Title: Effect of SCBs on Mechanical Performance of Pipe Grade HDPE Exposed to Chlorinated Water

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Reference 1: Hagen, A., Mantell, S.C. and Bhattacharya, M. (2020). "Morphology and Mechanical Performance of Pipe Grade HDPE Exposed to Chlorinated Water," ANTEC 2020, Society of Plastics Engineers, San Antonio (virtual), *Best paper award.*

Reference 2: Majewski, K., Mantell, S. C., and Bhattacharya, M. (2020). Relationship between morphological changes and mechanical properties in HDPE films exposed to a chlorinated environment. *Polymer Degradation and Stability*, *171*, 109027.

Reference 3:
Reference 4:
Reference 5:
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Images:

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Abstract:

HDPE is extensively used for water delivery, natural gas and oil delivery, and piping systems in nuclear power plants. Environmental conditions lead to changes in the polymer morphology that affect fracture behavior. To delay the onset of embrittlement, bimodal HDPE (with linear/linear with short chain branches SCB) is extensively used for piping and geomembranes. This study describes the morphology changes associated with degradation and the role of SCBs to prolong lifetime. Samples 50–100μm thick of a pipe-grade polyethylene were extruded and subsequently exposed for up to 3000 hours in a chlorinated water bath (5 ppm Cl at 65 C). The bath conditions were such that the oxidative reduction potential was 825 mV. The samples were characterized by tensile testing, size-exclusion chromatography with IR evaluation of SCB content, differential scanning calorimetry, and small-angle X-ray scattering. A significant reduction in weight-average molecular weight and a shift from a bimodal to a unimodal distribution occurred as the samples degraded. A significant increase in crystallinity did not occur until after 1250 hours of exposure. Tensile strength and elongation at break were reduced above 1250 hours of exposure as well. After 2250 hours of exposure, brittle behavior was observed, in which the average elongation at break was 12% (undegraded specimens had an average elongation at break of 390%). At this extent of degradation, the weight-average molecular weight was 9% of its undegraded value, and the crystallinity had increased from 70% to 85%. Average tensile strength was reduced from 31.8 MPa to 16.6 MPa as well. The additional evaluation of molecular weight data to include tracking SCB fraction reveals the role of SCB in delaying the onset of brittle behavior. We hypothesize that the presence of short-chain branching inhibited chemicrystallization until a threshold extent of chain scission had occurred.