Characterizing the Thermomechanical Properties of Metallic Nanocomposites for Energy-Storing Materials
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RESEARCH OBJECTIVE
A phase change polymer is a material that transitions reversibly from an amorphous to crystalline microstructure, enabling passive energy storage and subsequent release of energy. Static and dynamic mechanical analyses, in combination with thermal analysis, will correlate changes in polymer structure to phase change and overall system behavior. Due to these thermomechanical properties, the proposed polymer can be applied to energy storage devices, smart and adaptive armor, and lightweight defense and sensing systems. This project will investigate a material to be used for national defense applications, which aligns with the FURI research theme of security.

INTRODUCTION
The nanocomposite network is synthesized through crosslinking BADGE with Jeffamine polymers and then curing until they harden to a rubber-like state. It incorporates different concentrations (0, 0.25, 0.5, 0.75, 1, 2)% of nanoparticles in the polymer samples in order to investigate the dependence of the physical properties on the nanoparticle density.

Materials:
- Jeffamine D2000: A polymer made of difunctional primary amines with an average molecular weight of approximately 2000 used as the curing agent. [1]
- Carbon Nanotubes (CNT): Hexagonal lattice of carbon atoms rolled up to form a hollow cylinder with electrical conductivity, thermal, and tensile strength properties.
- Bisphenol A diglycidyl ether (BADGE): A thermosetting polymer used as constituent of epoxy resins which are crosslinked.
- Quantum Dots (QD): Added florescence effects for future studying.

References:

RESULTS AND ANALYSIS

- **Tensile strength testing**: The addition of pure QDs decreases the Young’s modulus and the stress at break while increasing the strain at break slightly. The addition of the mCNTs increased both characteristics. The optimum composite contain an intermediate loading of nanoparticles (0.75%). Over-doping occurs at when there is a loss of elasticity due to the addition of CNTs and QD (1%).

- **Glass transition temperature (Tg)**: Tg will occur at a small dip on the graph after the line peaks or plateaus. Any addition of CNTs will increase the Tg due to interfacial interactions between the CNTs and crosslinked resin matrix. [2] But as the graphs depict, there is little to no change with the addition of 0.75% mCNTs, a larger addition will potentially have greater effects on Tg.

- **Analysis**: Future work can be performed on the tensile analysis to further determine the CNTs effects on elucidate plastic deformation. Further DSC tests needed on the less optimum additions of CNTs in order to evaluate whether Tg would change more and if it would increase of decrease. Obtain data from DSC test to calculate and analyze the degree of crystallinity. Conduct Dynamic Mechanical Analysis (DMA) test to discover any microphase separations as well as the rubbery plateau modulus and the temperature window in which the material can be used.

FUTURE WORK