NOVA Chemicals
Polyethylene

Polyethylene Chemical Resistance Workshop

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Polyethylene Chemical Resistance Workshop

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Introduction

Polyethylene Chemical Resistance Workshop Introduction

Please keep the following in mind during the workshop

- Is there clear understanding in the industry between the various failure mechanisms ?
- How important is chemical resistance to your applications vs other potential failure modes?
- Are better preforming resins needed?

Polyethylene Chemical Resistance Workshop Definition

The chemical resistance of a polymeric material is its ability to withstand chemical attack with minimal change in appearance, dimensions, mechanical properties, and weight over a period of time.

- Test conditions include the length of exposure, concentration, temperature and internal stress
- The final classification as chemically resistant depends on the application

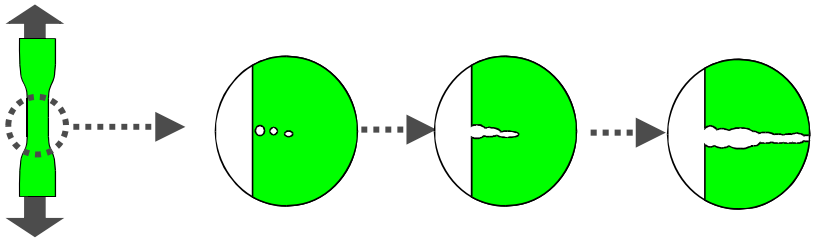
Reference: Mark, Herman F., et al. (1985). Encyclopedia of Polymer Science and Engineering Vol. 3. Chemically Resistant Polymers. John Wiley and Sons Inc. pg. 421-430

Polyethylene Chemical Resistance Workshop
Chemical Effects on Polyethylene

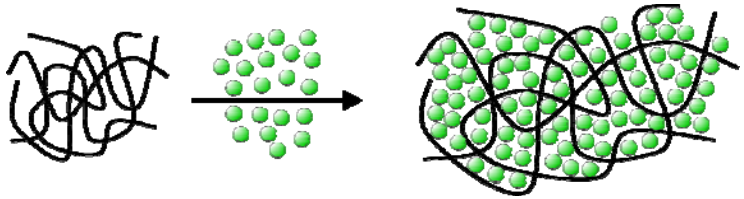
Chemical environmental effects on polyethylene may be divided into three categories:

1. Oxidation

2. Stress Cracking



3. Plasticization



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Chemical Effects on Polyethylene

Oxidizers

- The only group of materials capable of chemically degrading polyethylene

- Chemical effects may be gradual and may not be measureable over the short term
- Examples of strong oxidizers which potentially may be unsuitable for long term exposure to polyethylene:
    - *Nitric acid, fuming*
    - *Sulphuric acid, fuming*
    - *Mixture of nitric and hydrochloric acids (aqua regia)*
    - *Wet chlorine gas*
    - *Liquid bromine*

Reference: NOVA Chemicals SCLAIR® Resin Technical Literature

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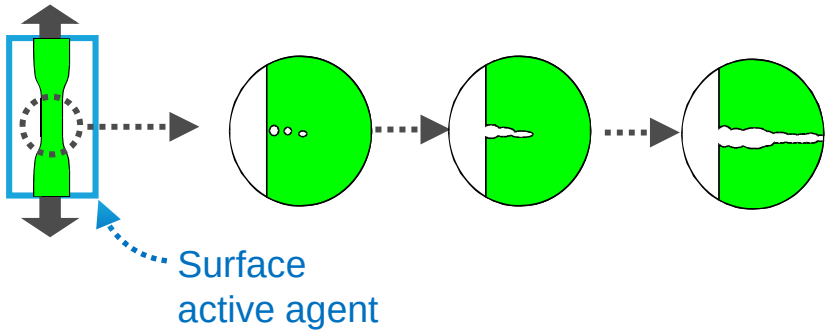
Chemical Effects on Polyethylene

Stress Cracking Agents

- Surface active agents can accelerate cracking when a molded part is under stress and under elevated temperature



- Surface active agents:
  - *Dilute detergent*
  - *Pure detergent*
  - *Cleaners*
  - *Glycol*
  - *Motor Oil*

- Stress on the polyethylene is contributed by the following:
  - *Applied forces*
  - *Part design*
  - *Residual stress*

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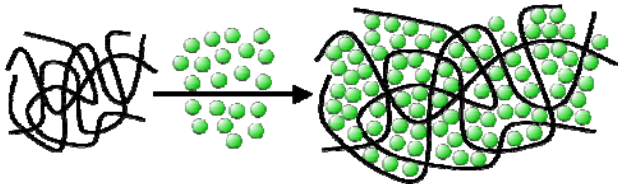
Chemical Effects on Polyethylene

Plasticizers

- Plasticization is the absorption of small molecules that migrate between the polymer chains, causing the plastic part to lose stiffness



- Additional effects include:
  - *Swelling*
  - *Weight gain*
  - *Softening*
  - *Loss of tensile yield strength*
  - *Loss in creep resistance*

Benzene or other aromatic hydrocarbons have strong plasticizing actions.

Other chemicals, such as gasoline, have a weaker plasticizing effect.

Reference: Crawford R.J., Throne J.L. (2002) Rotational Molding Technology. Plastics Design Library, William Andrew Publishing. pg. 56 – 57.

Polyethylene Materials and Chemical Resistance

Polyethylene Chemical Resistance Workshop
Polyethylene Materials

Key parameters for polyethylene:

1. Density (crystallinity)
2. Melt index (molecular weight)
3. Molecular weight distribution / modality
4. Comonomer type (octene, hexene, butene)
5. Additives

Polyethylene Chemical Resistance Workshop
Polyethylene Materials

Material Selection to Enhance Chemical Resistance

1. Increasing resin density

Increasing resin density increases crystallinity

↓

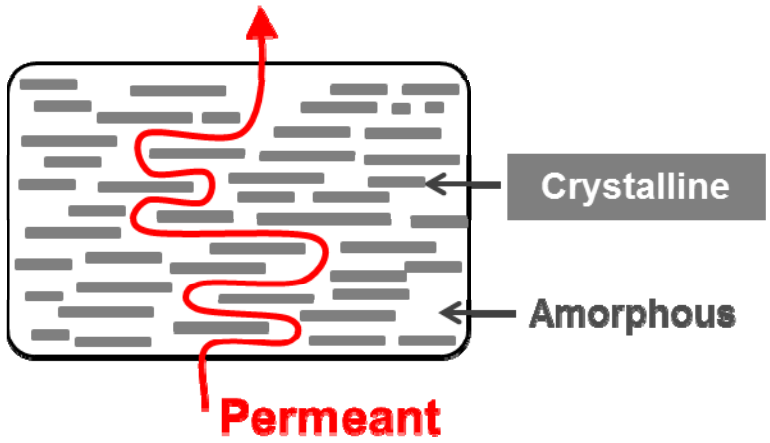
Creates a ‘tortuous path’ for permeants

↓

Reduces permeability

↓

Increases chemical resistance



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Polyethylene Materials

Material Selection to…

Enhance Chemical Resistance

1. Increase resin density
2. Lowering the melt index
3. Broadening the molecular weight distribution
4. Octene > Hexene > Butene

Enhance ESCR

1. Reducing resin density
2. Lowering the melt index
3. Broadening the molecular weight distribution
4. Octene > Hexene > Butene

It's critical to have a complete understanding of the end use application and requirements in order to select the optimum material

Test Methods

Polyethylene Chemical Resistance Workshop
Test Methods

- Suitability of polyethylene for a chemical contact application depends on
  - *Chemistry and concentration of the chemical*
  - *Expected service temperature and stress*
  - *Duration of exposure and whether it is intermittent or continuous*
- Standard laboratory tests can give only general guidance as to whether chemicals may be packaged in polyethylene
- Feasibility of any packaging system must be determined by extensive laboratory tests conducted **under conditions which approximate as closely as possible those expected in service**
- ASTM D543 “Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents”

Polyethylene Chemical Resistance Workshop
Test Methods – ASTM D543

High Level Summary

- Effect of chemical reagents on properties is determined by testing standard specimens (tests before and after immersion/stress).
- Specimen conditioning: immersion or wet patch depends upon the end use requirements. **If used as a container, immerse the specimens**.
- Limitations of the test results: reagent selection, concentrations, test duration, level of stress, temperature, and properties reported.
- Serves as a **guide to compare the relative resistance of various plastics** to typical chemical reagents.
- Test results vs actual performance: Correlation is dependent upon the **similarity between the testing and the end use conditions**.
- Review the hazards associated with the reagents and **implement suitable safety measures**.

Reference: ASTM D543-14 Standard Practice for Evaluating the Resistance of Plastics to Chemical Reagents

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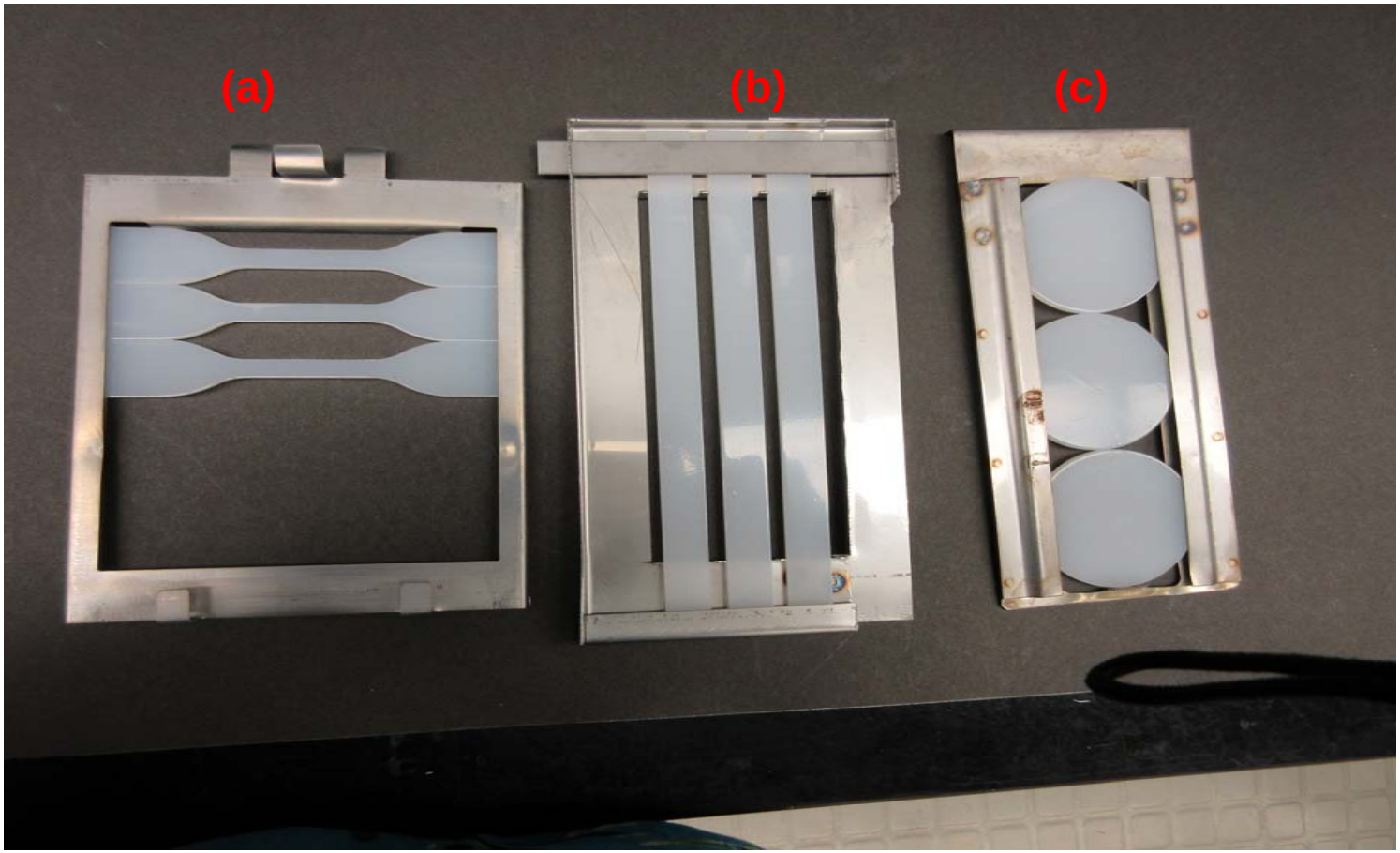
Test Methods – ASTM D543

Test Specimens:

(a) Tensile (b) Flexural Modulus (c) Weight and Dimension Changes



Polyethylene Chemical Resistance Workshop
Test Methods – ASTM D543 (4)

Immersion Test: **Procedure I (Weight & Dimension Changes)**
Procedure II (Mechanical Property Changes)

Polyethylene Chemical Resistance Workshop
Test Methods – ASTM D543 (4)

Immersion Test: **Procedure I (Weight & Dimension Changes)**
Procedure II (Mechanical Property Changes)

Summary

Polyethylene Chemical Resistance Workshop Summary

- Chemical environmental effects on polyethylene may be divided into three categories: oxidation, stress cracking and plasticization.
- Processing and part design influence chemical resistance and ESCR.
- With respect to material selection, increasing resin density and molecular weight improves chemical resistance.
- Laboratory tests should be conducted under conditions which are as close as possible to those expected in service. In particular, consider the chemistry and concentration of the chemical, expected service temperature and stress, the duration and type (intermittent vs. continuous) of exposure.
- ASTM D543 is a convenient method for evaluating the effects of various environments on plastics and can be used as a screening tool.

Acknowledgements

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References

1. Mark, Herman F., et al. (1985). Encyclopedia of Polymer Science and Engineering Vol. 3. *Chemically Resistant Polymers*. John Wiley and Sons Inc. pg. 421-430.
2. NOVA Chemicals SCLAIR® Technical Literature
3. Crawford R.J., Throne J.L. (2002) *Rotational Molding Technology*. Plastics Design Library, William Andrew Publishing. pg. 56 – 57.
4. ASTM D543-14 Standard Practice for Evaluating the Resistance of Plastics to Chemical Reagents, ASTM International

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