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# Study on Uniaxial Tensile Yield Characteristics of NEPE Propellant Considering Aging at Low Strain Rate

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## Extended Abstract

Solid rocket motors serve as the propulsion devices for solid missiles. During long-term storage, the propellant grain is subjected to various mechanical and environmental stresses, including self-weight, alternating temperature loads, and aging effects. Under low strain rate conditions, the propellant is particularly susceptible to damage modes such as matrix cracking, particle-matrix interface debonding, and particle breakage. These damage mechanisms can compromise the structural integrity of the entire engine, thereby affecting the safety and storage life of the missile and potentially leading to significant economic losses and resource wastage. The term dewetting in solid propellants refers to the phenomenon of interfacial separation between the filler and the matrix when subjected to tensile forces. Specifically, the filler detaches from the matrix, resulting in the disruption of the material's internal structure. Macroscopically, dewetting manifests as a yield behavior in the propellant. This is characterized by a distinct turning point in the stress-strain master curve. Dewetting is a critical phenomenon that severely compromises the structural integrity of solid rocket motor charges and represents a significant pathway for damage and failure in solid propellants. In the existing body of research, although various constitutive models of propellants have been established across different strain rates, the majority of these studies have primarily focused on medium and high strain rate conditions. These investigations have predominantly concentrated on the damage and fracture behaviors of propellants. In contrast, research on the mechanical properties of propellants near the dewetting point and the associated damage mechanisms at this critical juncture remains limited and requires further exploration. Therefore, investigating the yield behavior of solid propellants before and after aging, identifying the yield stress of solid propellants, and establishing their strength failure criteria under low strain rate conditions hold substantial engineering significance.

In this study, the uniaxial tensile behavior of nitrate NEPE (nitrate ester plasticized polyether) propellant was investigated over a low strain rate range of $1.190\times10^{-4}$ s$^{-1}$ ~ 2.381 s$^{-1}$. The yield characteristics of NEPE propellant under low strain rate conditions were analyzed in detail. The results demonstrate that the stress-strain curve of NEPE propellant during uniaxial tensile testing can be categorized into four distinct stages: linear viscoelasticity, yield, strain hardening, and fracture. The mechanical properties of the propellant were found to be rate-dependent. Specifically, the maximum tensile strength and fracture strength increased significantly with increasing strain rate. However, the strain value corresponding to the dewetting point on the stress-strain curve remained relatively constant at approximately 49.69%. Based on this observation, the stress at the dewetting point was defined as the yield strength of the propellant. A visco-elastic-plastic yield model incorporating aging effects was subsequently developed for NEPE propellant. By introducing a dynamic yield function and incorporating an aging factor, the relationship between the dynamic yield strength, viscoplastic strain rate, and static yield strength was established. Experimental data revealed that the static yield strength of NEPE propellant was 0.2483 MPa, which is significantly lower than the design strength specified in the experimental design strength. This finding provides a valuable reference for assessing the failure criteria of NEPE propellant. In addition, this study systematically investigates the damage mechanisms of NEPE propellant under varying strain rate conditions. The results reveal that at low strain rates, the particle-matrix interface exhibits relatively low strength, resulting in fracture behavior dominated by particle dewetting. As the tensile strain rate increases, the interface strength is enhanced, and the fracture behavior transitions to matrix failure. When the strain rate is further increases where the interface strength is comparable to the particle strength, the fracture behavior is characterized by a combination of matrix failure and particle dewetting.