

# Material Comparisons

We live in a fantastic world to have literally hundreds of colors available in dozens of different materials for hobby 3D printing

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## TPU "*Thermoplastic PolyUrethane*", TPE "*ThermoPlastic Elastomer*", Flexible-PLA, etc.

- Softest material straight from a filament printer
    - Has more in common with rubber than plastic
  - Best impact resistance
  - Adequate temperature resistance
    - Innate flexibility allows its use well above the glass transition temperature
  - Moisture
    - **TPU and TPE filaments MUST be dry!**
    - Moist filament has horrible print quality
    - Weaknesses are created in each layer by Steam bubbles
  - Uses
    - Anything that needs to be flexible or survive regular & significant impacts
    - If the low temp and flexibility aren't problems, this can be used in place of many other plastics
  - Issues
    - Flexibility, stretch, compression, etc. are REAL problems for some extruder styles
      - Bowden systems can usually deal down to 95a shore hardness materials if printed SUPER S L O W
      - Multi-Material systems can RARELY deal with 95a materials (MMU, Palette, AMS, etc.)
  - My Opinions
    - Medium to poor aesthetic print quality when compared to other filament materials
    - Printing flexible materials can offer many new possibilities for home 3D printers
      - Rubber mallet, corner bumpers, cane tips, protective cases, etc.
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# ABS "Acrylonitrile Butadiene Styrene"

- Requires higher temperature "All Metal" hot end
- Negative issues
  - Warping - Ambient closer to Tg helps
  - Possible layer delamination- Ambient closer to Tg helps
  - Noxious off-gassing - Enclosed printing with internal carbon filter or after-print venting helps
- Prefers enclosure/print chamber to be kept around half it's glass transition point (~50c)
- Any plastic containing Styrene stinks when printing and reacts with Acetone
- **Post-processing**
  - Can be Vapor Smoothed using Acetone for glassy smooth prints
  - Sands nicely by machine if kept cool, sanding by hand can be dusty
    - Recommend wet sanding when possible
  - Painting protects the plastic from UV deterioration and fills in layer lines

- **My Opinions**

- Mostly seal a 3d printer into an enclosure to keep both Heat and Stink inside while printing
  - Thin nylon photography tents might be OK if the room is already REALLY warm but they loose heat quickly
  - Thin plastic sheeting works better than nylon but suffers from poor insulation qualities if ambient temp is cool
  - Large cardboard box worked great but I didn't like unfolding the flaps to touch printer each time
  - IKEA LACK table with foam-core craft board walls/door made for excellent insulation
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# ASA "Acrylonitrile Styrene Acrylate"

- Requires higher temperature "All Metal" hot end
- Negative issues
  - Warping - Ambient closer to Tg helps
  - Possible layer delamination- Ambient closer to Tg helps
  - Noxious off-gassing - Enclosed printing with internal carbon filter or after-print venting helps
- Prefers enclosure/print chamber to be kept around half it's glass transition point (~50c)
- Any plastic containing Styrene stinks when printing and reacts with Acetone
- **Post-processing**
  - Can be Vapor Smoothed using Acetone for glassy smooth prints
  - Sands nicely by machine if kept cool, sanding by hand can be dusty

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## PLA "PolyLactic Acid", PLA+, PLA-Pro, etc.

- Stiffest material
  - Generally bends less easily than other materials
- Hardest material
  - Resists deformation by a pointy thing better than most (at least to start with...)
- Very poor temperature resistance
  - Prints left in a hot car will likely deform
- Very poor impact resistance
  - PLA Hammer + Nail = Plastic Shrapnel
- Very poor creep resistance
  - PLA shelf bracket + (insert time) = Shelf on floor
  - I use PLA for a ton of things, but when it MUST hold weight, I use PC or PA depending on impact requirement
- "+" and "Pro" modifiers vary wildly between manufacturers
  - **Test EVERY new material;** Make no assumptions about the modifiers or their expected properties

## • Deterioration

- Increased stringing with more moisture typically, but usually very mild compared to PETG, TPU, etc.
- Embrittlement with extended moisture or Ultraviolet light exposure
  - These traits seem to follow the base material rather than the additives or colorants
  - Some transparent, translucent, or silk filaments seemed to be significantly less affected

## • Post-processing

- Sanding PLA is *SLOW!* - If sanded too briskly the dust melts back onto the part, ruining the surface
- 3D Gloop is the only "consumer accessible" smoothing agent for PLA - Industrial chemicals are available
- Painting protects the plastic from UV deterioration and fills in layer lines
  - Lighter colors absorb less heat
  - Glossy finishes absorb less heat

## • Uses

- Anything that will live inside a home (No UV and low heat)
- No large physical stresses placed upon it (Creeping over time)

## • Known Exceptions (to the normal rules)

- Protopasta HTPLA (*High Temperature Polylactic Acid*)
  - Prints like normal PLA then heat treated at increasing temperatures to get ~100c heat deflection temp!
  - Warpage during heat treat process can be an issue for some part geometries
  - <https://proto-pasta.com/pages/high-temp-pla>
- Lay-Filaments Reflect-O-Lay Flexible PLA
  - Prints and physically acts like soft (<90) TPU/TPE
  - Feels somewhat "fuzzy" and a lot like rubber
  - Crazy retroreflector effect
  - <http://lay-filaments.com/LayFilaments-Overview+LightMeta5-b.pdf>

## • My Opinions

- Best for aesthetic print quality
  - Seems to "creep" under any significant stresses
  - Favorite material for prototyping \$\$\$ (*prototypes become finished products when they work the first time*)
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## PETG, PETG+, PETG-Pro, etc.

- Prints on most printers capable of PLA
  - Adequate temperature resistance
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## PC

- Requires higher temperature "All Metal" hot end
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## PP

- Requires higher temperature "All Metal" hot end
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## PA, Nylon, etc.

- Requires higher temperature "All Metal" hot end
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## PE

- Requires higher temperature "All Metal" hot end
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More to come...

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