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## EVOLUTION OF MICRODEFECTS IN POLYLACTIDE COATINGS UNDER ULTRAVIOLET EXPOSURE

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**Abstract.** This work investigates the evolution of microdefects in polylactide (PLA) coatings under ultraviolet exposure. UV-induced photooxidation leads to increased surface polarity, enhanced wettability, and formation of a low-molecular-weight phase. Scanning electron microscopy reveals the development of microcracks associated with shrinkage and originating in regions of residual stress. The results highlight the relationship between processing-induced heterogeneities and defect formation in PLA coatings.

**Keywords:** polylactide, ultraviolet degradation, microcracks, residual stresses, photooxidation, surface morphology, polymer coatings

The transition from petroleum-based plastics to bio-based polymers represents an important step toward reducing environmental impact and improving sustainability. Among such materials, PLA has attracted considerable attention due to its biodegradability and availability from renewable resources [1]. However, the application of PLA in coating systems remains insufficiently explored. As a relatively new and non-traditional material for such uses, PLA requires detailed investigation of its behavior under service conditions. In particular, understanding the mechanisms of defect formation under ultraviolet exposure is of high relevance [2]. The present work aims to analyze the morphological evolution of PLA-based coatings subjected to UV irradiation.

The purpose of the work is to establish the influence of ultraviolet exposure on the formation and evolution of characteristic microdefects in polylactide coatings and to evaluate their role in microcrack initiation.

PLA films based on Ingeo Biopolymer 4060D (NatureWorks, USA) were used as the object of study. The films were prepared by solution casting from dichloromethane and filled with 25 wt. % kaolin. Ultraviolet aging was performed according to ASTM D4329 using a 400 W UV-A fluorescent lamp for 8 h at  $60 \pm 5$  °C. Surface morphology and microstructural changes were analyzed by scanning electron microscopy (MIRA3 SEM, Tescan, Czech Republic).

After 8 h of UV exposure, a pronounced increase in surface tackiness of PLA films was observed. FTIR analysis confirmed that photooxidative degradation is accompanied by an increase in polar functional groups, primarily of carboxylic nature, with their relative content rising by approximately 1.7 times for neat PLA. This leads to enhanced surface polarity and wettability: the water contact angle for filled systems decreases from  $\sim 74^\circ$  to  $\sim 35^\circ$ . Accordingly, the surface energy increases due to the growth of the polar component from about 7 to 35–36 mJ/m<sup>2</sup>. The formation of a low-molecular-weight fraction results in strong adhesion to the substrate and is accompanied by the development of microcracks, as shown in Figure 1.

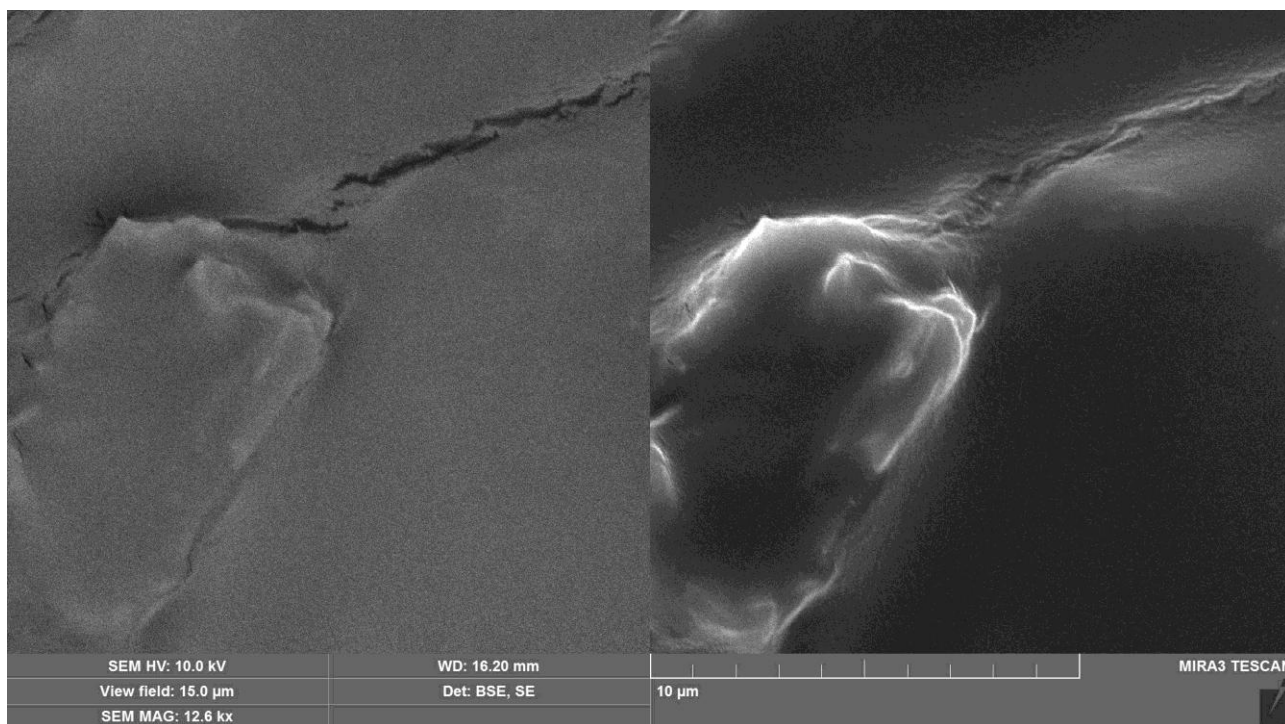


Figure 1 – Formation of surface cracks of UV aged PLA films

The formation of microcracks represents a distinct type of defect, differing from surface polarization effects. These defects are associated with shrinkage occurring during UV-induced degradation of PLA. Microcracks preferentially originate in regions where residual stresses are preserved after solution casting. As observed in Figure 1, crack initiation occurs at stress concentration points, such as particle edges, followed by their propagation across the surface. This indicates that the applied film formation method inherently contains structural inhomogeneities acting as defect precursors. Such behavior is consistent with previously reported studies on stress-driven degradation in polymer coatings [3].

The obtained results can be used to improve the design and processing of PLA-based coatings with enhanced resistance to UV-induced degradation, particularly in applications involving films, protective coatings, and sustainable packaging materials.

### CONCLUSIONS

The purpose of the work has been achieved by establishing the effect of ultraviolet exposure on the evolution of microdefects in PLA coatings. It was shown that UV-induced photooxidation leads to increased surface polarity and the formation of a low-molecular-weight phase. A specific defect type - microcracks associated with shrinkage - was identified. Their initiation in stress concentration zones confirms the critical role of residual stresses formed during film processing.

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