IOCM 2025 Conference

The 4th International Online Conference on Materials

3–6 November 2025 | Online

MDPI

Mechanical spectroscopy of polyurethane-based polymers for orthodontic aligners

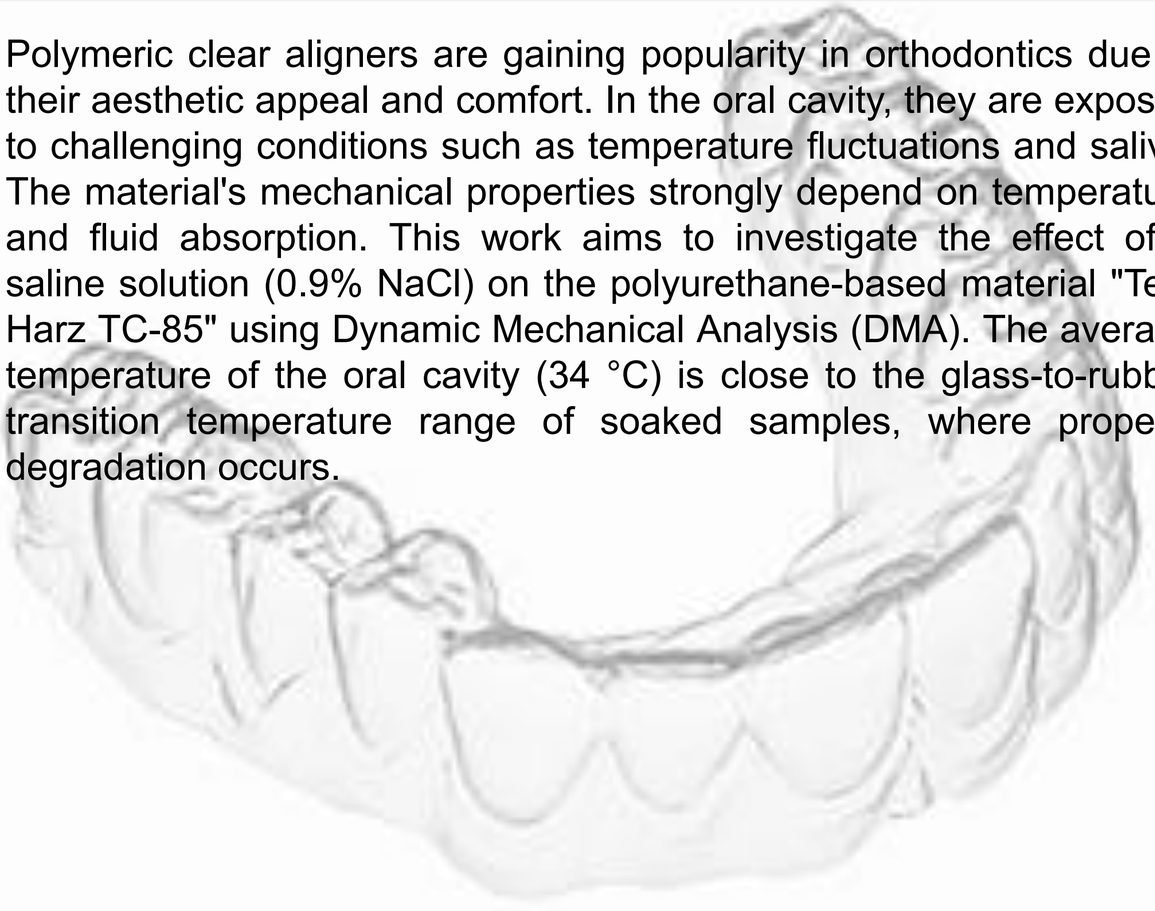
Luka Brenko[1], Luka Šimunović[2], Tatjana Haramina[1]

[1] Department of Materials, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, 10000 Zagreb, Croatia

[2] Department of Orthodontics, School of Dental Medicine, University of Zagreb, 10000 Zagreb, Croatia

INTRODUCTION & AIM

Polymeric clear aligners are gaining popularity in orthodontics due to their aesthetic appeal and comfort. In the oral cavity, they are exposed to challenging conditions such as temperature fluctuations and saliva. The material's mechanical properties strongly depend on temperature and fluid absorption. This work aims to investigate the effect of a saline solution (0.9% NaCl) on the polyurethane-based material "Tera Harz TC-85" using Dynamic Mechanical Analysis (DMA). The average temperature of the oral cavity (34 °C) is close to the glass-to-rubber transition temperature range of soaked samples, where property degradation occurs.



METHOD

Test specimens were fabricated using the DLP additive process (Digital Light Processing) from the Tera Harz TC-85 resin. DMA was performed in the temperature range from 20 °C to 88 °C. The frequency was 1 Hz, and the amplitude was 10 µm. The monitored parameters were storage modulus (*E'*), loss factor (tan *δ*), and glass transition temperature (T_g). Measurements were conducted in five phases: immediately after production, after 3 months of ageing at room temperature, after 5 days of soaking, after 10 days of soaking, and after 3 days of drying the material at room temperature.

RESULTS & DISCUSSION

Exposure of the material to saline solution led to a decrease in *E'*, tan *δ*, and T_g. This indicates that the solution acts as a reversible plasticiser. Saline solution molecules position themselves between macromolecules, increasing free volume and weakening intermolecular bonds. No significant difference was found in the mechanical spectra between samples soaked for 5 and 10 days, suggesting saturation after 5 days. At 35 °C, the storage modulus (*E'*) of soaked samples decreased by 59% compared to unexposed samples. Soaking in saline solution shifts the T_g peak for – 7 °C. Properties were almost fully recovered after three hours of drying at room temperature. Further drying for 3 days at room temperature proves the reversibility of the soaking effect.

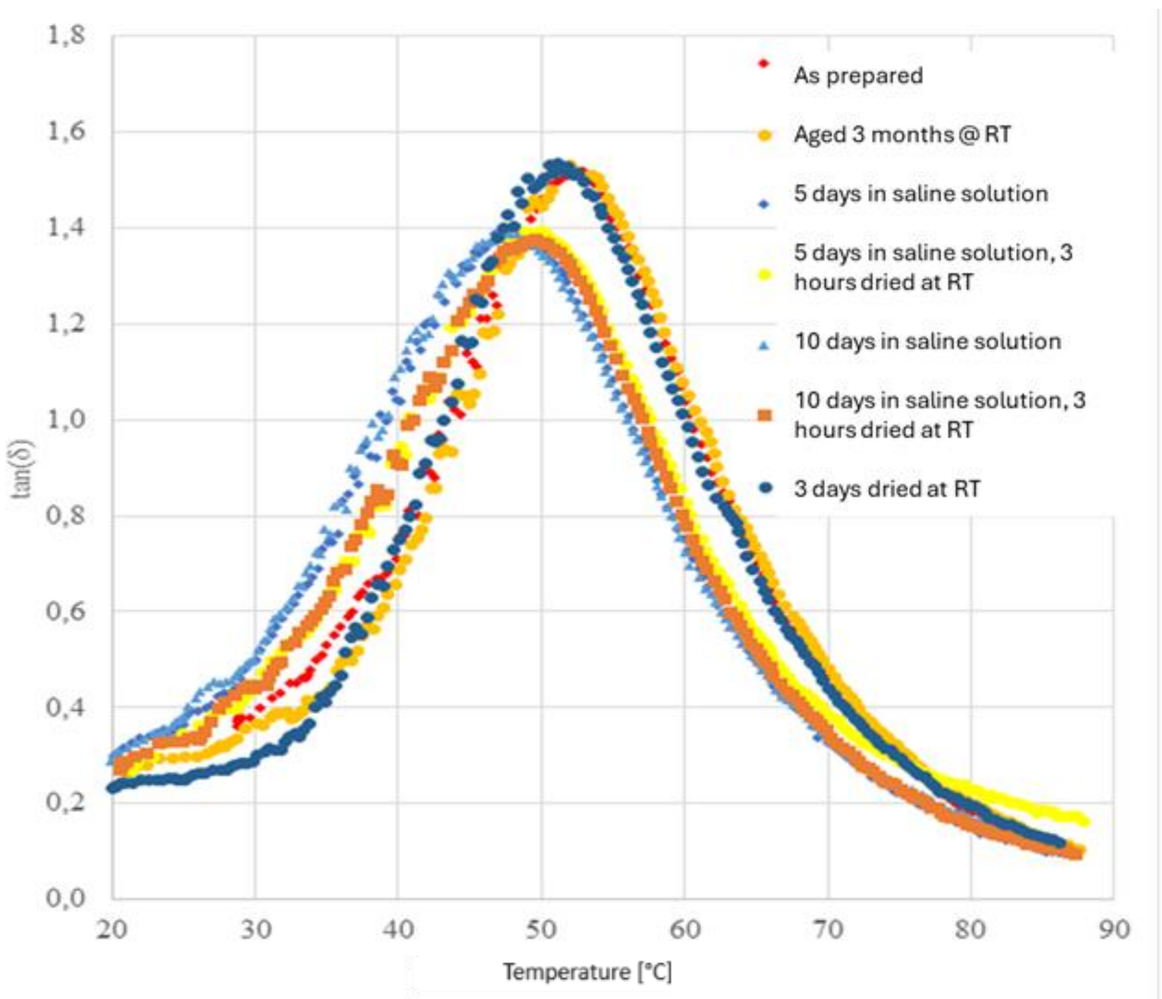


Figure 1. – Loss factor (glass to rubber transition peak)

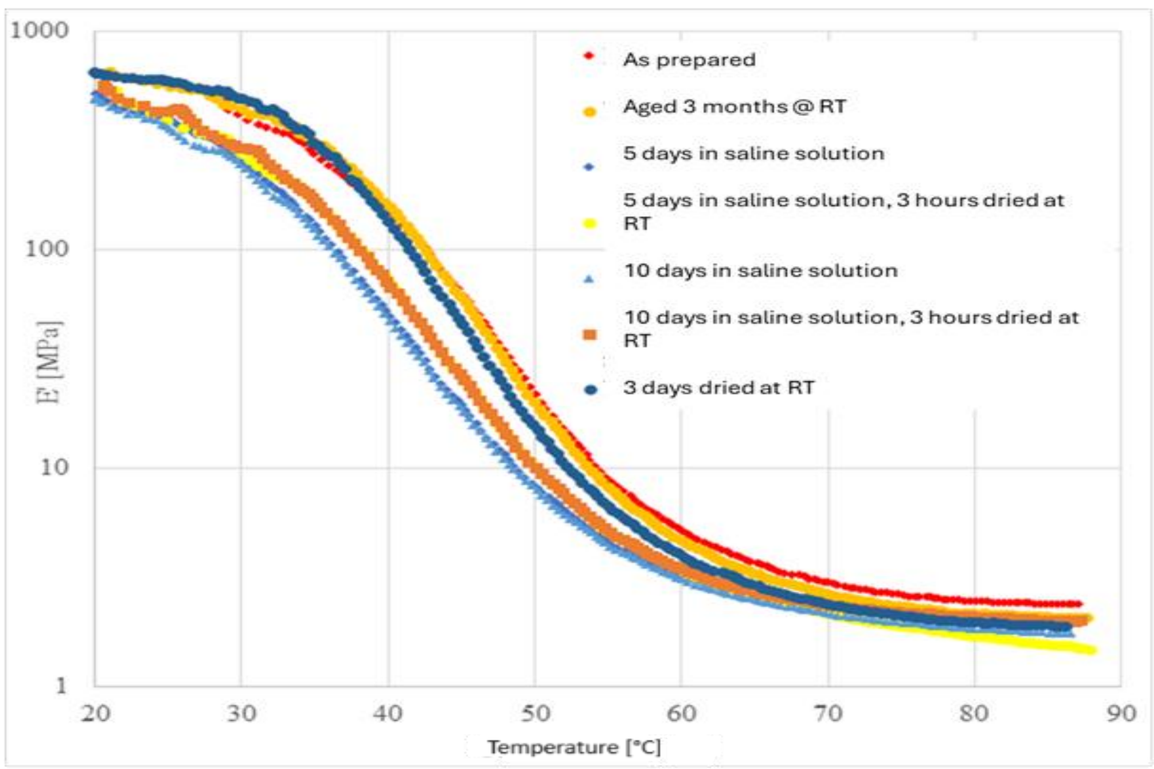


Figure 2. – Storage modulus (stiffness)

CONCLUSION

- Saline solution → reversible plasticiser for Tera Harz TC-85, causing a reduction in stiffness and lowering T_g
- Glass to rubber transition occurs at 30-33 °C for saline-exposed samples.
- Oral cavity temperature (~34 °C) > T_g of soaked samples → mechanical degradation during clinical use
- Possible loss of orthodontic aligner effectiveness

FUTURE WORK / REFERENCES

- Include in vivo testing for realistic performance assessment
- Compare 7-day vs. 14-day wearing protocols → determine if hydration kinetics support shorter replacement intervals