J Polym Res (2012) 19:9894
DOI 10.1007/s10965-012-9894-5

ORIGINAL PAPER

Characterization of shape memory behaviour of CTBN-epoxy resin system

Kavitha · A. Revathi · Sandhya Rao · Shylaja Srihari · G. N. Dayananda

Received: 8 November 2011 / Accepted: 14 May 2012 / Published online: 1 June 2012

Abstract Novel epoxy based shape memory polymers (SMPs) were prepared by blending bifunctional epoxy resin with varying content (0, 5, 10 and 15 wt %) of Carboxyl-Terminated Butadiene Acrylonitrile (CTBN) rubber and cured with a cyclo-aliphatic amine hardener. The epoxy/CTBN blends were chemically characterized by epoxy content and gel time measurements. Neat resin castings were prepared for conducting shape memory tests. The glass transition temperature (T_g) of the test sample was measured in order to fix the deformation temperature (T_{trans}). Shape memory (SM) cyclic tests were conducted on both unmodified and CTBN modified epoxy samples in order to comparatively assess their SM behavior. Compared to unmodified epoxy SMPs, the CTBN modified epoxy SMPs exhibited a significant increase in the number of SM cycles, which is attributed to the toughening effect of the CTBN phase.

Keywords Epoxy · CTBN · Shape memory · Glass transition temperature · Shape recovery

Introduction

SMPs are a class of active polymers which can undergo deformation at high temperatures, retain the deformed shape when cooled, and return to their original, unaltered configuration upon heating above the transition temperature, say, the glass transition temperature—T_g [1–3]. Due to their ease of fabrication and programmability, SMPs are found to be efficient alternatives to the well-established shape-memory alloys (SMAs). Compared to SMAs, SMPs are low density materials, capable of hundreds of percent recovery strain and are cost-effective. Another benefit of SMPs is their controllable activation temperature range that is linked to the T_g which can be tailored by modifying the chemistry of the polymer. SMPs can change their shape from temporary shape to their original shapes under appropriate stimulus such as temperature [4], light [5, 6], electricity [7, 8], magnetic field [9], etc. The shape memory effect in SMPs is governed by two components at the molecular level, one is cross-links in the polymer which determines the permanent shape and the other is switching segments which are used to maintain the temporary shape. SMPs can be either thermoplastic or thermosetting polymers. Polyethylene/Nylon 6 blends, Polystyrene / Polybutadiene blend, Polyvinyl acetate / Polylactic acid blends are some of thermoplastic shape memory polymers, while, epoxies, polyurethanes and styrene based resins are examples of thermosetting shape memory polymers. These SMPs possess high application potential for use in aerospace, biomedical and automotive sectors.

In this emerging area of SMPs, extensive work has been carried out on polyurethane (PU) based SMPs [10–12], since it is a low cost polymer, which can have Tg nearer to room temperature and also exhibit excellent shape memory behavior. Compared to PU based SMPs, lesser research content is available on epoxy based SMPs. Epoxy resins are widely used as structural materials in the aerospace and space applications due to their unique thermal and mechanical properties. Hence, studies on epoxy-based shape memory polymers for structural applications, is a niche area of research.

Kavitha · A. Revathi · S. Rao (✉) · S. Srihari · G. N. Dayananda
Center for Societal Missions & Special Technologies,
CSIR- National Aerospace Laboratories,
Bangalore 17, India
e-mail: sandhya.rao@nal.res.in