Low Density Polyethylene fracture

Ian Crotty 15 Feb 2017

**Properties**

LD is less crystalline than HD

“The high degree of branches with long chains gives molten LDPE unique and desirable flow properties”

SCG Slow crack growth.

The total time-to-failure that covers both these mechanisms has

been shown to be an index of the quality of a PE’s resistance to SCG under actual

service conditions.

Thus, to more directly determine a PE’s resistance

to external flaws, ASTM F 1473, “Standard Test Method for Notch Tensile Test to

Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins” (5)

was developed.

rapid crack propagation (RCP)

High density

polyethylene (HDPE) has up to 90% crystallinity, while LDPE exhibits crystallinity lower

than 50%

**Radiation Damage**

PE is radiation tolerant, LD is better than HD to gamma radiation.

BUT

Wikipedia UV radiation

Common synthetic polymers that can be attacked include [polypropylene](https://en.wikipedia.org/wiki/Polypropylene) and [LDPE](https://en.wikipedia.org/wiki/LDPE), where [tertiary carbon](https://en.wikipedia.org/wiki/Tertiary_carbon) bonds in their chain structures are the centres of attack. Ultraviolet rays interact with these bonds to form [free radicals](https://en.wikipedia.org/wiki/Free_radicals), which then react further with [oxygen](https://en.wikipedia.org/wiki/Oxygen) in the atmosphere, producing [carbonyl](https://en.wikipedia.org/wiki/Carbonyl) groups in the main chain. The exposed surfaces of products may then discolour and crack, and in extreme cases, complete product disintegration can occur.

<https://en.wikipedia.org/wiki/UV_degradation>

Why Was The Plastic Tubing Leaking?

https://www.thermofisher.com/blog/polymers2plastics/why-was-the-plastic-tubing-leaking/

Such materials are commonly formed as by-products of oxidation of polyolefin resins, such as polyethylene. Polyethylene can undergo oxidation through contact with chlorinated municipal water……absorption bands indicative of carbonyl functionality.

And;

distinct bands at 1715 cm-1 and 1740 cm-1 were present associated with carboxylic acids and esters

<https://www.thermofisher.com/content/dam/tfs/ATG/CAD/CAD%20Documents/Peer%20Reviewed%20Papers%20OR%20Third-Party%20Papers/Molecular%20Spectroscopy/FTIR/Thermo_Fisher_Scientific_Reprint2.pdf>

Also from Madison Group (Thermo Fisher)

<https://www.madisongroup.com/publications/Fractography-of-Pipe-Failures.pdf>

**Reaction mechanism for oxidation and degradation of high density polyethylene in chlorinated water**

Susan Mitroka, Timothy D. Smiley etc

Experiments with isotopic 18O2 gas demonstrated that molecular oxygen is partly responsible for formation of the carbonyl oxygen. Both HDPE Pipe and HDPE resin samples were demonstrated to form 4-chloro-2-methylbutan-2-ol and 2,3-dichloro-2-methylbutane as novel HDPE breakdown products which leached into chlorinated water. From these data, reactive species involved in the breakdown of HDPE pipe have been identified

**THE INFLUENCE OF MUNICIPAL WATER  
DISINFECTANTS ON TEMPRITE®,  
CHLORINATED POLY(VINYL CHLORIDE)  
PIPE AND FITTING COMPOUNDS**

ANDY OLAH, SENIOR R&D ASSOCIATE,  
GROUP LEADER- EXTRUSION  
POLYMER ADDITIVES AND SPECIALTY PLASTICS  
THE BF GOODRICH COMPANY

It is suspected that municipal water disinfectant additives such as chlorine, ozone, hydrogen peroxide, chlorine dioxide and bromine increase the oxidation reduction potential (ORP) which reduces the oxidative stability of certain plastic materials comprising both public and private water distribution systems.

<http://web.hershey.com.tw/hershey/en/flowguard/c05-4.htm>

Chlorine dioxide has been shown to be more aggressive towards polyolefins such as polyethylene than the other water treatment chemicals1

<http://www.pipa.com.au/sites/default/files/document/attachment/tn008.pdf>

**Some Plastics Can Be Adversely Affected by Drinking Water Disinfectants**

Anti-oxidants are added in polyethylene pipe formulations to extend their service lives (the anti-oxidants are preferentially attacked by the free-radicals and “sacrificed” – as long as they are available in the pipe). However, premature failures of HDPE water pipes have demonstrated that under some operating conditions the antioxidants are depleted and serious degradation of the pipe occurs. This is why PVC, not HDPE, pipes are typically used for swimming pool piping and manifolds where chlorine contact with plastic is required. Polyolefin pipes are not recommended for service in highly oxidative environments, which includes some drinking water systems.

<http://hdpeoxidation.com/>

Thesis

<https://www.diva-portal.org/smash/get/diva2:590038/FULLTEXT01.pdf>

<http://hdpeoxidation.org/Lundback%20-%20KTH%20Fibre%20and%20Tech%20-%20LT%20Perf%20Polyoelfins%20in%20Chlorinated%20Water%202005.pdf>

Disadvantages

Subject to “stress cracking” ??

Poor gamma radiation resistance. ??

Ref

<https://plasticpipe.org/pdf/chapter03.pdf>

<https://www.plasticstoday.com/extrusion-pipe-profile/nature-polyethylene-pipe-failure/6347137615310/page/0/2>

<http://www.personal.rdg.ac.uk/~spsolley/pe.html>

http://www.plasticmoulding.ca/polymers/polyethylene.htm

<http://www.upcinc.com/resources/materials/LDPE.html>

Pipe used in the RE chambers ALL supplied from Angst Pfister

Dia. 6 x 4mm

PE tube A03.758241.001 FT 12 1001 0604

EDH purchase

<https://edh.cern.ch/Document/SupplyChain/DAI/4539552> as an example

See notes in the above doc.

Price is same as in 2004, ie 0.33chf/m

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