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Chemical Aging of High-Density Polyethylene (HDPE-100) in Interaction with Aggressive Environment

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Abstract : Polyethylene (PE) pipes are one of the best options for water and gas transmission networks. The main reason for such a choice is its high-quality performance in service conditions over long periods of time. PE pipes are installed in contact with different soils having various chemical compositions with confirmed aggressiveness. As a result, PE pipe surfaces undergo unwanted oxidation reactions. Usually, the polymer mixture is designed to include some additives, such as anti-oxidants, to inhibit or reduce the degradation effects. Some other additives are intended to increase resistance to the ESC phenomenon associated with polymers (ESC: Environmental Stress Cracking). This situation occurs in contact with aggressive external environments following different contaminations of soil, groundwater and transported fluids. In addition, bacterial activity and other physical or chemical media, such as temperature and humidity, can play an enhancing role. These conditions contribute to modifying the PE pipe structure and degrade its properties during exposure. In this work, the effect of distilled water, sodium hypochlorite (bleach), diluted sulfuric acid (H2SO4) and toluene-methanol (TM) mixture are studied when extruded PE samples are exposed to those environments for given periods. The chosen exposure periods are 7, 14 and 28 days at room temperature and in sealed glass containers. Post-exposure observations and ISO impact tests are presented as a function of time and chemical medium. Water effects are observed to be limited in explaining such use in real applications, whereas the changes in TM and acidic media are very significant. For the TM medium, the polymer toughness increased drastically (from 15.95 kJ/m² up to 32.01 kJ/m²), while sulfuric acid showed a steady augmentation over time. This situation may correspond to a hardening phenomenon of PE increasing its brittleness and its ability for structural degradation because of localized oxidation reactions and changes in crystallinity.

Keywords : polyethylene, toluene-methanol mixture, environmental stress cracking, degradation, impact resistance
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