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ABSTRACT

Environmental Stress Cracking of Polymers

L. Andena1, M. Contino1, F. Olla1, F. Scavello2, D. Ferri2

1Dipartimento di Chimica, materiali e ingegneria chimica “G. Natta”
Politecnico di Milano, Italy
2Versalis S.p.A, San Donato Milanese, Italy

Slow crack growth (SCG) is usually the most dominant failure mechanism in polymer products, typically occurring over extended periods under sustained low-stress conditions. This phenomenon is particularly critical in applications requiring long-term durability, such as gas pipes, water distribution systems, and storage tanks.
A phenomenon closely related to SCG is Environmental Stress Cracking (ESC), in which the progression of slow crack growth is accelerated when a polymer is exposed to surface-active agents under stress. These agents do not alter the polymer's chemical structure but drastically reduce the time to failure, by accelerating crack initiation and propagation. In ESC, the same crack growth mechanisms observed in SCG occur, but at a significantly accelerated rate due to environmental factors, making it a critical consideration in the design of polymer products intended for long-term use under stress.
The resistance to ESC is typically evaluated using standard methods, which unfortunately are quite limited in terms of both the amount of information provided (typically a single ranking parameter) and their accuracy, hindering the possibility of establishing clear structure-properties relationships for the materials under investigation. Over the years we developed an alternative approach, based on fracture mechanics (FM), which provides a much richer picture about the active ESC mechanisms and allows the identification of clear structure-properties relationships. These insights enable the optimization of the long-term performance of polymers under various stress conditions, at the same time providing reliable quantitative predictions of product lifetime, which can be of high interest for the industry.