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THE IMPACT OF ION-EXCHANGE TREATMENT ON THE DEGRADATION BEHAVIOR OF ALUMINOSILICATE GLASS

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ABSTRACT

Aluminosilicate glasses (AGs) are widely used in consumer electronics, particularly as cover glass for smartphone screens. To improve the mechanical properties of these glass articles, they undergo an additional ion-exchange process, which significantly enhances their mechanical strength. This chemical strengthening process involves replacing smaller Na^+ ions in the subsurface of the glass with larger K^+ ions, resulting in very high compressive stress near the surface. Despite the benefits of this treatment, chemically strengthened glasses (CSGs) are relatively expensive; however, most of them ultimately end up in landfills after their useful life due to the lack of a proper circular economy to recycle or remanufacture and reuse them. To establish a sustainable circular economy for CSGs, several challenges must be addressed, such as determining the degradation state of end-of-life CSGs and overcoming the difficulties associated with re-machining such materials.

Therefore, this study aims to assess the weathering-induced degradation of AG before and after the ion-exchange process. The findings will allow a deeper understanding of the impact of ion-exchange on the degradation behavior of AGs. To achieve this, two sets of AG (untreated and ion-exchanged) were subjected to accelerated weathering tests. The accelerated weathering machine allowed for precise control of parameters such as temperature, humidity, UV radiation, and exposure time. The first three parameters were based on the cycle recommended in ASTM G154, while the samples were removed from the machine after 3-24 days of exposure. After weathering, the samples were analyzed to detect any deterioration in their properties, including scratch resistance, hardness, surface compression stress, surface roughness, transparency, and changes in composition and structure. The results reveal that short-term weathering has a negligible impact on glass properties due to the robust structure of this glass type and the high compressive stress on its surface. However, long-term weathering significantly deteriorates the glass properties, particularly surface roughness, hardness, and scratch resistance. Furthermore, the findings indicate that the surface compressive stress in ion-exchanged CSG samples mitigates glass deterioration to some extent.

The significance of this research lies in demonstrating that AGs, both untreated and ion-exchanged, exhibit excellent resistance to short-term weathering. Additionally, by providing detailed insights into their degradation behavior under harsh weathering conditions over the long term, this study identifies the properties most susceptible to deterioration. This knowledge can guide decisions on whether end-of-life untreated/ion-exchanged AG is suitable for reuse in its original purpose or can be repurposed for alternative applications.

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