Progress in Polymer Science 37 (2012) 1720–1763

Contents lists available at SciVerse ScienceDirect

Progress in Polymer Science

journal homepage: www.elsevier.com/locate/ppolysci

Recent advances in shape–memory polymers: Structure, mechanism, functionality, modeling and applications

Jinlian Hu*, Yong Zhu, Huahua Huang, Jing Lu

Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

ARTICLE INFO

Article history:
Received 8 February 2012
Received in revised form 8 June 2012
Accepted 12 June 2012
Available online 18 June 2012

Keywords:
Shape–memory polymer
Smart materials
Modeling
Switch
Stimuli-sensitive

ABSTRACT

Research on shape–memory polymers (SMPs) has been actively conducted for more than three decades. Recently, interest in this area has intensified. Even though there have been a number of related review papers published in the past 3 years, a generalized view on the important aspects of SMPs that would give a holistic picture of this promising area of research is still lacking. This paper will provide a comprehensive review that integrates the achievements in studying SMPs and their derivatives, such as composites and compound structures, as well as their current applications. Concepts, principles/modelings, structures and related synthesis methods, applications and future trends will be examined.

Abbreviations: SMMs, shape–memory materials; SMAs, shape–memory alloys; SMPs, shape–memory polymers; SMPUs, shape–memory polyurethanes; SMEs, shape–memory effects; SMPUU, shape–memory polyurethane-urea; SMF, shape–memory fiber; T_g, glass transition temperature; T_m, crystal melting temperature; T_i, isotropic temperature; T_{trans}, transition temperature; T_r, room temperature; R_f, shape fixity rate; R_r, shape recovery rate; TPU, thermoplastic polyurethane; ATMET, acyclic triene metathesis; CA, cellulose acetate; CD, cyclodedextrin; CNFs, carbon nanofibers; CNTs, carbon nanotubes; CNWs, cellulose nano-whiskers; DA, Diels–Alder; FT-IR, Fourier transform infrared spectroscopy; HSCs, hard-segment contents; IPNs, Interpenetrating polymer networks; LC, liquid crystalline; LCE, liquid crystalline elastomer; SCLCN, side-chain liquid crystalline network; CIE, crystallization-induced elongation; MIC, melting-induced contraction; EOC, poly(ethylene-co-1-octene); LSMPs, light-sensitive shape–memory polymers; MWCNTs, multi-walled carbon nanotubes; SWCNTs, single-walled carbon nanotubes; PB, poly(1,4-butadiene); PCL, polycaprolactone; PBA, poly(butylenes glycol adipate); PBPSF2, poly(1,4-butylenesuccinate-co-1,3-propylene succinate) prepolymer; PLGA, oligo[(rac-lactide)-co-glycolide]; PE, polyethylene; PEG, polyethylene glycol; PEO, polyethyleneoxide; PPO, poly(propylene oxide); PET, polyethyleneterephthalate; PFSA, perfluorosulphonic acid ionomer; PLLA, poly(L-lactic acid); POSS, polyhedral oligomeric silsesquioxane; PPD, poly(ω-pentadecalactone); PTMG, poly (tetramethylene ether glycol); PTFE, polytetrafluoroethylene; PVA, poly(vinyl alcohol); PVC, poly(vinyl chloride); PVDF, polyvinylidene fluoride; FEP, fluorinated ethylene propylene; Py-SMPUs, pyridine containing SMPUs; PDMS, polydimethylsiloxane; PMMA, poly(methyl methacrylate); EBs, embryoid bodies; SPR, plasmon resonance; MEF, metal-enhanced fluorescence; NIL, nanoimprint lithography; TE-NIL, thermal embossing NIL; SF-NIL, step-and-flash NIL; ROMP, ring-opening metathesis polymerization; TPCO, trans-polycyclooctene; TPI, trans-polyisoprene; PHAs, poly(3-hydroxyalkanoate)s; H-bondings, hydrogen-bondings; UPy, ureidopyridinone; UV, ultraviolet; WVP, water vapor permeability; XPS, X-ray photoelectron spectroscopy; Fe_3O_4, iron(III) oxide; WLF, Williams–Landel–Ferry equation; DFT, density functional theory; CTH, close then heal; SEM, scanning electron microscope; WAXD, wide-angle X-ray diffraction; CLEG, the network obtained by incorporating PEG segments as side chains with one end dangling into PCL; MACL, the network consisting of poly(cyclohexyl methacrylate) chains cross-linked by PCL; PDCL, the network consisting of cross-linked star-shaped hydroxy-telechelic PPD and PCL.

* Corresponding author. Tel.: +852 27666437; fax: +852 27731432.
E-mail address: tchujl@inet.polyu.edu.hk (J. Hu).

0079-6700/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.progpolymsci.2012.06.001

Contents