4-D Printed Low-Cost Novel Shape Memory Polymers for Industrial, Robotics and Disaster Relief Applications

Ramesh, Vallabh (School: duPont Manual High School)

Shape Memory Polymers (SMP) are a special class of materials that have the ability to return from a deformed state to its original shape when induced by an external stimulus, such as temperature. Limited work has been done in this emerging field, and the technique involves printing a block copolymer composition using a 3-D printer, then activating the 4th dimension of shape change with applied heat. This work was inspired by nature (Mimosa Pudica plant) to design and develop polymeric structures that respond to stimuli. Various polyurethane blend compositions were evaluated and a low-cost novel elastomeric composition was successfully developed and processed using standard polymer extrusion techniques. Filaments of 1.75 mm diameter were prepared for use in a FDM printer. The SMP developed is elastic and has an impressive 600% elongation. Recovery analysis studies of stretched filament conducted at elevated temperature (80°C) showed around 95% shape recovery. These filaments can lift objects about 200% of their original weight, which makes these compositions useful in a variety of applications. CAD designs were used to develop complex shapes and structures. In the robotics field, 4-D printed physical sensors for mapping temperature were demonstrated as a novel signal generator and heat activated [4-D] robotic tendons can be fabricated as a low-cost alternative. In the industrial and automotive field this work demonstrated superior performance for impact absorption and shape recovery. 4-D printed rapidly deployable structures that recover via heat activation were created for military and disaster relief applications. This novel 4-D printing technique provides a customizable approach to developing unique solutions to various scientific challenges across industries.

Awards Won:
NC State College of Engineering: Scholarship to attend NC State Engineering Summer Camp