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1. Introduction

Solar panels are essential components of satellites that harvest solar energy as a source of power to support their operation. Due to their thin shapes and relatively complex and intricate structure, solar panels need to be folded in such a way as to enable a safe and simple launching procedure without causing any damage or harm to the panels. Then, they unfold when the satellite reaches in space.

This research concerns the application of a thermoplastic polymer by incorporating it into the elastic hinge as an actuator to facilitate the unfolding process of the panels with minimal impact. The field of smart or responsive materials has been growing rapidly day by day in recent decades. Researchers can now fabricate structures that can respond to external mediums or stimuli, like temperature, pressure, electric current, heat, humidity, and light, in many interesting ways [1]. These fabricated structures using smart materials can act as sensors and actuators, are self-repairable, or change shape on demand.

2. Materials and methods

The polymeric composite investigated in this research includes the thermoplastic polymer (thermoplastic polyurethane, TPU) as a matrix and carbon fibers as reinforcement to facilitate joule heating. The heating-responsive shape memory effect in this thermoplastic polymeric composite was used to perform the deployment of the hinge in a controlled manner. To demonstrate the deployment of the solar panels in a space satellite and the unfolding of a hinge, an experimental setup was created, as shown in Figure 1. The polymeric composite was attached to the metallic measurement tape, and an electric current was used to stimulate its recovery to its initial shape.

The mechanical properties of TPU, elastic cloth, and composite were characterized using the uniaxial tensile test on a Shimadzu 10 kN UTM with a constant strain rate of 10^{-3} s^{-1}. The Differential Scanning Calorimetry (DSC Model Q200) technique was used to study the melting of TPU and the glass transition temperature.

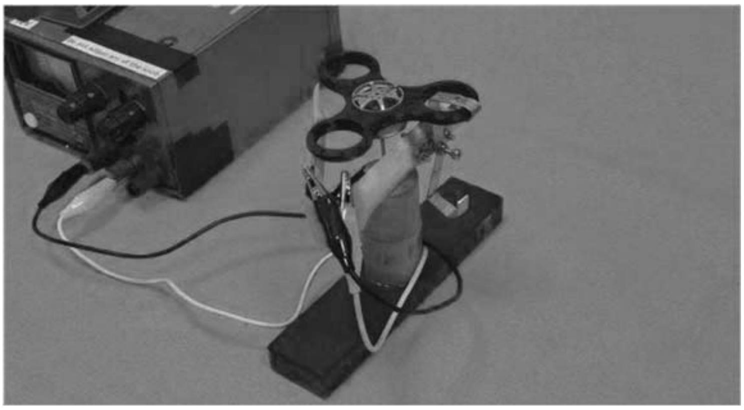

Figure 1. Experimental setup to demonstrate the controlled deployment of polymeric composite hinges.

3. Results and discussion

The mechanical properties of the polymeric composite obtained by the tensile test lie in between those of TPU and elastic cloth. The DSC graph (heat flow vs. temperature) of TPU 265A reveals the following thermal properties:

The TPU 265A begins to melt at nearly 50 °C.

The melting peak temperature (T_m) is 57.32 °C.

The crystallization begins at a temperature of approximately 23 °C.

The crystallization peak temperature (T_P) is 18.88 °C.

The measuring tape was bent at 180° into two equal lengths and then released to its natural position without applying any force. The bent tape acts as a hinge. After performing the rotation of the hinge 10 times, the average number of rotations the ball bearing made from its starting position to its final position was recorded. The results showed that the rotation without the application of polymeric composite at the hinge was significantly higher (630° rotation) than that with the application of polymeric composite at the hinge with the electric power supply, which was 1-2° rotation.

4. Conclusions

Through this research, experimental research was performed to investigate the optimal operating conditions and demonstrate the feasibility of achieving minimal impact during unfolding. The application of the TPU to a recyclable deployment hinge is possible. It can be heated and cooled multiple times without degrading its properties. The temperature required to become soft and viscous is not too high (around 50 °C). Moreover, it is light in weight, easy to manipulate, and less costly than the other materials.

References

1. Wang, C.; Pek, J.X.; Chen, H.M.; Huang, W.M. On-Demand Tailoring between Brittle and Ductile of Poly (methyl methacrylate) (PMMA) via High Temperature Stretching. Polymers 2022, 14, 985.