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TTS R Package: Non-parametric Time-Temperature Superposition for Materials Lifetime Prediction

We present a novel non-parametric method (MNAT) within materials reliability studies to apply the Time-Temperature Superposition (TTS) principle, enabling prediction of long-term viscoelastic material behavior from short-term accelerated tests—critical for polymers, composites, adhesives, and advanced materials where full-scale durability testing spans decades.

This work presents the TTS R package (CRAN) implementing the MNAT methodology, a non-parametric approach based on first-derivative curve shifts that outperforms traditional Arrhenius/WLF models across glass transition regions. Unlike parametric methods requiring restrictive temperature assumptions, MNAT delivers smooth master curves via GAM regression with bootstrap confidence bands, following Explainable AI principles for full model transparency.

The open-source TTS package democratizes accelerated lifetime testing for Industry 4.0 materials engineering, from adhesives to composites. Real Ocean Engineering validation confirms adhesive viability vs. welding (weight/emissions reduction).

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