SHAPE MEMORY PROPERTIES OF THE CHS-E520 AND CHS-E531 EPOXY RESINS WITH THE HARDENER P11

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1. Introduction

Shape memory epoxy resins are a group of shape memory polymers. Synthesis and properties of the shape memory epoxy resin E-51 with DDM curing agent are described in [1] and [2]. This is the motivation for the test of shape memory properties of the epoxy resins CHS-E520 and CHS-E531 with the hardener P11. Both resins are easily available at the market and can be used for the manufacturing of composite materials. The hardener P11 was chosen due to ease of its use.

2. Methods

All materials were used as supplied. The mixing ratios for the both resins were 100%, 80% and 60% of the amount of the hardener recommended by the producer. All materials were mixed and cured at room temperature. Bose Electroforce 3200 testing machine was used for the DMA. Glass transition temperature T_g of each material was determined as the peak of the loss modulus E''. Zwick/Roell Z050 testing machine with thermal chamber was used for tensile tests at 20° C and at 80° C (i.e. approx. 30° C above T_g).

3. Results

Results of the DMA are presented in Tab. 1 and in Fig. 1 – 4. Shape memory properties are summarized in Tab. 2. Young modules from tensile tests below and above T_g are compared in Tab. 3. The influence of the amount of hardener on stress-strain curves is shown in Fig. 5 and 6.

Composition	Weight mixing ratio	T_g [° C]
CHS-E520 + P11	100+11	58.7
CHS-E520 + P11	100+8.8	54.2
CHS-E520 + P11	100+6.6	41.4
CHS-E531 + P11	100+12	58.8
CHS-E531 + P11	100+9.6	50.7
CHS-E531 + P11	100+7.2	43.6

Tab. 1. Glass transition temperatures T_g determined form the peak of the loss module E''.

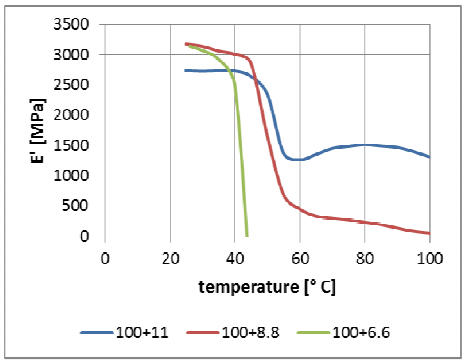

Fig. 1. Measured dependence of the storage modulus E' on temperature for the epoxy CHS-E520.

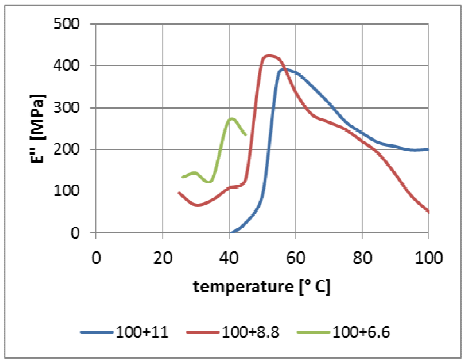

Fig. 2. Measured dependence of the loss modulus E'' on temperature for the epoxy CHS-E520.

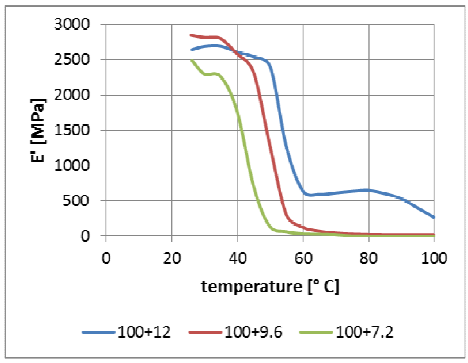

Fig. 3. Measured dependence of the storage modulus E' on temperature for the epoxy CHS-E531.

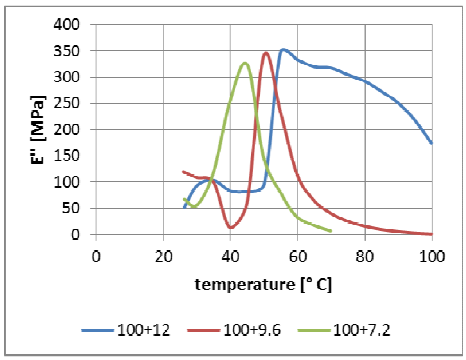

Fig. 4. Measured dependence of the loss modulus *E''* on temperature for the epoxy CHS-E531.

Composition	Weight mixing ratio	Shape retention ratio [%]	Shape recovery ratio [%]
CHS-E520+P11	100+11	99.6	93.8
CHS-E520+P11	100+8.8	99.9	96.5
CHS-E520+P11	100+6.6	98.9	0.023
CHS-E531+P11	100+12	99.6	99.8
CHS-E531+P11	100+9.6	99.9	99.9
CHS-E531+P11	100+7.2	99.6	99.9

Tab. 2. Shape memory properties.

Composition	Weight mixing ratio	E 20° C [MPa]	E 80° C [MPa]
CHS-E520+P11	100+11	3 333	1 980
CHS-E520+P11	100+8.8	3 450	31.25
CHS-E520+P11	100+6.6	3 549	2.93
CHS-E531+P11	100+12	3 157	1 078
CHS-E531+P11	100+9.6	3 479	14.3
CHS-E531+P11	100+7.2	3 456	8.33

Tab. 3. Young's modulus at 20° C and 80° C determined from the tensile test.

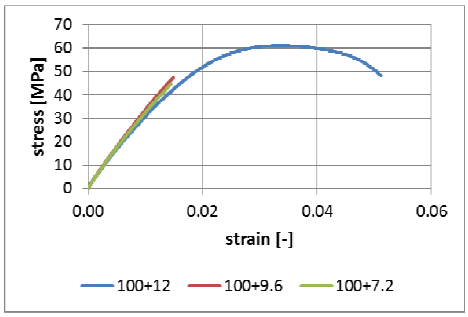

Fig. 7. Comparison of stress-strain curves of CHS-E531 at 20° C.

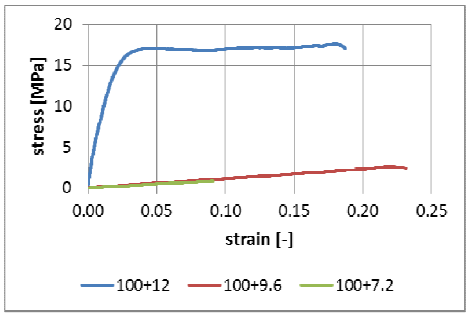

Fig. 8. Comparison of stress-strain curves of CHS-E531 at 80° C.

4. Remarks

- Both epoxy resins CHS-E520 and CHS-E531 shows shape memory properties.
- Composition influences both glass transition temperature and mechanic properties of cured epoxy resin. Stress-strain curve at 80° C shows clearly that this influence have to be taken into the account at shape memory epoxy systems.
- Epoxy resin CHS-E531 has better shape memory and mechanical properties and will be considered for the further investigation.

Acknowledgements

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References

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