THE EFFECT OF MIXED ACETONE/DMSO SOLVENT ON THE POROSITY OF EPOXY-BASED POLYMER FILMS WHICH ARE FORMED BY A CHEMICAL SOLUTION DEPOSITION METHOD

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In recent decades, the popularity of porous thin-film materials has grown rapidly. Thin porous polymer films are widely used in various functional applications [1]. On the one hand, the porosity of polymer films makes them more sensitive to the analyte, but on the other, enhanced porosity of films decreases their physical-mechanical properties. Therefore, porosity control is a very important factor in obtaining such polymer films. One way of this control is using a mixed solvent at obtaining porous polymer films by a chemical solution deposition method.

The purpose of the work was to investigate the effect of binary acetone/DMSO solvent on the morphology of polymer films based on epoxy polymer. The porosity of polymer films as criteria under the various volume ratios of co-solvents was used.

In this work was used liquid diglycidyl ether of bisphenol A (DGEBA) epoxy resin (Epoxy 520, Spolchemie, Czech with epoxy equivalent weight 184). Diethylenetriamine (DETA, Dow Chemical) was used as a hardener. Acetone and dimethylsulfoxide (DMSO) were utilized as solvents. All of the solvents were purified before use.

Thin films were obtained by chemical solution deposition method from mixed solvent acetone/DMSO at the ratio of components (v/v): 10/90; 20/80; 30/70; 40/60; 50/50 respectively. First, 0.1 g/mL solutions of DGEBA in a respective mixed solvent were obtained. Then, DETA was added into each solution to achieve a stoichiometric ratio of DETA/DGEBA close to 10/1 w/w. Thin films were spin-coated onto the pre-cleaned coverslips at 1000 rpm for 0.5 min and cured at room temperature for 24 h in a vacuum. The thickness of the obtained polymer films was 1.0 mm.

The SEM method was used to investigate the surface topography of the polymer films. From the results obtained, it follows that the films are porous materials with an average size of open pores from 1.4 μm to 42.8 μm. In this case, the concentration of open pores is from 2.4 % to 7.5 %. By IR spectroscopy [2], the total porosity of the films was determined, it ranged from 31.3 % to 77.5 %. At the same time, one showed that the lowest film porosity of 31.3 % corresponds to the closest binary solvent solubility parameter of 22.0 $MPa^{1/2}$ to the polymer solubility parameter. Hildebrand solubility parameter (δ) of initial acetone, DMSO, and epoxy polymer have equal 19.9, 26.6, and 22.8 $MPa^{1/2}$ respectively [3]. The parameter δ of binary acetone/DMSO solvent is equal from 20.5 till 23.3 $MPa^{1/2}$.

Thus, we can conclude that the porosity of the studied films directly depends on the thermodynamic affinity of the polymer with the solvent. The structures of polymer films with the smallest number and size of pores were formed at close values of the solubility parameters of solvent and polymer. Furthermore, the number and size of the pores in films increase when the thermodynamic affinity of the polymer and solvent deteriorates because of the phase separation process.

References

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