containers, and electronic devices. When printing with PETG, it is essential to maintain precise control over the temperature, speed, and bed conditions. A moderate printing temperature of 220-245°C is recommended, along with a slow-to-medium speed of 15-55 mm/s. The optimal bed temperature for PETG is between 70-75°C. PETG offers exceptional printability and laminating characteristics, making it an excellent choice for signages, store fixtures, credit cards, and other applications where clarity and durability are essential. While PETG has numerous benefits, its weakness lies in its susceptibility to degradation under UV exposure. Unlike ASA, PETG's strength can rapidly decrease when exposed to constant sunlight. Additionally, PETG is more prone to abrasion compared to other filament materials. For new users, it is crucial to exercise caution when working with PETG. The filament has a narrow "sweet spot" and requires precise control over printing parameters to achieve optimal results. It is recommended to avoid using PETG for support structures due to its exceptional strength, which can make removal challenging. Setup for HIPS support material, reducing frustration. Turn on the cooling fan mid-print for PETG, but avoid warping by printing without cooling for the first few layers. Then, turn it off and back on again for the remaining layers. Print slowly or enable retraction to prevent stringing. For best results, start with a slow speed of 15 mm/s and adjust as needed. PETG properties: high impact strength, heat-stable, can withstand steam sterilization, good chemical resistance. However, it's difficult to work with, worst choice for support material, and quickly degrades under UV light. TPU (Thermoplastic Polyurethane) characteristics: very flexible, good impact resistance, abrasion-resistant, stable against solvents and oils. It's prone to deformation in the extruder, cannot be polished or sanded. Applications include sporting goods, footwear, inflatable objects, and cases for mobile phones. Printing temperature: 200-220°C; speed: 15-30 mm/s; bed temperature: 80-100°C; cooling: no fan for first two layers, medium setting for remaining layers. TPU Filament: Tips for Success ----- When working with TPU filament, it's essential to treat the material with care. Here are some tips to help you achieve success: * **Use an extruder instead of a Bowden extruder**: This allows the filament more room to move without deforming. * **Print at very low speeds**: as TPU can easily bend and contract under stress. Start with 15 mm/s and gradually increase as long as your extruder doesn't clog. * **Disable retraction**: as this can cause the filament to stretch, compress, and ultimately lead to a clog. ASA (Acrylonitrile Styrene Acrylate) Material: Properties and Applications ----- ASA is a highly durable material with good resistance against UV degradation, weathering, and stress cracking. It also has impact resistance and is heat-stable. However, it can be prone to stringing and warping. Properties: * Durable * Resistant to UV degradation and weathering * Less prone to stress cracking * Good impact resistance * Heat-stable * Chemically stable Applications: * Garden fixtures * Outdoor sports equipment * Road signages * Automotive parts Printing Settings: * **Temperature**: 230-250 °C * **Speed**: 40-70 mm/s * **Bed temperature**: 90-110 °C * **Cooling**: No cooling fan; use bed enclosure instead To ensure successful printing with ASA, it's crucial to use an adhesion aid that's compatible with the material. A heated bed is also necessary for proper adhesion. You can opt for ABS glue or Kapton tape, which provides a smooth surface finish. When printing ASA, make sure to work in a well-ventilated area and cover your build platform. This will prevent unwanted drafts and ensure your prints cool down rapidly, reducing warping. To conserve ASA filament, it's best to use it only when necessary, as it can be quite expensive. You may want to save it for projects that require its superior weathering resistance and UV resistance. ASA has some drawbacks, including lower impact strength compared to ABS and a tendency to string and warp. It also requires higher temperatures during printing. On the other hand, polycarbonate is known for its exceptional strength, high impact resistance, and good optical properties. It's an excellent choice for creating strong 3D printed objects that can withstand harsh conditions. However, polycarbonate requires specific settings during printing, including a higher temperature range and no cooling fan. A bed enclosure is necessary to prevent warping. Polycarbonate has several advantages, including its ability to flex without breaking or deforming. It also exhibits good heat stability and optical properties comparable to glass. Its prints can look really good and be used for applications that require transparency. However, polycarbonate is a demanding filament that requires experience and specific settings during printing. It's not recommended for beginners. When working with polycarbonate filament, it's essential to choose the right adhesion aid as some adhesives may degrade at higher temperatures. A combination of Kapton tape and ABS slurry is often recommended. Tips for printing with polycarbonate include: 1. **Print cold and slow**: The recommended temperature for polycarbonate is 300 °C, but not all printers can reach this temperature. To print successfully, you'll need to either use a higher-temperature printer or reduce the speed to around 15 mm/s. 2. **Print in a well-ventilated area**: Polycarbonate printing requires high temperatures and bed adhesives, which can produce fumes. Ensure good ventilation and place an enclosure around your build platform to prevent warping. 3. **Be prepared for errors**: Polycarbonate can be challenging to work with, even for experienced 3D printing professionals. Be prepared for mistakes, as common issues include warping, stringing, and clogged nozzles. However, polycarbonate is relatively inexpensive, so you may be able to afford a few misprints. Polycarbonate offers several benefits, including: * Excellent strength and impact resistance * Heat-stable * High tensile strength * Good optical properties However, it also has some drawbacks, such as: * Resistant to scratches but prone to warping and stringing * Prints at high temperatures, which can be challenging for some printers * Difficult to work with due to its specific requirements Carbon fiber is a unique material that offers exceptional strength-to-weight and strength-to-volume ratios. It's often used as an additive in composite materials, particularly in applications where weight is crucial. Carbon fiber has several benefits, including: * Very strong and lightweight * Abrasion-resistant * Exceptional rigidity and durability However, it also requires specific printing conditions, such as a higher temperature (20-30 °C above the plastic base) and slower speed (50% slower than standard). Additionally, carbon fiber filaments typically require a bed temperature of 45-60 °C. Filaments with carbon fiber offer unique properties, but they can be challenging to work with. Unlike other filaments, the carbon fibers don't melt during printing; instead, they remain solid and are conveyed through the nozzle along with the plastic matrix. This characteristic can quickly wear down brass nozzles, so it's recommended to use heat-treated steel nozzles. The plastic matrix may vary between brands, requiring different printing parameters. Carbon fiber filaments are specialty materials that come with their own set of challenges. They're expensive, require special accessories, and can be brittle. However, they offer unparalleled strength-to-weight ratios, making them suitable for specific applications. Tips for printing with carbon fiber: 1. Keep the filament path simple to prevent snapping. 2. Print at a slower pace to reduce stress on printer parts. 3. Consider using a nozzle with a larger bore to reduce clogging risks. Carbon fiber filaments are ideal for mechanical parts, protective devices, and sports applications where exceptional strength, rigidity, and durability are crucial. Conductive filaments are often confused with carbon fiber filaments, despite their distinct differences. While both contain carbon, the key distinction lies in the percentage of carbon and its molecular arrangement. Conductive filaments have a significantly higher concentration of carbon, arranged in a "honeycomb lattice" pattern that allows for electricity transmission. Compared to carbon fiber filaments, conductive filaments are made with a larger proportion of graphite layers, held together by standard filament plastic such as PLA or ABS. This material has a unique niche and is extremely fun to work with, allowing for custom designs with embedded electrical circuits. Conductive filaments have been touted as the future of wearable electronics, enabling seamless integration into fabrics that can adapt to any shape or form. They also excel at creating customized containers that act as electromagnetic or radiofrequency shields. However, these filaments are significantly more expensive, up to three or four times the cost of standard filaments. They also face challenges similar to other composite materials, including wear on brass nozzles and exceptional brittleness. Tips for printing with conductive filaments include: 1. Don't expect it to conduct electricity like metal - graphite layers have limitations in terms of current handling. 2. Take usual precautions for composite filaments - prepare a smooth filament path, use a wide-orifice steel nozzle, print at a slightly higher temperature, and slow down the printing speed. Pros: Can conduct small amounts of electricity Can be used to create custom electronics Cons: Expensive Can wear down the nozzle Brittle filament Not as conductive as metals Excellent aesthetics: Metallic filaments simulate metal's look, can be sanded and polished, prints at low temp (190-220°C), printing speed (50-80mm/s). No heated bed required; cooling fan set to max. Key features: Unique appearance, high metal content, easy to heat up. Printing tips: 1. Check manufacturer's recommended printer parameters. 2. Consider adding support structures for overhanging parts. 3. Don't use metallic filament for functional parts due to brittleness. These composite filaments have a composition of 80% metal and 20% PLA, offering a nice heft and rigid prints. While not as durable as pure PLA, they still provide excellent aesthetics. Don't rely on metallic filaments for load-bearing objects or constant impact. PROS: Superior aesthetics, various metal types available, and faster heat-up. CONS: Wears down brass nozzles quickly, brittle filament, heavy prints. Magnetic Filament Material: Iron powder in PLA matrix Properties: Creates ferromagnetic objects that react to magnets. Applications: Custom trinkets, jewelry, magnetic sensors, stators for motors, and magnetic storage media. Printing Parameters: * Temperature: 215-225°C * Speed: 60-80 mm/s (start low at 10-20 mm/s for the first two layers) * Bed Temperature: Not necessary, but optimal with a heated bed set at 60°C * Cooling: No fan initially, start cooling at 10-20% setting for later parts of the print Tips: 1. Print slowly and avoid rapid cooling to prevent warping. 2. Finish prints with a "rusted look" by sanding them. Note: Magnetic filaments create ferromagnetic objects that react to magnets but cannot act as magnets themselves. Wood filaments offer a unique way to create custom wooden designs using a standard desktop FDM printer. These filaments are made from a suspension of wood powder in PLA matrix, resulting in a wood-like finish and a pleasant smell while printing. Wood filaments are also resistant to warping, 100% biodegradable, and have good layer adhesion. Some benefits of using wood filaments include unique magnetic properties, rigid and hefty prints, and the ability to finish with glossy or matte surfaces. Additionally, wood filaments can be finished to give them a rusted look. However, there are some drawbacks to consider, such as brittle printed objects, filament that is also brittle, and a tendency to warp during printing. To get the most out of your wood filaments, it's important to avoid leaving leftover filament in the nozzle for long periods, as this can cause burning and leave a hardened residue. You can also experiment with different printing temperatures to achieve unique looks. Finally, consider finishing your prints with varnish or lacquer to enhance their appearance. You can finish your 3D prints by sanding, polishing, and applying a wood varnish or lacquer. This process enhances the visual appeal of your wood print, making it resemble real wood. Additionally, finishing with varnish helps prevent moisture from entering the material and preserves its quality. The advantages of using glow-in-the-dark filament include: * Superior aesthetic * Resistant to warping * 100% biodegradable * Emits a pleasant smell during printing * Versatile finishing options However, there are some drawbacks to consider: * Creates brittle prints * Brittle filament * Expensive Glow-in-the-dark filaments can be used for various applications, such as custom trinkets and jewelry, display items, toys, outdoor safety marks, and signages. The optimal printing parameters for this type of filament depend on the plastic material used, which can be either PLA or ABS-based. PLA-based glow-in-the-dark filaments are recommended for beginners due to their simplicity and ease of use. For experienced printers, an ABS-based material may offer increased strength. When printing with glow-in-the-dark filaments, consider the following tips: 1. Increase shell thickness for a brighter glow 2. Use a wide-diameter nozzle to prevent filament abrasion Foolproof Solution: Use Nozzles with Wider Openings (0.5-0.6 mm) Sandstone Filament Properties: Simulates stone carving, resistant to warping, rigid, brittle, and abrasive. Aesthetics: Unique visual appeal, available in different colors. Cons: Creates brittle prints, brittle filament, expensive, and abrasive. Applications: Display items, custom trinkets and jewelry, design pieces, and architectural models. Printing Parameters: Temperature: 165-210°C Speed: 50-60 mm/s Bed Temperature: Heated bed not necessary, but optimal at 60°C. Cooling: Cooling fan at max setting. Tips: 1. Print at different temperatures (165-210°C) to achieve unique finishes. 2. Enable maximum cooling to prevent print collapse and promote layer hardening. 3. Finish sandstone prints by sanding and painting for a polished look. Unique Selling Points: Superior aesthetics, can be finished in various ways, and simulates stone carving without the skill and effort of physical carving. The world of FDM filaments isn't without its quirks - warping CONS can result in brittle prints, and pricey options are often heavy on the abrasive side. It's not a comprehensive list, though; there are many unique filament types out there, like those infused with hemp or cotton fibers, even glass or spent grains from beer making. As the desktop 3D printing industry continues to thrive, we anticipate an influx of new and innovative filaments hitting the market in the years to come.