J Nanopart Res (2020) 22: 226
https://doi.org/10.1007/s11051-020-04963-y

RESEARCH PAPER

Luminescent composite based on epoxy polymer and silica nanoparticles doped by terbium(III) complex

L. M. Amirova · K. A. Andrianova · A. R. Khazieva · A. R. Mustafina · S. V. Fedorenko · I. R. Nizameev · A. A. Khannanov · R. R. Amirov

Received: 23 April 2020 / Accepted: 20 July 2020 / Published online: 29 July 2020

Abstract The interaction of the NPEL-128 epoxy oligomer with silica nanoparticles doped with terbium(III) complex with *p*-sulfonatothiacalix[4]arene was studied for two types of nanoparticles: possessing silanol hydroxyl groups on the non-modified surface of the nanoparticles (SNs) or amino and hydroxyl groups on the amino-modified silica surface (ASNs). The possible reaction schemes of amino and hydroxyl groups on the surface of ASNs with epoxy molecules were revealed using IR spectroscopy and DSC. Based on the obtained data, a method for producing epoxy nanocomposites was developed, and their thermophysical, physicomechanical, and luminescent properties were investigated. The chemical bonding of epoxy with ASNs compared with that of SNs allows one to obtain a higher dispersion and uniform distribution of the nanoparticles in the polymer matrix, as well as to increase the glass transition temperature of the polymer. Due to the presence of terbium(III) complex in silica nanoparticles, the cured epoxyamine polymer filled by ASNs exhibits luminescent properties.

Keywords Silica nanoparticles · Epoxy resin · Nanocomposites · Luminescent materials

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11051-020-04963-y) contains supplementary material, which is available to authorized users.

L. M. Amirova · K. A. Andrianova
A.N. Tupolev Kazan National Research Technical University, Tolstoy Str., 15, Kazan, Russian Federation 420012

A. R. Khazieva · A. R. Mustafina · S. V. Fedorenko · I. R. Nizameev
Arbuzov Institute of Organic and Physical Chemistry, FRC Kazan Scientific Center of RAS, Arbuzov Str. 8, Kazan, Russian Federation 420088

A. A. Khannanov · R. R. Amirov (✉)
Chemical Institute, Kazan Federal University, Kremlyovskaya Str. 18, Kazan, Russian Federation 420008
e-mail: rramirov58@mail.ru

Introduction

Due to impressive mechanical, anticorrosive, dielectric properties, thermal stability, resistance to solvents, and ease of preparation, epoxy composite materials with various fillers are widely used in the paint and varnish, automotive industry, construction, oil, and energy sectors (Hodgkin et al. 1998, Levchik and Weil 2004, Nguyen et al. 2015). In the last decade, nanosized particles of TiO_2, Al_2O_3, ZrO_2, etc. have been used as fillers of epoxy resins to increase thermal and mechanical properties (Abdollah and Abbas 2009, Al-Turaif 2010, Sajjad et al. 2012, Samuel et al. 2010).

Silica nanoparticles (SiO_2) are of particular interest as fillers for epoxy resins (Zou et al. 2008; Bray et al. 2013; Chen et al. 2008; Abdollahi et al. 2018; Zhang et al. 2019). Unlike many other nanoscale fillers, they are chemically inert, stable, optically transparent, and nontoxic (Yan et al. 2007; Andreani et al. 2015). In addition, for subsequent effective binding to epoxy resin, the surface of silica nanoparticles can be easily modified by various functional groups (e.g., anhydride, glycidyl,