Supplementary Information

A Soft Shape Memory Reactor with Controllable Catalysis Characteristics

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Abbreviations

NIPAm: N-isopropyl acrylamide

BIS: N,N'-Methylenebisacrylamide

AAm: acrylamide

SF: sodium fluorescein

XRD: X-ray diffraction

TEM: Transmission electron microscopy

TGA: Themogravimetric analysis

DLS: Dynamic light scattering

SMR: Shape memory reactor

LCST: lower critical solubility temperature

Materials

Unless otherwise noted, chemicals were obtained from the Sigma-Aldrich and used as received without further purification. NIPAm, BIS, AAm, sodium borohydride, sodium bisulfite, potassium peroxydisulfate, and SF were purchased from the Sinopharm Chemical Reagent Co., Ltd (China) and were used as received. Silver nitrate is the product of Aladdin Industrial Co., Ltd (China) and used as received. Water used for the reaction and catalysis was collected from the Direct-Q UV System (Millipore).

Preparation of the shape memory reactor

Just as shown in Scheme S1, this soft shape memory reactor was fabricated in a two-layer form composed of a thermosensitive control layer and a substrate layer. The thermosensitive control layer containing silver particles was firstly polymerized, and then one side of it was exposed to the aqueous solution of acrylamide, which allowed for the formation of the double layer reactor after the polymerization of acrylamide. In detail, NIPAm (0.40g), BIS (0.02g) and silver nitrate(0.30g) were dissolved in 3ml deionized water. After being dispersed with sonication, the mixture solution was initiated by redox initiator (sodium bisulfite (0.01g), potassium peroxydisulfate(0.03g)) at room temperature. The encapsulated silver nitrate was then reduced by an excess of sodium borohydride. Then, the prepared PNIPAm hydrogel contained silver

nanoparticles was taken out and immersed into distilled water for at least 2 days to remove the unreacted mass. During this period of time, the water was replaced every 12 h.

In this way, the control layer containing silver nanoparticles was prepared. To get the two-layer reactor, the one side of the control layer prepared was exposed to a 2ml aqueous solution containing AAm (0.40g), N,N'-Methylenebisacrylamide (0.02g), sodium bisulfite(0.01g), potassium peroxydisulfate(0.03g). After polymerization, the resulted two-layer hydrogel containing silver nanoparticles was profusely washed with methanol and water. This shape memory reactor prepared was named AgSR-A. For a comparative study, two controls named "AgSR-D" and "SR-A" were also prepared under comparable conditions. AgSR-D was also a two-layer reactor in which however both layers were polymerized with acrylamide, and silver nanoparticles contained in either layer (herein D means 'dead', in contrast to A 'active' in AgSR-A). SR-A was almost the same with AgSR-A, except for no any silver nanoparticles contained in the thermosensitivity control layer.
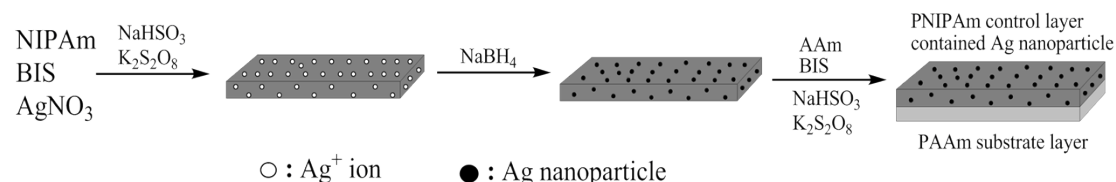
Scheme S1 Preparation route of the two-layer shape memory reactor

Measurements

XRD data were measured on a Philips 1730 powder X-ray diffractometer. TEM experiments were carried out on a JEM-2100 transmission electron microscope. TGA was performed using a NETZSCH STA449C instrument, with a heating rate of $10℃$ min^{-1}.

DLS experiments were performed on a Bettersize-2000 dynamic light scattering apparatus. Thermosensitive control layer in AgSR-A and SR-A, and the substrate layer in both of them were grind to little particles. All samples were kept at given temperatures for at least 10 min before acquiring the hydrodynamic radius (R_h) to

allow equilibrium reaching. The relative change (R_c) of hydrodynamic radius at a given temperature, which reflected the volume change ratio of the thermosensitive control element comparing with the substrate element, was calculated as follows[5]:

$$R_c = [(\frac{R_h - R_d}{R_d})_S - (\frac{R_h - R_d}{R_d})_T] \times 100\%$$

Herein, R_d is the size of dried particles. S indicates the particle from substrate layer and T represents the particle from thermosensitive control layer.

The electrochemical tests were employed on a CHI 760E electrochemical workstation equipped with a three-electrode configuration, in which the Pt wire inserted in the control layer of the two-layer hydrogel was adopted as the working electrode, along with Au-plate counter electrode and Ag+/AgCl ref. electrode.

The catalytic property of the prepared shape memory reactor was evaluated using the reducing reaction of SF with $NaBH_4$ catalyzed by silver nanoparticles. SF (4mg/L) was added into an excess amount of $NaBH_4$ to form 50ml solution, in which one of two-layer hydrogels prepared (1.2g) was then added. The reduction of SF was monitored by a UV-2550 spectrophotometer at 490nm. The reported values were the mean of three measurements.

Fig. S1. Photograph of the two-layer shape memory reactor prepared. The small picture inserted is a partial amplified image
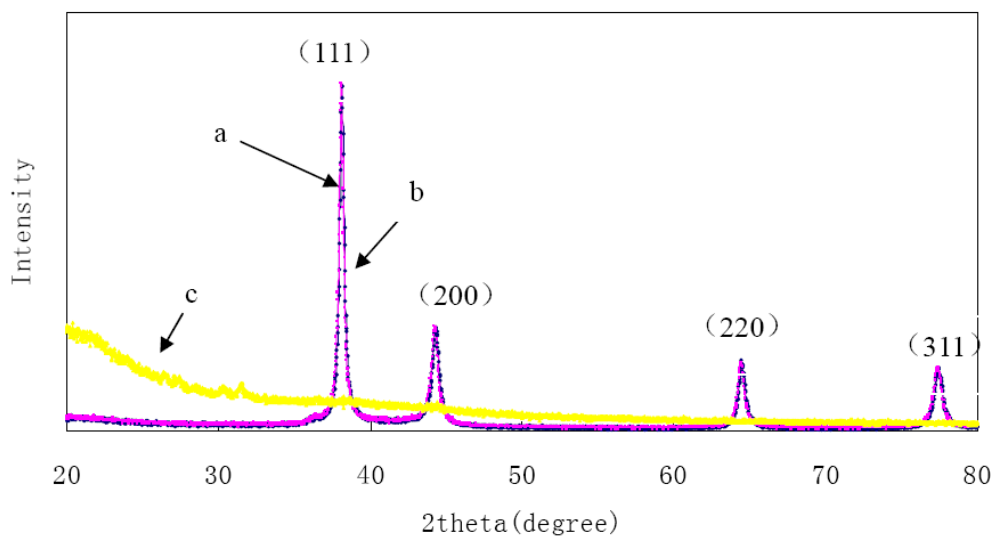
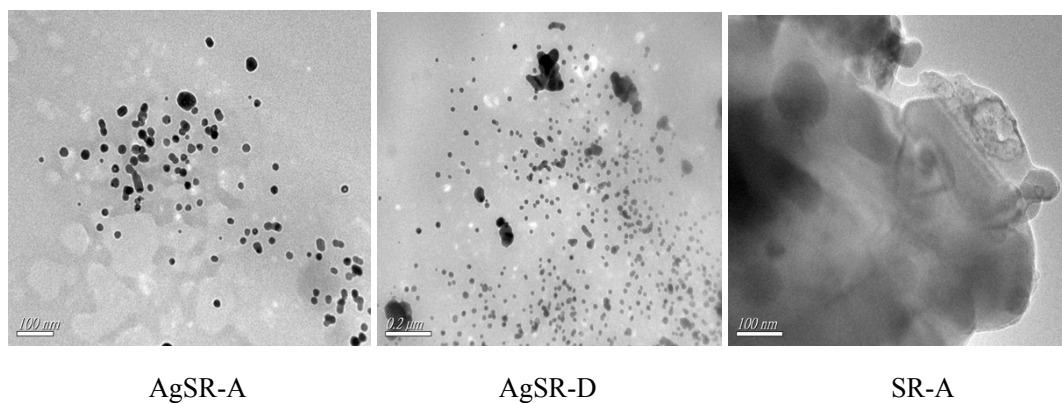Fig. S2. XRD patterns of the prepared reactors: (a)AgSR-A; (b)AgSR-D; (c)SR-A

AgSR-A　　　　　　　　　AgSR-D　　　　　　　　　SR-A
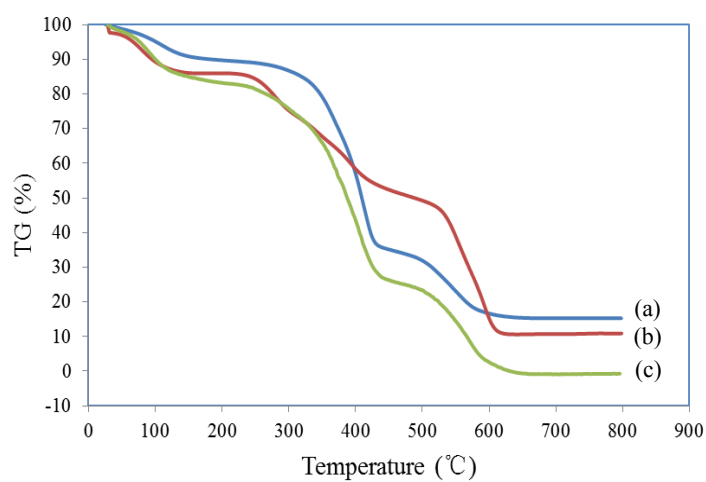
Fig. S3. TEM images of the reactors prepared

Fig. S4. Themogravimetric analysis of the reactors prepared, (a) AgSR-A, (b) AgSR-D, (c) SR-A
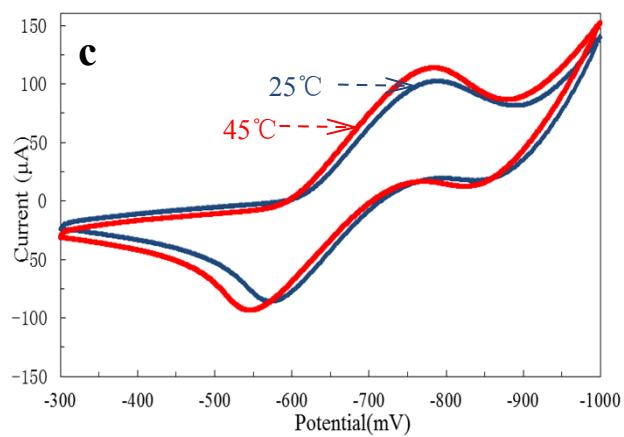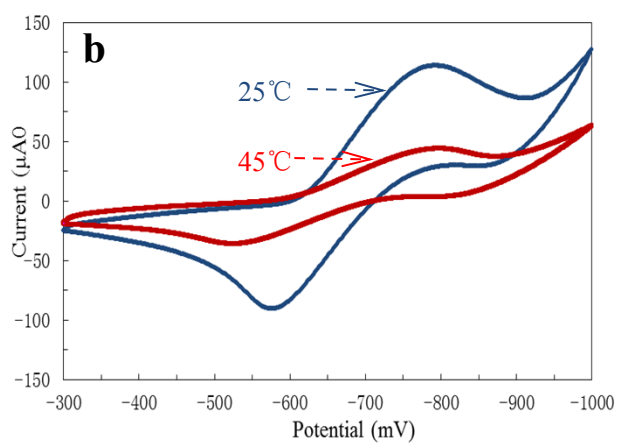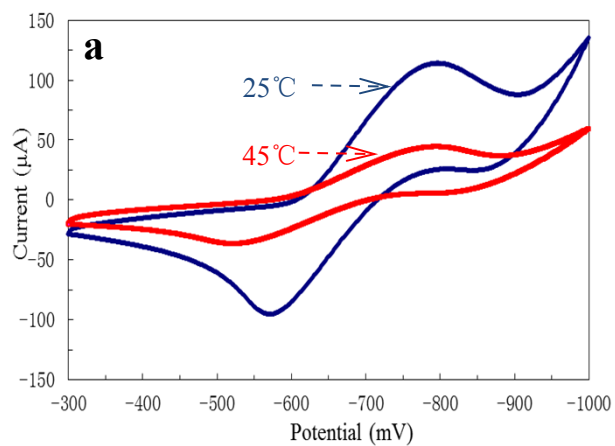
Fig. S5 CV profiles with tunable access to the control layers of the prepared reactors (a: AgSR-A; b: SR-A; c: AgSR-D)