BENDING PROPERTIES OF DOPED EPOXY RESIN

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Abstract: *The objective of this study was to evaluate the three point bending properties of doped epoxy resin. Sodium and potassium dichromate doped epoxy resin obtained by ultra-sonication strategies is a novelty in the field of the ultra-sonicated composite materials. The epoxy system WWA-WWB from Resoltech had been used as matrix. Bending tests were conducted as recommended by ISO 178/2001. Test speed for all tests was set at 5 mm / min. The tests were carried out on TESTOMETRIC M350-5AT machine. The doping method had been developed as part as research activity under the Project POSCCE 12P01.024/CD111.*

Keywords: *bending properties, doped epoxy resin, sodium and potassium dichromate*

1. Introduction

In recent years' considerable efforts have been made to improve the quality and reliability of thermosetting polymer materials [1, 2]. Improved mechanical properties of polymers increased their potential commercial applications [3]. The ultra-sonication of epoxy resins constitutes a new research branch and being in continuous development. Ultrasound treatment is one way of improving the polymer material, in particular in the components matching phase of a composite and the formation of its structure. Ultra-sonication during polymerization is a very efficient method to increase the dispersion of salts in the pre-polymer mixture, in the case of thermoset polymers [4]. Under the action of ultrasound there is a change in homogenization, viscosity, relaxation time, and strengthening [5]. The technique of modifying the polymer by doping them is very new and is challenged by some difficulties when the used doping agents are smaller and smaller. The properties of such modified polymer properties are not depending only on their basic properties but also on properties of modifying agent and its dispersion. The field of the ultra-sonicated composite materials together with salts doped epoxy resin has not been studied enough. In comparison with the widely used modifying agent [6, 7] adding salts and ultra-sound exposure into the epoxy matrix may have different effects on the bending properties of the epoxy composites.

For this study the ultra-sonication is considered as a challenge. Therefore in the present paper we intend to analyze the bending properties of sodium and potassium dichromate doped epoxy resin treated with ultrasound. The mechanical properties of polymers are of interest [8], in particular in all applications where polymers are used as structural materials. Mechanical behaviour involves the deformation of a material under the influence of applied forces [9, 10, 11].

The preceding analysis of the existing literature shows that the influence of ultra-sound exposure time on bending properties of doped epoxy resin was not enough investigated.

The main objective of this work was to study the bending behaviour of ultra-sonicated sodium and potassium dichromate doped epoxy resin. Three types of matrix compositions were analysed, namely epoxy resin, as well as epoxy resin enhanced with nitro-solvent and ultra-sonicated sodium and potassium dichromate composites.

2. Experimental

The epoxy system WWA-WWB from *Resoltech* had been used as matrix (Table 1). The decision regarding the use of the two salts: sodium and potassium dichromate, was imposed by their availability, their properties (with high emphasis on thermal and chemical properties), their flexible way of use and the novelty of their usage to form epoxy composites. Crystals of potassium dichromate and sodium dichromate were initially subjected to a process of mechanical grinding and then were dissolved in nitro-solvent. The obtained solutions were mixed in epoxy system.

The doping method can be found in detail in other works published before [12, 13].

The amounts of salts had been computed such as the doping levels to be of 1 alkaline ion at 5000, 400 and 100 bisfenol A molecules.

The ultra-sonication strategie consists on usage of ultra-sound processor UP100H equipped with MS3 sonotrode having 3mm diameter and acoustic power of 460W/cm^2 and using 5minutes ultra-sound exposure time and above mentioned concentrations of doping salts (fig. 1). 8 materials had been formed.

2 of them are considered as reference materials and they are: **Resin**-the epoxy resin, **RUD**-the resin with nitro-solvent and ultra-sonicated. **PU1, SU1** - ultra-sonicated 1 potassium ion respectively 1 sodium ion at 5000 bisfenol A molecules; **PU2, SU2 -** ultra-sonicated 1 potassium ion respectively 1 sodium ion at 400 bisfenol A molecules; **PU3, SU3** - ultra-sonicated 1 potassium ion respectively 1 sodium at 100 bisfenol A molecules; For each material five samples were formed (P1, P2, P3, P4 and P5).

Bending tests were conducted as recommended by ISO 178/2001. Test speed for all tests was set at 5 mm / min (fig.2). The tests were carried out on TESTOMETRIC M350-5AT machine.

Table 1 Resoltech system composition.

RESOLTECH WWA Resin	
components	content
C13/C15-alkygycidyleter	15%
Bisphenol-A-(epiclorhydrin)	70%
Formaldehyde	15%
RESOLTECH WWB4 Hardener	
components:	content
Propylidynetrimetanol	100%

Figure 1: *Ultrasonic Processor UP100H during epoxy treatment.*

Figure 2: *The bending specimen sample.*

3 Results and discusions

Figure 3 shows the force-displacement curve for epoxy resin. The displacement speed for all materials was 5 mm / min.

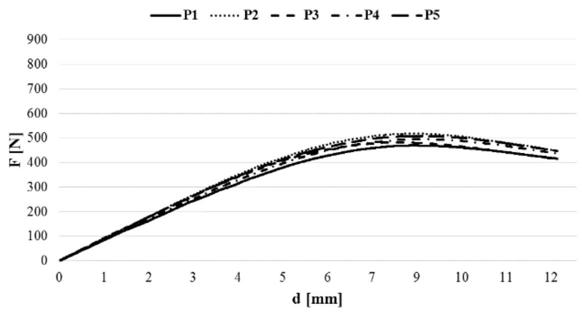

Figure 3: *Force-dispacement curve for epoxy Resin.*

Figure 4 shows the force-displacement curve for the resin with nitro-solvent and ultra-sonicated. This clearlyshows that the resin with nitro-solvent and ultra-sonicated material is softer than epoxy resin.

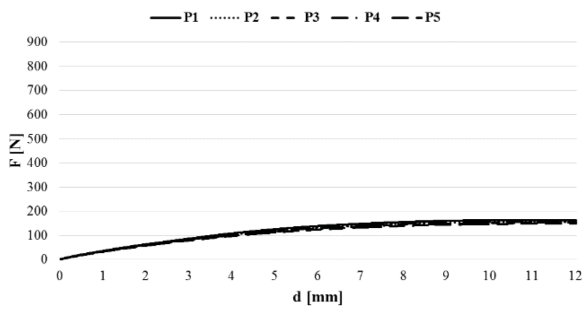

Figure 4*: Force-displacement curve for RUD*

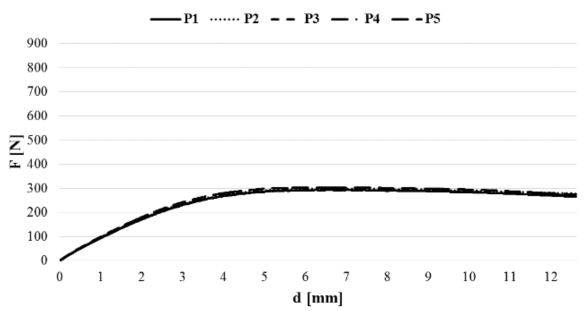

Figure 5: *Force-dispacement curve for PU1*

Figures 5, 6 and 7 shows the force-displacement curves for ultra-sonicated potassium dichromate for all concentrations. Material improvement (for PU2 and PU3) can be explained either by the interaction of chromate ion with organic components under the action of ultrasound or by a chromium ion dissociation with oxygen releasing. For PU2 and PU3, all specimens were broken, and therefore these materials seem to be the most rigid.

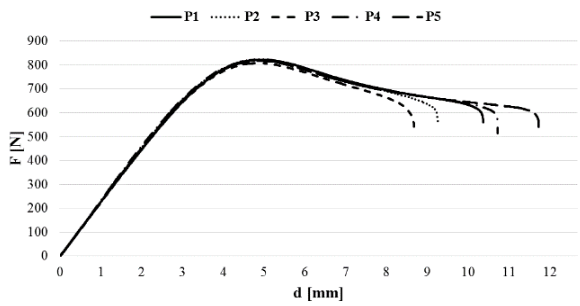

Figure 6: *Force-dispacement curve for PU2*

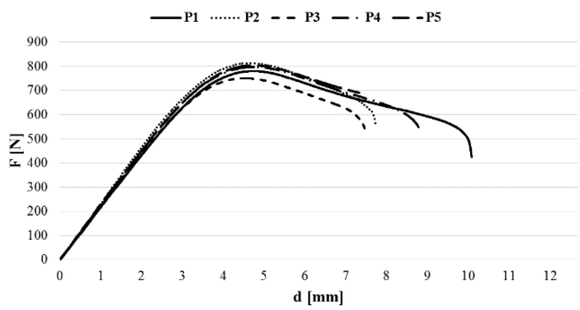

Figure 7: *Force-dispacement curve for* PU3

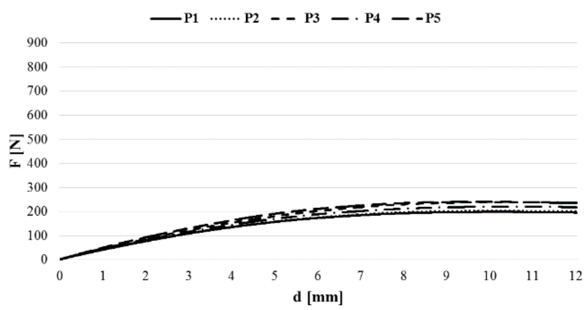

Figure 8: *Force-dispacement curve for* SU1

Regarding ultra-sonicated sodium dichromate materials, appear to be less rigid than those formed by potassium dichromate (fig.8, 9 and 10). At high concentrations, in terms of this study, material properties appear not to depend on the type of used salt. Increasing the salt concentration leads to the restoration of the general properties of the resin if it is considered that the addition of the nitro-solvent or pre-polymer mixture ultra-sonication lead to impairment of these properties.

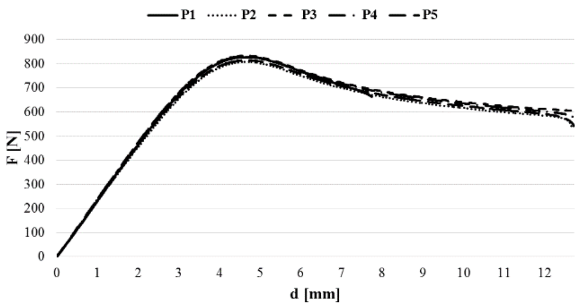

Figure 9: *Force-dispacement curve for* SU2

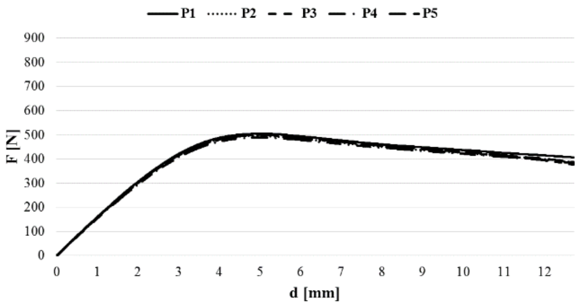

Figure 10: *Force-dispacement curve for* SU3

4 Conclusions

1. Bending experiments were performed with a machine from ”Dunărea de Jos” University of Galaţi.

2. Tested specimens were cut out from epoxy resin, the ultra-sonicated epoxy resin, ultra-sonicated 1 potassium ion respectively 1 sodium ion at 5000, 400 and 100 bisfenol A molecules.

3. Breaking phenomens for PU2 and PU3 materials show that this are very rigid materials (PU3 more rigid than PU2 material).

4. Good dispersion of and potassium dichromate into the matrix was achieved for all composite materials. Moreover, independently of the efficiency of particles dispersion, bending was not improved by the ultra-sonication.

5. The force-displacement curve for SU1 is similar to the PU1 composite material curve. This means that bending does not depend on used doping agent.

6. The bending loading increases for ultra-sonicated potassium dichromate compared to ultra-sonicated sodium dichromate.

7. Regarding ultra-sonicated sodium dichromate materials, appear to be less rigid than those formed by potassium dichromate.

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