

Response to “Comment on ‘Water-driven programmable polyurethane shape memory polymer: Demonstration and mechanism [Appl. Phys. Lett. 97, 056101 (2010)]”

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Response to “Comment on ‘Water-driven programmable polyurethane shape memory polymer: Demonstration and mechanism [Appl. Phys. Lett. 97, 056101 (2010)]’”

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Although the chemoresponsive feature has been demonstrated in a few types of shape memory polymers (SMPs) (e.g., in Refs. 1 and 2), our understanding of the underline mechanism for triggering their shape recovery is still largely qualitatively.³ As such, the framework proposed in Ref. 4, despite of rather preliminary, could be a good initial step toward a more precise scheme for quantitative simulation in future. From this point of view, this piece of work⁴ is plausible. It is noticed that the derivation of the proposed framework in Ref. 4 starts from the thermodynamics of polymer solution,⁵ and the polymer refers to a particular SMP as a whole.

It must be pointed out that we should consider the special microstructure that enables the shape memory feature in chemoresponsive SMPs. Similar to other SMPs which respond to other stimuli, the two-segment structure is the cornerstone for their shape memory phenomenon. Refer to the schematic illustration in Fig. 1. At low temperatures, the elastic segment and transition segment are tangled together [Fig. 1(a)]. The SMP is stiff and in the glass phase. At high temperatures, the transition segment becomes soft, and thus the SMP is in the rubber phase and can be easily deformed [Fig. 1(b)]. Upon cooling back to the low temperature, the transition segment becomes hard again, so that the elastic recovery of the elastic segment is largely prevented [Fig. 1(c)]. Consequently, elastic energy is stored in the elastic segment. If the transition segment is significantly softened by a particular solvent, the elastic segment can recover its original shape and thus, releases the stored elastic energy in it. Bearing this two-segment characteristic in mind, we can see that the selected solvent for triggering the shape recovery should be able to significantly soften the transition segment, while the reaction with the elastic segment should be minimized.

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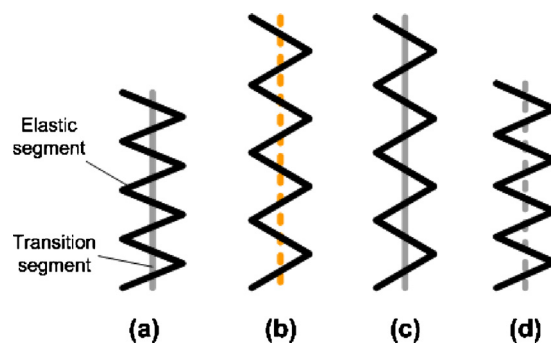


FIG. 1. (Color online) Schematic illustration of the underline mechanism in a chemoresponsive SMP. (a) Original configuration in which the elastic and transition segments are tangled together (transition segment is shown as a straight line for better visualization); (b) stretching at high temperature (transition segment becomes soft and can be easily deformed, while the elastic segment is elastically deformed accordingly); (c) temporary shape at low temperature (transition segment becomes hard at low temperature and thus the recovery of the elastic segment is prevented); (d) shape recovery upon exposure of a solvent which causes the softening of transition segment (the elastic energy in the predeformed elastic segment is release).

From above discussion, we can conclude that the derivation of the framework should start from the thermodynamics of transition segment/solvent, instead of the whole SMP, which includes both elastic and transition segments. On the other hand, since the softening process is difficult to be reversed, most likely chemoresponsive SMPs can only be used once.

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