

The Use of PVDF in Additive Manufacturing

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Nile Polymers

- Manufacture parts from PVDF using injection molding
 - Cable Ties
 - Mixers
 - Snap Lock Fittings

Advantages

- High quality surface
- Large quantities
- Tight tolerances

Disadvantages

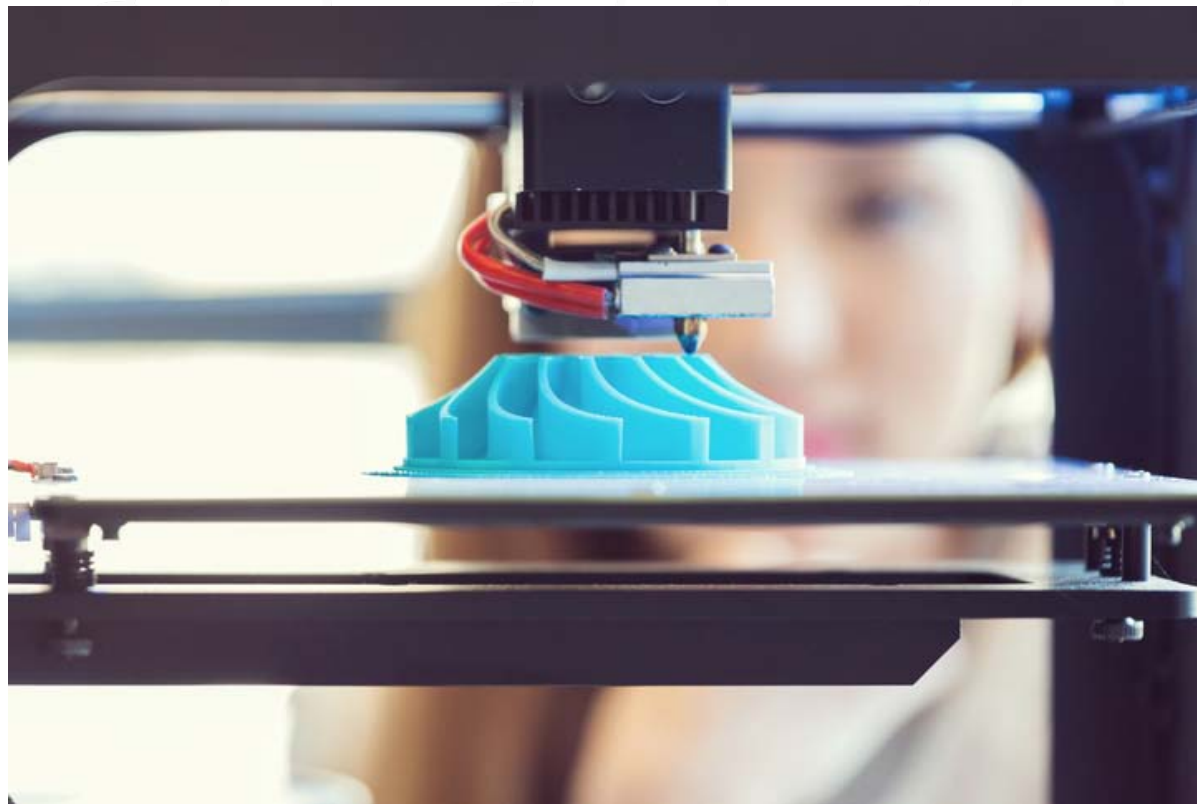
- Mold cost
- Manufacturing time
- What if only 20 parts are needed?



Fusion Deposition Manufacturing (FDM)

- **Advantages**
 - Lower entry cost
 - Prototype
 - Manufacture small quantities
- **Disadvantages**
 - Consumer grade materials

What is FDM?



What is PVDF?

Polyvinylidene Fluoride

Zero flame propagation - LOI > 40%

Resistant to UV and ionizing radiation

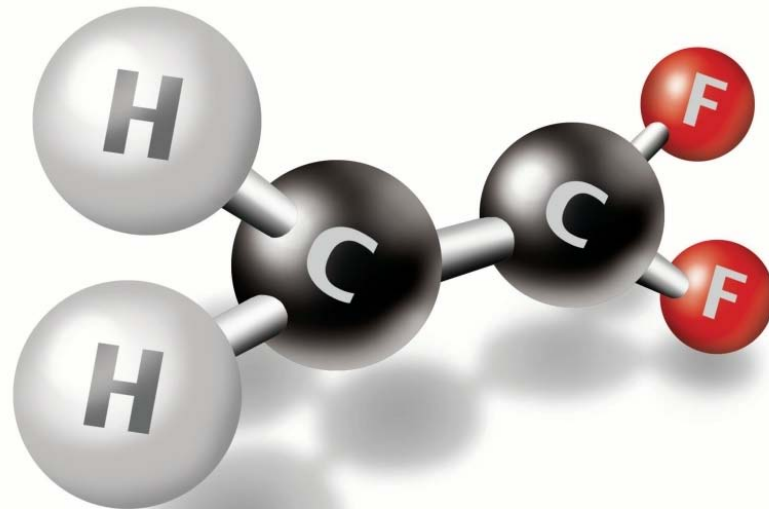
Excellent chemical resistance

- Acids, caustics, solvents

Several varieties including Kynar®

PVDF manufactured by Arkema

- ppb extraction level
- USP Class VI



Process Advantages of Kynar® PVDF

- 1 Variety of homopolymer and copolymers available
- 2 Wide melt processing window
- 3 Non-corrosive melt
- 4 Melt compatibility with acrylics

3D Printing Process

**Kynar® 710
homopolymer
reactor bead**

**Filament
extrusion
using
desktop
extruder**

**Printing on
Lulzbot
Mini
machine**



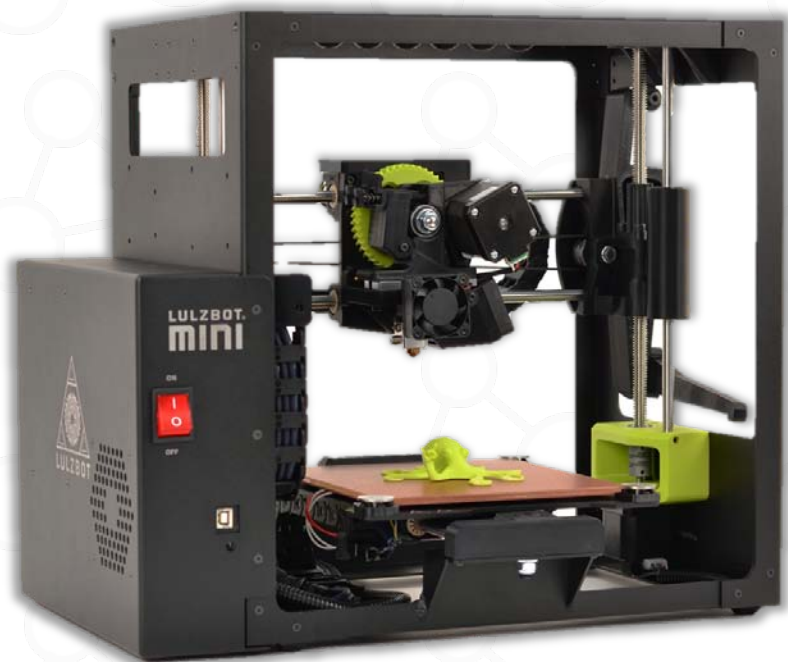
Kynar® 710 Homopolymer

- Melting Temperature: 165 - 172 C
- Elongation at Break: 20 - 100%
- Tensile Strength: 45 - 55 Mpa
- Excellent Creep Resistance
- Well known history in the CPI industry

Lab Extrusion

- Vertical extrusion format
- 0.5mm to 3.0 mm filament
- ~ 0.5 - 1.0 kg per hour
- Four separate heating zones in the barrel
- Extrusion of materials up to 450 C
- Filament diameter controlled by laser measurement feedback to the pulling wheel
- Quick material change out





Lulzbot Mini

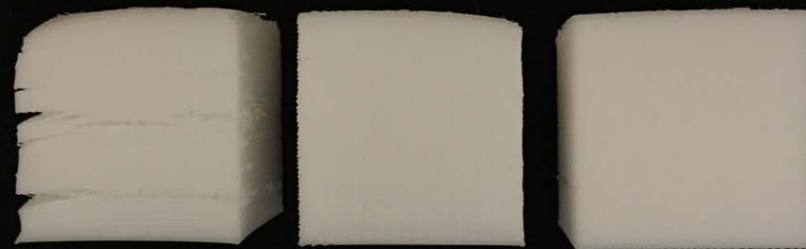
- Control Material Parameters
 - Extrusion Temperature
 - Heated Bed
- Simple to clear hot end
- Tolerant of filament diameter variations
- Auto leveling and self cleaning features
- Wide installation base

Printing Guidelines with PVDF

- Use every adhesion technique available:
 - Heated bed slows cooling rate and helps reduce part warpage (100 C)
 - Glue stick on the heated bed as an adhesive
 - PEI print surface
 - 10 mm raft
- Nuclear Option: Use of PMMA (Plexiglass®) as the print surface
- Print temperature: 240 C
- Print rate: 30 mm/sec



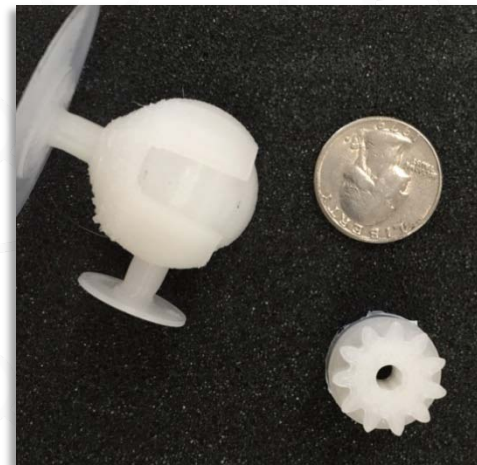
50 cm Test Cube Results



Sample	Material	Raft	Infill	Print Speed	Layer Height	Print Time
Left	Kynar® 710	10 mm	50%	50 mm/sec	0.38 mm	~4 hours
Center	Kynar® 710	10 mm	50%	40 mm/sec	0.25 mm	~6 hours
Right	Kynar® 710	10 mm	50%	30 mm/sec	0.14 mm	~8.5 hours



Examples of Kynar® PVDF Prints





Market Status of PVDF Filament

- Filament is not easy to source
- Filament is very expensive
- Nile Polymers Fluoronar™ PVDF Filament with Kynar® 710
 - Available in 1.75mm and 2.85 mm sizes
- 3D Printer in every lab and facility



Thank You!

Booth 808

