

Accelerated Weathering-Induced Surface Degradation of Polyethylene Terephthalate and Melamine Etherified Resin Nonwoven Fabrics

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Plastic degradation caused by environmental stressors ultimately leads to the formation of microplastics and, subsequently, nanoplastics, which are among the most persistent and harmful environmental pollutants, posing risks to ecosystems and human health (Gewert et al., 2015). Because degradation and fragmentation begin primarily at the plastic surface, a detailed understanding of surface-related physicochemical changes is essential for elucidating degradation pathways of plastic materials. Accelerated weathering tests provide an effective method for studying plastic degradation under realistic environmental conditions by simulating ultraviolet (UV) radiation, temperature fluctuations, moisture, and oxygen exposure. These controlled tests condense years of natural weathering into weeks or months, enabling systematic evaluation of degradation mechanisms (Allen and Edge, 1992; Wypych, 2018). Monitoring changes in surface chemistry, morphology, wettability, and surface charge allows identification of rate-limiting processes and structure–property relationships that govern polymer stability.

In this study, polyethylene terephthalate (fPET) and melamine etherified resin (fMER) nonwoven fabrics were investigated to elucidate the evolution of their physicochemical properties under accelerated aging conditions. For the first time, these materials were subjected to accelerated aging in a xenon weathering chamber for 11 cycles, each cycle comprising simulated sunlight and rainfall, corresponding to a total of 11 weeks of natural outdoor exposure. Degradation-induced changes were comprehensively evaluated using a multi-technique approach, including mass loss measurements, infrared spectroscopy, optical microscopy, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), contact angle analysis, surface zeta potential measurements, and high-resolution surface chemical characterization by X-ray photoelectron spectroscopy (XPS). This integrated methodology enables a detailed assessment of early-stage degradation processes and material-specific aging, providing new insight into the stability and environmental durability of nonwoven polymer systems. The results showed a decrease in contact angle for both materials after aging, indicating increased surface polarity, accompanied by measurable mass loss. XPS analysis revealed no significant change in the atomic composition of fPET, whereas a reduction in nitrogen content was observed for fMER, suggesting material-specific degradation pathways.

Overall, the results show that understanding the evolution of physicochemical properties during accelerated weathering is crucial for linking short-term laboratory testing with long-term environmental performance. This knowledge is essential for informed material design, sustainability assessment, and environmental risk evaluation, supporting the development of plastics with improved durability and more predictable life-cycle behavior.

Gewert, B., Plassmann, M. M., and MacLeod, M. (2015). Pathways for degradation of plastic polymers floating in the marine environment. *Environmental Science: Processes & Impacts*, **17**, 1513–1521.

Allen, N. S., and Edge, M. (1992). *Fundamentals of Polymer Degradation and Stabilization*. Springer, Berlin.

Wypych, G. (2018). *Weathering of Plastics: Testing to Mirror Real Life Performance*. ChemTec Publishing.