# PLA (30% natural fiber)



## General information

**Designation**

Polylactide / Polylactic acid (30% natural fiber filled)

**Tradenames**

Fibrolon (FKuR Kunststoff GmbH); Kareline (Kareline Oy Ltd.); Transmare Bio (Transmare Compounding

**Typical uses**

PLA reinforced with natural fibers is used for extruded profiles, diapers, pens, electronic cases, homeware, personal care products, medical devices and automotive parts. The current record is based on PLA filled with

## Composition overview

**Compositional summary**

(CH(CH3)CO2)n + bamboo fiber. The lactic acid is produced from sugar (dextrose) with plant starch origins e.g. corn, wheat, sugar beets and sugar cane.

| | | |
|---|---|---|
| Material family | Plastic (thermoplastic, semi-crystalline) | |
| Base material | PLA (Polylactic acid / polylactide) | |
| % filler (by weight) | 30 | % |
| Filler/reinforcement | Cellulose | |
| Filler/reinforcement form | Short fiber | |
| Additive | Impact | |
| Renewable content | 100 | % |
| Polymer code | PLA-I-NX30 | |

## Composition detail (polymers and natural materials)

| | | | | | |
|---|---|---|---|---|---|
| Polymer | | 60 | - | 70 | % |
| Impact modifier | | 0 | - | 10 | % |
| Woodflour / cellulose | | 30 | | | % |

## Price

| | | | | | |
|---|---|---|---|---|---|
| Price | * | 2.54 | - | 3.24 | USD/kg |
| Price per unit volume | * | 3.28e3 | - | 4.24e3 | USD/m^3 |

## Physical properties

| | | | | | |
|---|---|---|---|---|---|
| Density | | 1.29e3 | - | 1.31e3 | kg/m^3 |

## Mechanical properties

| | | | | | |
|---|---|---|---|---|---|
| Young's modulus | | 5.19 | - | 5.32 | GPa |
| Yield strength (elastic limit) | * | 72.2 | - | 75.9 | MPa |
| Tensile strength | | 55.6 | - | 58.4 | MPa |
| Elongation | | 1.45 | - | 1.56 | % strain |
| Elongation at yield | * | 0.737 | - | 0.794 | % strain |

| | | | | |
|---|---|---|---|---|
| Compressive modulus | * 5.19 | - | 5.32 | GPa |
| Compressive strength | 86.7 | - | 91.1 | MPa |
| Flexural modulus | 4.69 | - | 4.81 | GPa |
| Flexural strength (modulus of rupture) | 56.6 | - | 59.5 | MPa |
| Shear modulus | * 1.88 | - | 1.9 | GPa |
| Poisson's ratio | * 0.38 | - | 0.4 | |
| Shape factor | 6.5 | | | |
| Hardness - Vickers | * 18 | - | 19 | HV |
| Hardness - Rockwell M | * 53 | - | 54 | |
| Hardness - Rockwell R | * 35 | - | 36 | |
| Hardness - Shore D | 77 | - | 84 | |
| Fatigue strength at 10^7 cycles | * 24.2 | - | 24.9 | MPa |
| Mechanical loss coefficient (tan delta) | * 0.102 | - | 0.104 | |

## Impact & fracture properties

| | | | | |
|---|---|---|---|---|
| Fracture toughness | * 4.01 | - | 4.26 | MPa.m^0.5 |
| Impact strength, notched 23 °C | 1.9 | - | 2.1 | kJ/m^2 |
| Impact strength, unnotched 23 °C | 8.1 | - | 8.93 | kJ/m^2 |

## Thermal properties

| | | | | |
|---|---|---|---|---|
| Melting point | 145 | - | 175 | °C |
| Glass temperature | 52 | - | 54 | °C |
| Heat deflection temperature 0.45MPa | 51 | - | 53 | °C |
| Heat deflection temperature 1.8MPa | 53 | - | 55 | °C |
| Vicat softening point | 62 | - | 67 | °C |
| Maximum service temperature | * 45 | - | 55 | °C |
| Minimum service temperature | -20 | - | -12 | °C |
| Thermal conductivity | * 0.146 | - | 0.153 | W/m.°C |
| Specific heat capacity | * 1.26e3 | - | 1.33e3 | J/kg.°C |
| Thermal expansion coefficient | * 106 | - | 112 | µstrain/°C |

## Electrical properties

| | | | | |
|---|---|---|---|---|
| Electrical resistivity | * 2.5e17 | - | 4.8e17 | µohm.cm |
| Dielectric constant (relative permittivity) | * 4.38 | - | 4.56 | |
| Dissipation factor (dielectric loss tangent) | * 0.0963 | - | 0.117 | |
| Dielectric strength (dielectric breakdown) | * 13.2 | - | 13.7 | MV/m |

## Magnetic properties

| | |
|---|---|
| Magnetic type | Non-magnetic |

## Optical properties

| | | | | |
|---|---|---|---|---|
| Refractive index | * 1.44 | - | 1.46 | |
| Transparency | Opaque | | | |

## Critical materials risk

| | | | | |
|---|---|---|---|---|
| Contains >5wt% critical elements? | No | | | |

## Absorption & permeability

| | | | | |
|---|---|---|---|---|
| Water absorption @ 24 hrs | 0.7 | - | 1.1 | % |
| Water absorption @ sat | * 1 | - | 1.8 | % |
| Humidity absorption @ sat | * 0.3 | - | 0.55 | % |
| Water vapor transmission | 7.1 | - | 9.1 | g.mm/m².day |
| Permeability (O2) | 11 | - | 53 | cm³.mm/m².day.atm |

## Processing properties

| | | | | |
|---|---|---|---|---|
| Polymer injection molding | Acceptable | | | |
| Polymer extrusion | Limited use | | | |
| Polymer thermoforming | Limited use | | | |
| Linear mold shrinkage | 0.16 | - | 0.4 | % |
| Melt temperature | 150 | - | 210 | °C |
| Mold temperature | 5 | - | 35 | °C |
| Molding pressure range | 55 | - | 100 | MPa |

## Durability

| | |
|---|---|
| Water (fresh) | Acceptable |
| Water (salt) | Acceptable |
| Weak acids | Acceptable |
| Strong acids | Unacceptable |
| Weak alkalis | Acceptable |
| Strong alkalis | Unacceptable |
| Organic solvents | Limited use |
| UV radiation (sunlight) | Good |
| Flammability | Highly flammable |

## Primary production energy, CO2 and water

| | | | | |
|---|---|---|---|---|
| Embodied energy, primary production | * 44.4 | - | 48.9 | MJ/kg |
| CO2 footprint, primary production | * 2.36 | - | 2.6 | kg/kg |
| Water usage | * 1.35e3 | - | 2.12e3 | l/kg |

## Processing energy, CO2 footprint & water

| | | | | |
|---|---|---|---|---|
| Polymer extrusion energy | * 5.81 | - | 6.11 | MJ/kg |
| Polymer extrusion CO2 | * 0.436 | - | 0.458 | kg/kg |
| Polymer extrusion water | | | | |

| | | | | |
|---|---|---|---|---|
| | * 4.76 | - | 7.14 | l/kg |
| Polymer molding energy | * 14.5 | - | 15.2 | MJ/kg |
| Polymer molding CO2 | * 1.09 | - | 1.14 | kg/kg |
| Polymer molding water | * 10.7 | - | 16 | l/kg |
| Coarse machining energy (per unit wt removed) | 0.531 | - | 0.557 | MJ/kg |
| Coarse machining CO2 (per unit wt removed) | 0.0398 | - | 0.0418 | kg/kg |
| Fine machining energy (per unit wt removed) | 0.916 | - | 0.96 | MJ/kg |
| Fine machining CO2 (per unit wt removed) | 0.0686 | - | 0.0721 | kg/kg |
| Grinding energy (per unit wt removed) | 1.34 | - | 1.41 | MJ/kg |
| Grinding CO2 (per unit wt removed) | 0.101 | - | 0.106 | kg/kg |

## Recycling and end of life

| | | | | |
|---|---|---|---|---|
| Recycle | ✔ | | | |
| Embodied energy, recycling | * 15.1 | - | 16.6 | MJ/kg |
| CO2 footprint, recycling | * 0.8 | - | 0.884 | kg/kg |
| Recycle fraction in current supply | 0.1 | - | 1.1 | % |
| Downcycle | ✔ | | | |
| Combust for energy recovery | ✔ | | | |
| Heat of combustion (net) | * 15.1 | - | 17.5 | MJ/kg |
| Combustion CO2 | * 1.37 | - | 1.44 | kg/kg |
| Landfill | ✔ | | | |
| Biodegrade | ✔ | | | |

## Notes

**Other notes**

PLA is a renewable thermoplastic polyester manufactured from plants such as sugarcane, corn and tapioca. PLA can be amorphous or semi-crystalline. Various blends of D and L enantiomers are available, making available a broader range of properties. PLA products are considered environmentally friendly as their production uses approximately 50% less energy and produces 60% less CO2 than petroleum based products e.g. PET, PC, PS and nylon. Natural fibers that can be used as a filler include coir, cotton, flax, hemp, jute, kenaf, ramie, silk, sisal, bamboo, abaca and wool.

## Links

ProcessUniverse

Producers

Reference

Shape