University of Colorado
TECHNOLOGY TRANSFER OFFICE

Dual Cure Polymer Systems

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IP Status:

Patent pending; available for licensing.

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Background

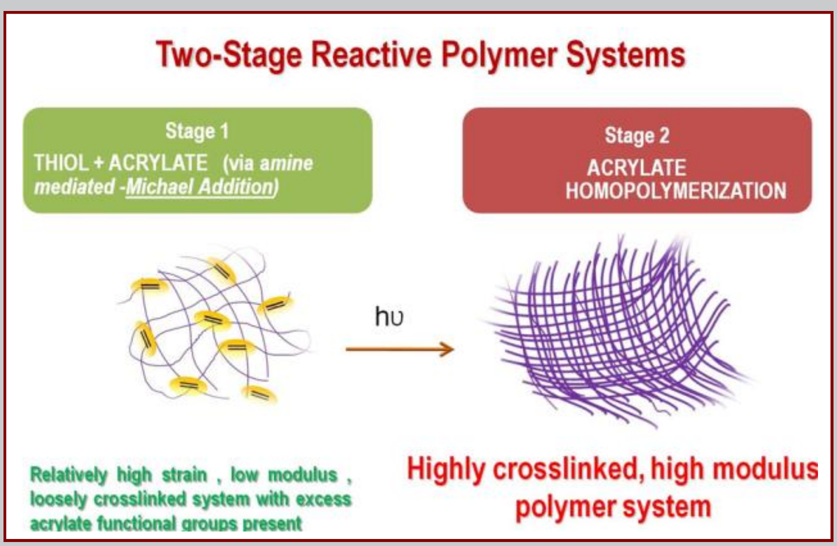
Polymers and polymeric composites are indispensable materials in the field of manufacturing, combining the advantages of low density, highly-specific mechanical properties and high resistance to corrosion.

Shape memory polymers (SMPs) are polymeric smart materials that can return from a deformed state (temporary shape) to their original ("permanent" or "memorized") shape by application of an external stimulus, such as temperature or light change. However, a drawback of SMP systems, especially for biomedical applications, is a lack of mechanical strength and modulus once the material has undergone its shape change from its temporary shape to its permanent shape.

Technology

A University of Colorado research team led by Dr. Christopher Bowman has developed a novel dual-cure shape memory polymer system which has the capacity for high strains and deformation at the end of the Stage 1 cure, but produces a final polymeric device with high modulus and stiffness at the end of a Stage 2 cure. This allows storage of the SMP device in a variety of temporary shapes followed by a transition to a final device shape after the device is deployed to its target location.

One example of this type of dual-cure system is the use of a non-stoichiometric mixture of thiol and acrylate monomers. In the first stage of the cure process, the monomers undergo cross-linking by a Michael addition mechanism to form a stable first stage polymer having ideal shape memory responses and a high strain capacity. In the second stage of the cure process, unreacted acrylate monomers undergo photo-induced polymerization to form a stable second stage polymer with a higher modulus than the Stage 1 polymer. This is illustrated in Figure 1:



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Applications

This system is appropriate for all applications that can exploit SMP systems, including biomedical applications in orthopedics, dental materials, stents, and endovascular coils. The unique properties of these materials also enable the introduction of refractive index gradients, or patterns, into the final polymer. Applications of these optical properties include optical interconnects and manufacture of contact lenses among others.

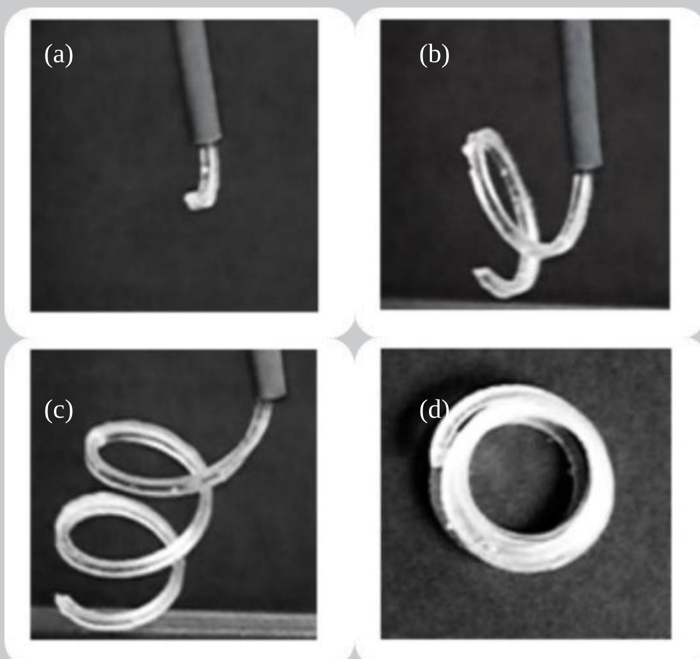

Figure 2, above, illustrates the shape memory programming and recovery of the system. As the coils are deployed from the catheter (1b-1c) and exposed to a temperature close to their Tg, they undergo a shape change from their temporary stored shape to their permanent, coiled shape (1d). The material has now attained its Stage 1 properties.

Table 1, below, demonstrates the Stage 2 properties that can be achieved once the polymeric device is in its permanent shape:

T_g (°C)	Compression Modulus (MPa)	T_g (°C)	Compression Modulus (MPa)
10 ± 3	18 ± 4	150 ± 7	1400 ± 50

Key Documents

Dual Cure Polymer Systems. PCT filed November 4, 2011.

Two-Stage Reactive Network Forming Systems. Advanced Functional Materials. 2012 April; 22(7):1502-1510; PDF available on request.

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