Low/medium density PE

General information

Overview

PE-LD: The original "Polythene" (1933) and produced in very high volumes today. Approx. 3% lower density than PE-HD.
PE-LLD: Like PE-LD, but with improved mechanical properties.

Strengths

PE-LD: Very cheap, good chemical and hydrolysis resistance, high impact strength at low temperatures, excellent electrical properties, transparent in thin films, good processability.
PE-LLD: Compared to LDPE: higher tensile strength, higher impact strength and puncture resistance, lower thickness films can be blown. Highest environmental stress cracking resistance of the PEs.

Limitations

PE-LD: Low tensile strength, stiffness, heat distortion and maximum operating temperatures. Burns very easily, poor UV resistance, high gas permeability (particularly CO2), susceptible to environmental stress cracking particularly from surfactants, high mold shrinkage. High friction and poor wear properties. While insoluble in all organic solvents, will swell in aliphatic and aromatic hydrocarbons (more so than HDPE).
PE-LLD: Lower gloss, higher mold shrinkage, not as easy to process, and has a narrower temperature range for heat sealing cpmoared to LDPE.

Designation

PE-LD, LDPE, Polythene, Polyethene, Poly(methylene) - IUPAC Commission on Macromolecular Nomenclature.
PE-LLD, LLDPE

Typical uses

PE-LD: Chemically resistant fillings, bowls, lids, gaskets, toys, containers, packaging film, film liners, squeeze bottles, heat sealed films for metal laminates, pipe, cable covering, core in UHF cables.
PE-LLD: Lower thickness films can be used than with LDPE, leading to wide use in packaging, particularly film for bags and sheets, cable sheathing, toys, buckets and containers, piping.

Composition overview

Compositional summary

PE-LD: Homopolymer of ethylene with a long-chain branched structure, branching on approx. 2% of carbon atoms. Branches disrupt and reduce crystallinity compared to HDPE - resulting in a more flexible, but lower strength material, with slighty lower density.
PE-LLD: Linear copolymer of ethylene with alpha-olefins such as butene, hexene, or octene. 'Short-chain branching' introduced by the comonomers, together with a more controlled molecular weight distribution from the production process, results in a material with improved mechanical properties compared to PE-LD.

Material family	Plastic (thermoplastic, semi-crystalline)
Base material	PE-LD (Polyethylene, low density)

Effect of composition

UV stabilized grades available though with reduced tensile strength. Addition of carbon black protects PE against photo-oxidation. Compounds of biologically degradable polymers, e.g. Polysaccharides, starch, PSAC, with PE (up to 94%) are biodegradable. Higher ratios of starch can cause processing problems. Other PE compounds with UV-sensitive or photo-sensitive molecules (e.g. iron dialkylthiocarbamate) are photodegradable.

Processing properties

First commercial production	1939

Available forms

Pellets, powder, film.

Forming

PE-LD: Excellent for blow molding, extrusion, injection molding, and rotational molding, structural foam molding also easy. PE grades with higher melt viscosities (though not as high as LLDPE) and sufficient melt strength must be selected for blow molding. Pre-drying not necessary. High specific heat capacity - high energy costs and long cooling times (relative to many other polymers). Melt should have as little contact with air as possible to prevent oxidation. Various powder processes such as fluidized bed coating of metals.
PE-LLD: Essentially the same as LDPE though not as easy to process. Less favorable shrinkage properties, not as suited to blow molding as its melt viscosity is significantly higher than LDPE. 20-30% reduction in output when using equipment designed for LDPE.

Machining

PE-LD: Reasonable machinability. Care must be taken not to let the material get too hot as it is likely to become tacky due to frictional heating. Easy to stamp (when thin walled).
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Joining

PE-LD: Suitable for bonding though not good, as PE has low solubility, so rarely practiced. Suitable for many common adhesives. Very suitable for friction, hot plate, and hot gas welding. Ultrasonic welding difficult though can produce a good bond and radio frequency bonding not possible. Suitable for laser welding. Self-tapping screws can be used.
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Surface treatment

Very difficult to paint. Printing possible only with surface pre-treatment (oxidation).

Geo-economic data for principal component

Annual world production	3.94e7	ton/yr

Notes

Other notes

Many PE grades meet FDA guidelines for use in contact with food.