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Development of a Computational Model for Accelerated Aging and Material Degradation in Varying Temperature and Environment

Strategic, defense, infrastructural and engineering installations are often in environments that are exposed to extreme weather conditions and are designed to function with little or no maintenance. With the advent of engineered materials, polymers are increasingly being used in all products, including as replacement for metals. However, polymers exposed to varying and extreme temperatures can degrade chemically over time. To study the degradation simulated tests are carried out in labs but it is very difficult to imitate and maintain the exact environmental conditions for a longer duration, which in turn makes it challenging to collect good, reliable, and quality data. In this research we use the noise reduction technique on sample data to enhance the time-temperature superposition technique. The principle of time-temperature superposition (TTS) states that the viscoelastic behavior of a material at a given temperature can be predicted by measuring its behavior at a different temperature and scaling the time axis by a factor known as a shift factor. The aging behavior of polymers can be predicted using time-temperature superposition master-curves, which account for the effect of temperature on the viscoelastic properties of the polymer. To construct these master-curves, horizontal and vertical shift factors are calculated to superimpose viscoelastic data taken at different temperatures onto a reference temperature curve. A well-known geometric algorithm, based on minimizing the arclength between two data points, is utilized to determine the shift factors, though it struggles with noisy data. This research aims to enhance this geometric algorithm by implementing noise reduction techniques. The developed computational model for accelerated aging procedure, using machine learning techniques, will greatly improve material degradation predictions.