Interface and durability assessment of an epoxy-thermoplastic film for reusable adhesive bonding in horseshoeing

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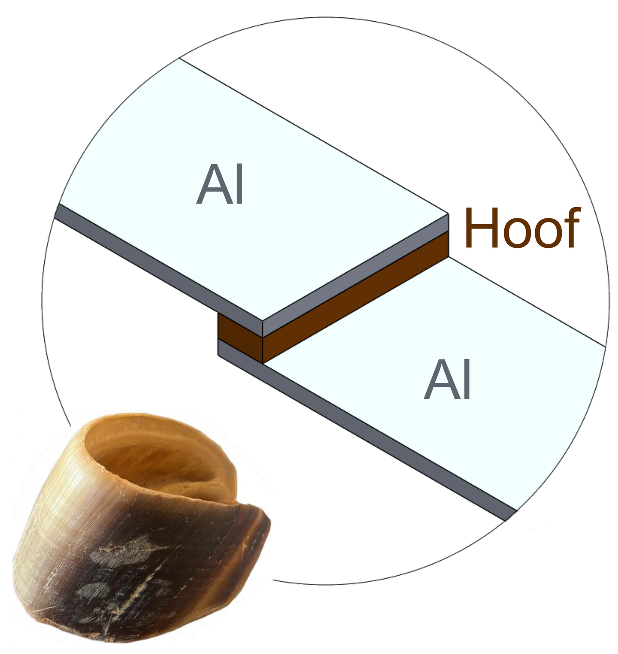
Introduction

Epoxy-thermoplastic film adhesives are high-performance structural hot melts that combine rapid heat-activated bonding, high strength, and debonding-on-demand capability, making them attractive for applications such as glue-on horseshoeing. However, thin-film processing at elevated temperatures can promote void formation within the bondline, a common manufacturing challenge in this class of materials. While such defects may not significantly affect static strength, they can accelerate contaminant diffusion and compromise long-term durability. This work investigates interfacial behavior, void origin, and moisture diffusion of a commercial epoxy-thermoplastic film adhesive over a representative horseshoeing cycle.

Adhesion performance

Adhesion assessment on hoof substrates

To reproduce the bonding orientation of horseshoeing, limited hoof wall dimensions required adapting a standard SLJ geometry by inserting a hoof sample within the overlap and bonding it to aluminum adherends. Joints were tested at 1 mm/min for preliminary adhesion assessment.



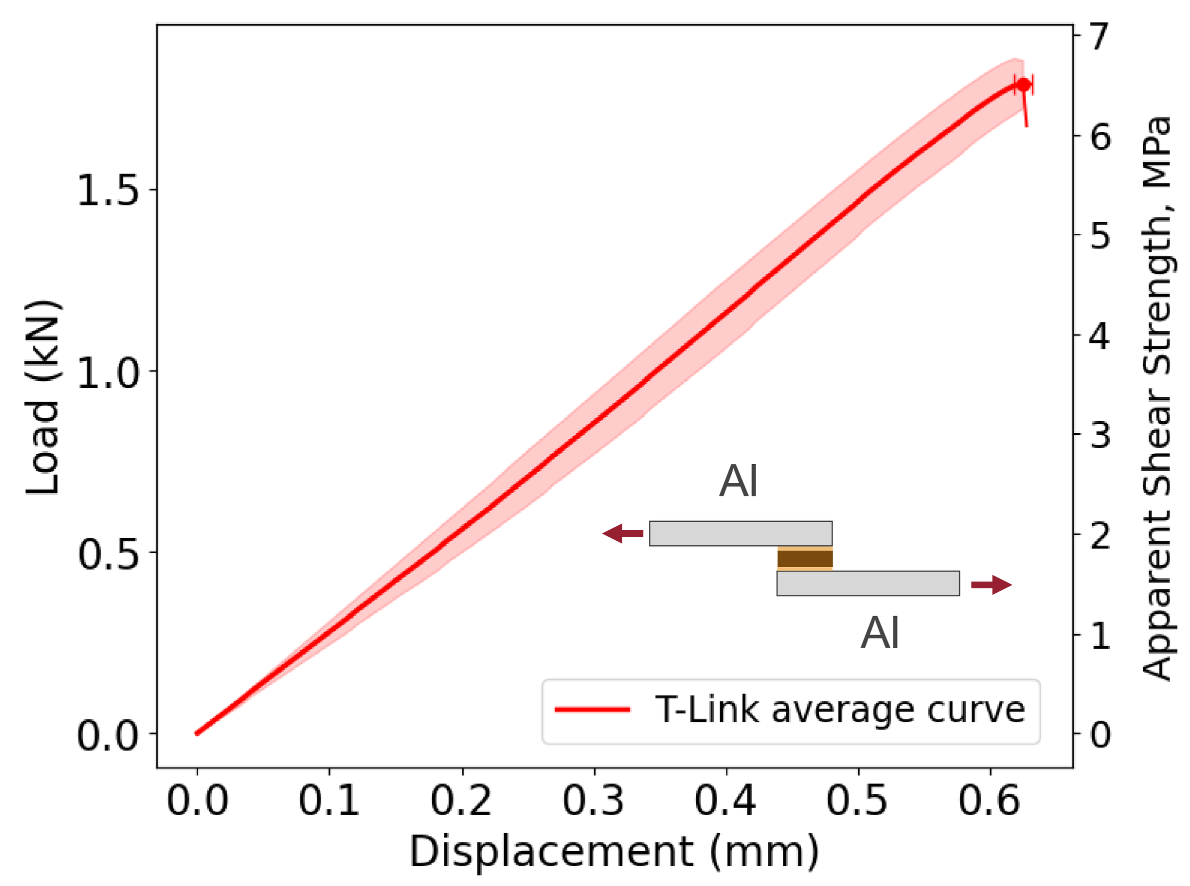


Figure 1: Load–displacement curve and corresponding apparent shear strength of Al-Hoof-Al joints.

Failure mode analysis

Failure occurred predominantly at the adhesive–substrate interface, consistent with previous SLJ tests on other substrate types. A recurrent issue in all joints was the presence of voids within the adhesive layer, formed during joint processing leading to further investigation on its origin and causes.

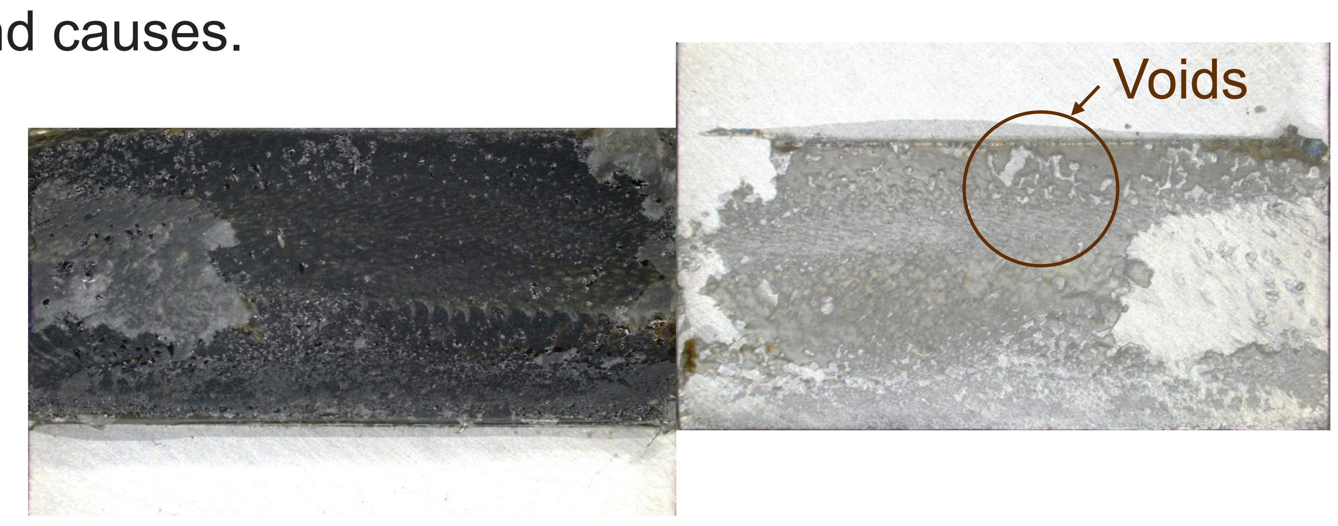


Figure 2: Failure mode of Al-Hoof-Al joints, showing interfacial failure and voids on the adhesive layer.

Understanding void formation and implications on joint durability

TGA and GC-MS analysis

TGA performed under processing conditions showed only 2.47% mass loss, attributed to moisture desorption near T_g. Also, GC-MS detected no material-derived volatiles. Thus, voids likely arise from air entrapment and absorbed moisture rather than volatile release, highlighting the need for uniform pressure and preferably vacuum during bonding.

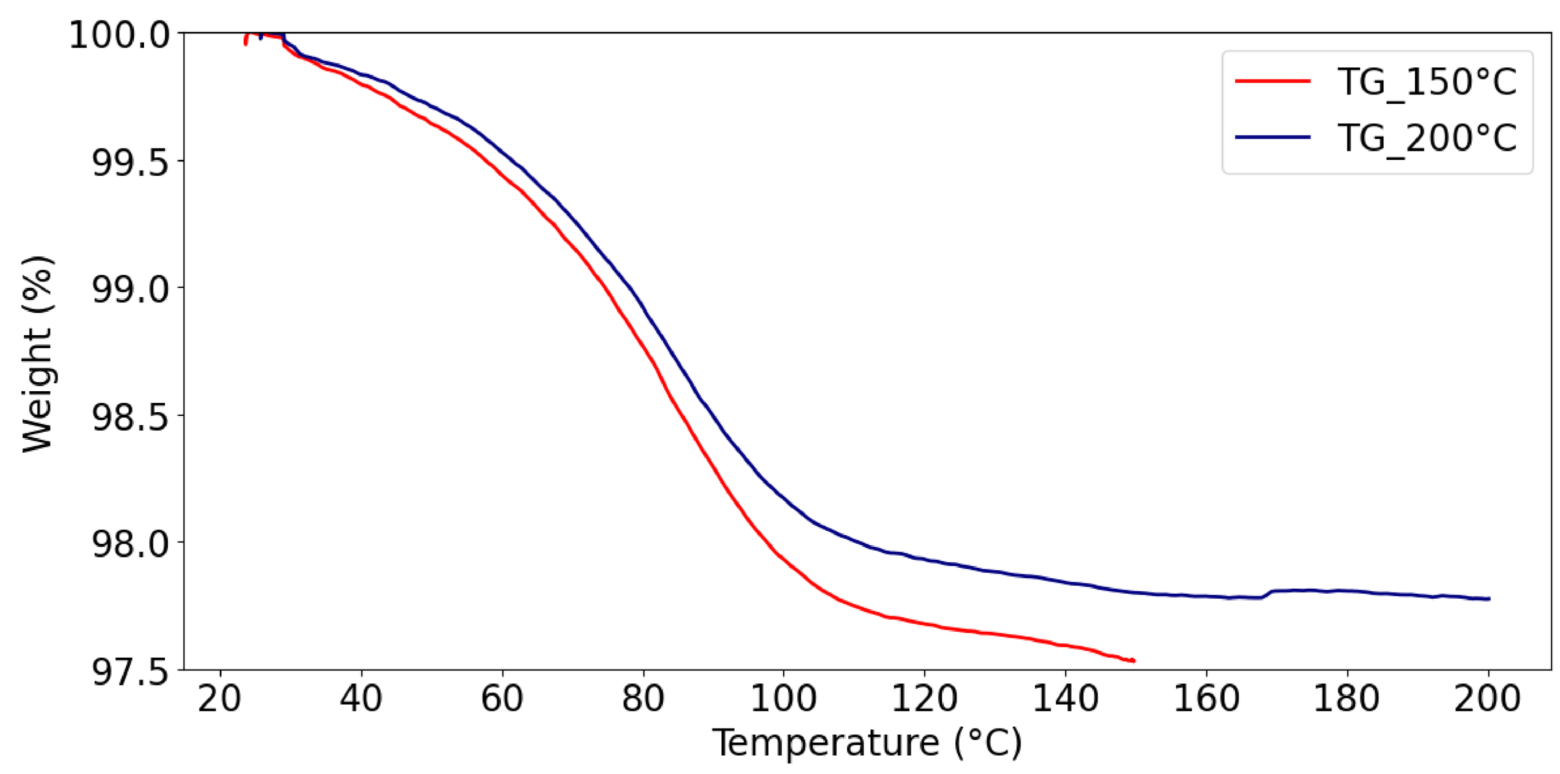


Figure 3: TGA profile of studied adhesive during its processing conditions.

Moisture diffusion study

The studied hot-melt adhesive (HMA) exhibits water diffusion behavior comparable to a commercial horseshoeing glue, indicating competitive durability. However, if voids persist in the final application, mitigation strategies such as silicone edge sealing are required to limit accelerated uptake and premature joint failure.

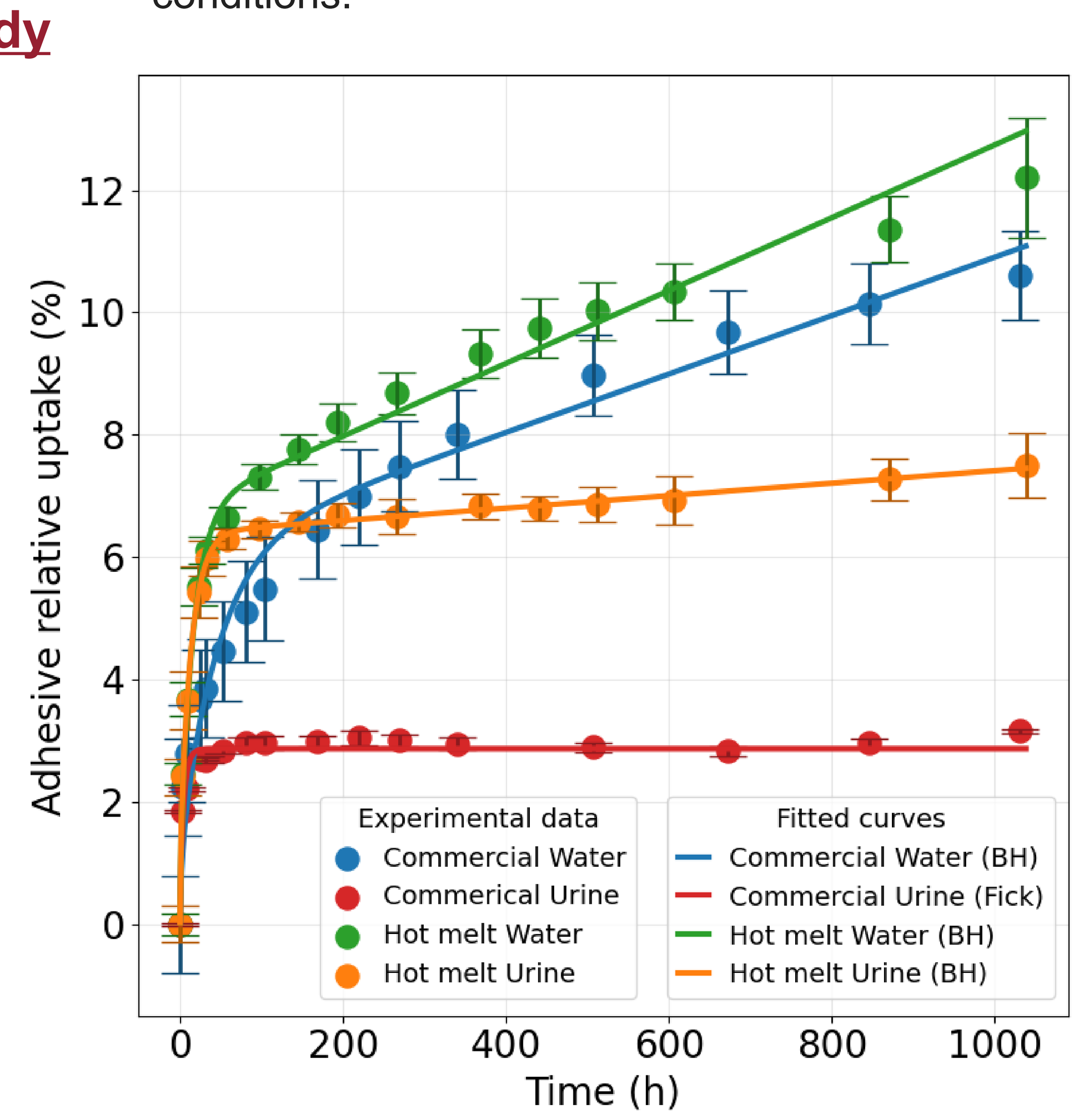


Figure 4: Relative uptake of HMA *VS* commercial glue in water and synthetic cattle urine at 55 °C for 6 weeks.

Conclusions

The studied hot melt adhesive shows competitive adhesion and diffusion behavior; void control is critical to prevent premature failure and ensure durable performance.

Acknowledgements

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