Polymers

PU (Polyurethane)

Thermoset
Crosslinked molecular chains

Supplied in **liquid** form

Chemical process
(heat applied to speed up the polimerization)

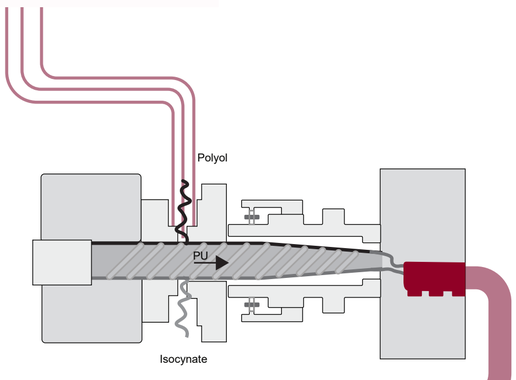
Irreversible process
(cannot be remelted for recycling)

Polyol resin + Isocynate
(+ surfactants, catalysts etc)

PU

PU (simple water reaction / processing on conventional casting / injection machines)
Density range: 250 to 1200 kg/m3

Tailor made
Versatility to adjust properties



Highest variety in density and hardness **(gradients)**

Softer and more **flexible** results

Easier to adjust and combine **colors**

Needs a release agent to take off from the mold

From **shock enhancement** (hight rebound) to **shock absorption** (low rebound)

Liquid — Foam — Solid

Due to the great variety of density and hardness that can be obtained with PU, you can play with variable density throughout the shoe and create multi-injection designs that flow around the upper.

Thermoset
Crosslinked molecular chains
(Cannot be melted down)

TPU (Thermoplastic Polyurethane)

Thermoplastic
Linear molecular chains

Supplied in **solid** form

Physical process
(heating > melting > shaping > solidifying)

Reversible process
(can be recycled by remelting)

Additive properties: hardness, hidrofobic, abrasion resistance, color...

Compact TPU (conventional thermoplastic injection molding machines)
Density range: 1100 to 1230 kg/m3

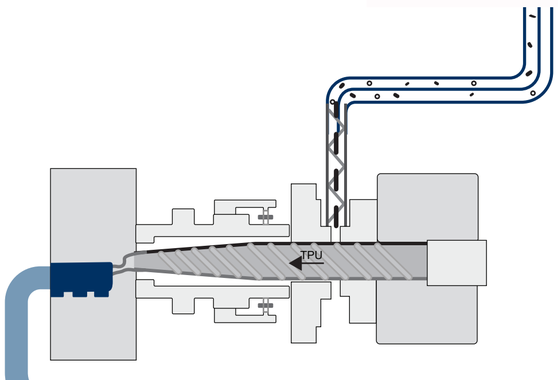
TPU Pellets + Additive Pellets (needed properties)

TPU

eTPU *(expanded TPU, also known as TPU beads, "popcorn" or "Boost" material) consists of TPU particles that are expanded to form closed cells around tiny pockets of air. This process requires specific machinery, and it is generally done under very highpressure and temperature – called "supercritical foaming" – or it requires chemical blowing agents. The process is relatively insufficient and wasteful, since it can result in broken beads or beads that are not fully expanded.*
Density range: can go down to 150 kg/m3

eTPU

Pre-established properties
Wide variety of grades available



More **durable** and **tenacious**

Hight resistance to **abrasion**

Easy **to color**

Can be melted and **remolded** whenever the melting temperature is reached

Solid

Soccer cleats are often made in TPU due to the high abrasion resistance and hardness that you can achieve. TPU is also used for films, logos and yarns, so you can technically make a full TPU shoe keeping in mind that each component will likely have a different hardness and chemical structure.

Thermoplastic
Linear molecular chains
(Can be melted down - repolimerized)

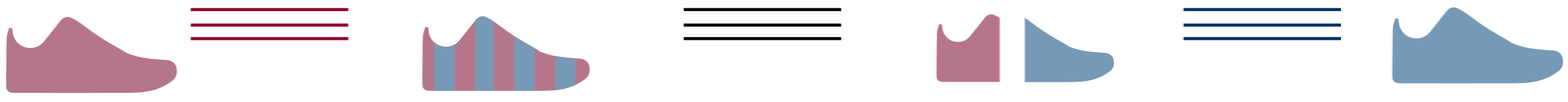
HUNTSMAN
Enriching lives through innovation

Outsoles

Midsoles
Insoles
Skins sprays
Coatings
Binders
3D printing resins

Yarns
Films
Welded logos
Inserts
3D printing filament / powder
TPU beads
Adhesives

Full PU — **PU + TPU** mixed, but inseparable — **PU + TPU** mixed, but separable — **Full TPU**



Change of properties
Granulated appearance
Mixed colors (granulated mix)

Mechanical recycling
Grinding up the material and use it as filler with virgin PU binder

Thermal recycling
Remelting and re-extruding the material

Change of properties
Mechanical performance
Mixed colors (fluid mix)

Chemical recycling
Since this method requires large scale and usually has a higher footprint than mechanical and thermal recycling, it is advisable to do this after several lifecycles, not after only one.

1) Acidolysis or Glycolysis. Use of heat to break the weakest bondings to the basics to obtain the polyol

2) Depolimerization = O2 + Heat + chemicals + vacuum. Depolymerizing PU/TPU back to their molecular building blocks.

Requires big volume of shoes

Hight energy consumption

Large carbon footprint

01 The materials

02 How is it applied?

03 The lifecycle