

Modification of epoxy resins by thermoplastic polyurethanes based on polycarbonate diol

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Abstract

The modification of epoxy resins with thermoplastic polyurethanes with good elastic characteristics was done in this thesis. The impact of synthetic polyurethane based on polycarbonate diol (5,10, and 15% by weight in proportion to epoxy), as well as the proportion of rigid elastomeric segments (20, 25, and 30% by weight), on the epoxy composite networking process was investigated. A differential scanning calorimeter (DSC Q20 TA Instruments) was used to evaluate the networking of epoxy hybrid materials at three different heating speeds (5, 10 and 20°C/min). Thermoplastic polyurethane films with varying percentages of hard segments (20, 25, and 30% by weight) were utilised to modify epoxy resins. In different weight percentages relative to the resin, synthesised polyurethane elastomers were added to the epoxy (5, 10 and 15 wt percent). A composite mixture was stirred using a magnetic stirrer at 60°C for 2 hours to blend elastomers and epoxides. The mixture is then agitated for another 20 minutes in an ultrasonic bath for greater homogeneity. The Jeffamine D-2000 cross-linker was then added to the binary component that had been created. The new reaction mixture was then vacuum dried for an hour to eliminate any remaining CO₂ bubbles. The reaction mixture is put onto polypropylene plates to make films. The polypropylene plates were placed in the dryer after 24 hours at room temperature, where the process of networking modified epoxy resins lasted an additional 4 hours at TPUs (thermoplastic polyurethane elastomers) are segmented copolymers comprising urethane and alternately dispersed flexible soft segments and more stiff hard segments. Polyether and polycarbonate diols are used as soft segments in traditional TPUs polyester, whereas aliphatic diols (primarily butane-1,4-diol (BD)) and aromatic (primarily 1,1'-methanediylbis(4-isocyanatobenzene) (MDI)) or aliphatic diisocyanates (mostly 1,1'-methanediylbis(4-isocyanato)). TPUs are widely used in a variety of fields, including medicine, footwear, and the car sector, but new materials with improved characteristics and versatility are still needed. As a result, alterations to standard TPUs are made to their main chain, side chains, and the polymer surface itself. My colleagues and I recently demonstrated TPUs that had been adjusted in the main chain. 2,2'-[sulfanediylbis(benzene-1,4-diylxy)]diethanol (diol OSOE), 2,2'-[oxybis(benzene-1,4-diylsulfanediyl)]diethanol, or 2,2'-[sulfanediylbis(benzene-1,4-diylsulfanediyl)]diethanol commercial diisocyanates, such as MDI, diethanol, Commercial polymer diols, such as aliphatic polyether diol of Mn=1000g/mol Mn=1000g/mol and aliphatic polycarbonate diol of Mn = 2000 g/mol, and HMDI and 1,6-

diisocyanatohexane (HDI) (PCD). Thermal stability and tensile strength (up to 44 MPa) were found to be quite excellent in these polymers. TPUs based on aliphatic diisocyanates were also resistant to yellowing and showed good transparency in some circumstances. When compared to polymers made using conventional chain extenders, those made with sulfur-containing chain extenders had greater adhesion qualities to metals as well as increased refractive index and transparency.

The current research focuses on a new TPU modification that involves introducing carboxylic groups into hard segments using 3-hydroxy-2-(hydroxymethyl)-2-methylpropanoic acid (DMPA). I picked some of the previously disclosed TPUs for this study, such as those based on diol OSOE, HDI or HMDI, and PCD.

These functionalized polyurethanes are highly desired in biomedicine since the presence of carboxylic groups improves their biocompatibility; on the other hand, the grafting and mixing of diverse polymers enhances their biocompatibility. These organisations might be utilised to alter the surface. These polymers may also be used to make anionomers once the carboxylic groups are ionised, and the anionomers may be used to make coatings and adhesives, among other things.

The TPUs that were created were colourless and transparent. THF, N,N-dimethylacetamide (DMAc), N,N-dimethylformamide (DMF), N-methyl-2-pyrrolidone (NMP), 1,1,2,2-tetrachloroethane (TChE), and dimethyl sulfoxide (DMSO) were all insoluble in the HDI-based TPUs. As a result, their molar masses could not be established. The HMDI-based ones, on the other hand, showed substantially lesser resistance to the aforementioned solvents, which might be due to their amorphous forms (see DSC results). THF, DMAc, DMF, and TChE were totally soluble, whereas NMP was moderately soluble and DMSO was insoluble. As with polyurethanes synthesised by melt polymerization, these polymers have high MnMn (in the range of 110 103–143 103 g/mol) and M wM w (in the range of 219 103–255 103 g/mol) values, as well as a comparatively low molar-mass dispersity, ranging from 1.61 to 2.26. Other researchers were able to create polyurethanes with similar molar-mass dispersity. ATR-FTIR spectroscopy was used to analyse the chemical structures of all of the TPUs. Their suggested structures were confirmed by the obtained spectra. The absorption peaks of the urethane, carbonate, carboxylic, and ether groups, as well as the benzene ring, methylene, and methyl groups, were noted. There was no isocyanate signal about 2270 cm⁻¹ in any of the spectra,

Extended Abstract

suggesting complete NCO conversion. The major absorption bands are listed below, and example spectra may be seen in Fi. A one-step catalysed melt polyaddition was used to create new colourless, transparent, high-molar-mass TPUs with aliphatic polycarbonate soft segments and hard segments created by a combination of two chain extenders, diol OSOE and DMPA, with HDI or HMDI. Based on the results of the experiment, it can be concluded that TPUs have excellent tensile strength, with polymers based on HMDI exhibiting greater values (41.2–49.3 MPa vs. 37.8–44.9 MPa). They also stated that there was more

transparency (transmittance at 800 nm: up to 92.7 percent vs. up to 75.4 percent). TPUs based on HDI, on the other hand, have lower Tgs (36 to 29 °C vs. 20 to 0 °C) and a higher degree of microphase separation. The thermal stability of both types of TPUs was good. Their 1 percent mass loss temperatures were kept within the range of 260–268 °C. Furthermore, the acquired results suggest that these DMPA-modified TPUs had better transmittance, hardness, tensile and adhesive strengths, but inferior elongation at break and somewhat lower thermal stability than the non-modified counterparts.

Biography

Milorad Ninkovic is a chemical engineer, graduated 2013 at University of Novi Sad, department for polymer materials. Moved to Toronto in 2013. It was determined that with the increase in the share of hard segments of polyurethane, as well as the increase in the content of the added elastomer, the temperatures of the maximum reaction rate of the networking and activation energy of the reaction of the epoxy resin interaction decrease, which confirms the catalytic effect of thermoplastic polyurethanes based on the polycarbonate diol.

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