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LyondellBasell Develops Modified Environmental Stress Crack Test for Homopolymer HDPE

High density polyethylene provides excellent resistance to the attack of most chemicals; however, some surfactants and detergents can cause loss of physical properties to molded parts due to the propagation of microscopic cracks in the polymer. This property is measured by its environmental stress crack resistance (ESCR). Depending on the resin properties (melt index, density, molecular weight distribution), the ESCR of the product will also change. The correct HDPE resin must be used for the intended application.

When using HDPE, it is desired to have the correct balance of stiffness, impact and ESCR for the end-use application. The injection molder is also interested in excellent processability so that cycle times can be reduced and production can be increased. As shown in Figure 1, an effort to improve ESCR through changes in resin properties will typically cause a change in another physical property.

One of the most common ways to measure ESCR is by the Bell Bent Strip ESCR Test (ASTM D 1693). In this test specimens are die-cut from a compression molded plaque and notched to a standard depth. This notch, which is across the specimen, helps to speed the test time because it increases the surface area available for attack. After the specimens are bent and inserted into a fixture to create stress, a solution of Igepal[®], a known ESC agent, is added to a test tube that contains the fixture and sample. The sample is then placed into a heated bath and checked for failures on a periodic basis to determine an F₅₀ value.

ASTM D 1693 is useful for most HDPE products, but it does not allow for measurement differences among homopolymer injection molding HDPE products (greater than 0.960 g/cc). As illustrated in Figure 1, as density increases, ESCR decreases and stiffness increases. The higher stiffness of the material results in more induced stress on the part in the fixture. As a result when higher density HDPE products are tested in the Bell Bent Strip ESCR Test, little, if any, differences are seen.

	Increase in Melt Index	Increase in Density	Broader MWD
Processability	Increases	—	Increases
Stiffness	—	Increases	—
Impact	Decreases	Decreases	Decreases
ESCR	Decreases	Decreases	

Figure 1: Typical Effects of Resin Properties on Physical Properties

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[®] Igepal is a registered trademark of Rhône-Poulenc Co., Inc.



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LyondellBasell Develops Modified Environmental Stress Crack Test for Homopolymer HDPE (continued)

Although homopolymer HDPE is not used in applications requiring significant levels of ESCR, some level of ESCR may be desired for applications, such as those needing periodic washing with cleaning solutions. Differences between products can be determined by the following LyondellBasell modified version of the Bell Bent Strip Test. Test specimens measuring 5" x 0.5" x 0.125" are injection molded at standard conditions. The specimens are then bent and inserted into a fixture channel that is 1 13/16" wide. The sample parts are not notched. The fixture and specimens are placed into a jar containing 10% Igepal and monitored over time to measure the part failure at a temperature of 50 C.

By following this procedure, less stress is placed onto the parts in two ways. First there is no notch, which slows the ESC phenomena. The LyondellBasell modified ESCR test also provides a more generous radius. This helps to relieve some of the stress associated with the higher stiffness of homopolymer HDPE resins. As a result, differences can be seen among homopolymer products as shown in Figure 2.

When lower density HDPE products (0.945 – 0.956 g/cc) of similar molecular weight are tested with the modified ESCR test, the specimens exceed 1,000 hours before failure; therefore, the standard ASTM Bell Bent Strip ESCR Test is better suited for these types of products.

	Homopolymer 1	Homopolymer 2	Homopolymer 3	Copolymer 1
Melt Index, g/10 min	3.7	5.0	6.6	4.9
Density, g/cc	0.962	0.961	0.963	0.953
Melt Flow Ratio	31	25	31	27
ESCR (ASTM D 1693 A), Hours	5	5	5	24
LyondellBasell Modified ESCR, hours	120	24	45	1,000+

Figure 2: ESCR Comparison of Various HDPE Products