ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

[1.] JIŘÍ BOBEK

INJECTION MOLDED BIODEGRADABLE POLYMER STUDY

Abstract:
This paper is next of the papers series which is biodegradable plastics properties considering. Concretely biopolymer HL103 was chosen for this series. Biologic degradation was realized in nature compost and acid and alkaline solution. Mechanical properties change was observed in dependence on time after production. Testing specimen production was realized by injection molding.

Keywords:
biodegradable, plastics, mechanical, tests

INTRODUCTION

The world most used plastics PE and PP biodegradability improving modification is searched due to their large produced volume. It is not easy to find right PE or PP modification which is acceptable with regard to ecologic site. Some PE and PP applications – concretely various packaging application is possible to substitute not with modified PE or PP but with entirely different materials – fully biodegradable plastics. Behavior knowledge of these materials is necessary to successful using these materials. Fully biodegradability of all material components is the basic advantage comparing to conventional petrolic polymers.

For this study was proposed experiment which should simulate concrete conditions of plastic parts using. Biodegradable polymer behavior during this conditions (which are described below) is observed in dependence to time after production.

Experiment is using for observation normalized testing specimens which were produced by normalized molds with injection molding on conventional molding machine – ENGEL VICTORY 80/25.

Observation is based on next mechanical properties tests:

- tensile test (ČSN EN ISO 527-1,2,
- flexural test (ČSN EN ISO 178),
- impact IZOD test (ČSN EN ISO 180),
- Shore D hardness test (ČSN EN ISO 868) [1][2][3][4]

and specimens (see fig. 1) surface analysis.

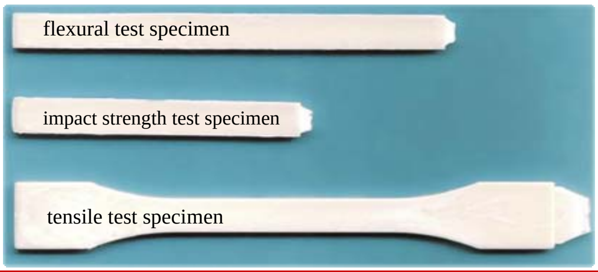

Fig. 1 Mechanical properties test specimens

Mechanical properties as same as surface appearance are observed 1st, 10th, 20th, 30th, 40th, 50th and 60th day after production.

Specimens (see fig. 1) are immediately after production placed to four another areas which should simulate real plastics using conditions. The first area is water solution with neutral pH (7±0,2), second area is water solution with acidic

pH (2±0,2) third area is water solution with alcalic pH (11±0,2) and fourth is area of natural compost with compost activator based on bacteria and enzyme combination (biocatalyst) improving biodegradation. pH of water solution was periodically measured with ACIDIMETR 333 and possible changes of pH was regulated that pH was constant during experiment in interval ±0,2 from nominal value.
Scheme of whole experiment is shown below:

SPECIMEN PRODUCTION → IMMEDIATELY PLACING SPECIMENS TO CHOSEN AREAS

→ after 1 day – mechanical properties tests, surface analysis
→ after 10 days - mechanical properties tests, surface analysis
→ …
→ after 60 days - mechanical properties tests, surface analysis

THE RESULTS

The flexural modulus made the biggest mechanical properties change as specimens were longer in each area. This is probably caused of high sensitivity of this mechanical property to property of skin part of specimen which is the first degraded part of the specimen. Fig. 2 shows flexural modulus dependence on time by each area specimen placement.

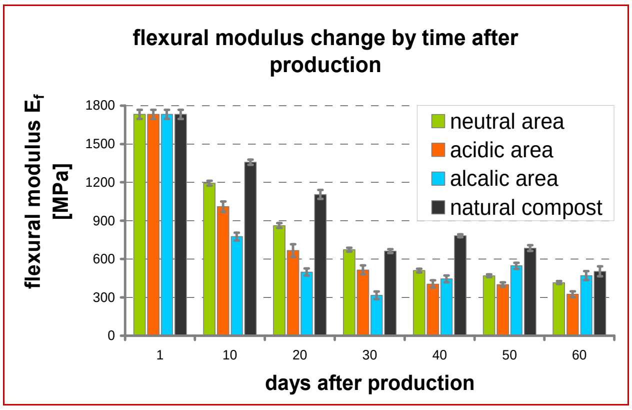

Fig. 2 Flexural modulus results

Same reason of flexural modulus change caused relatively high decrease of flexural strength as shown on fig. 3.
In the opposite of mentioned above, some mechanical properties did not make significant change. The first of them is tensile strength as is shown on fig. 4.

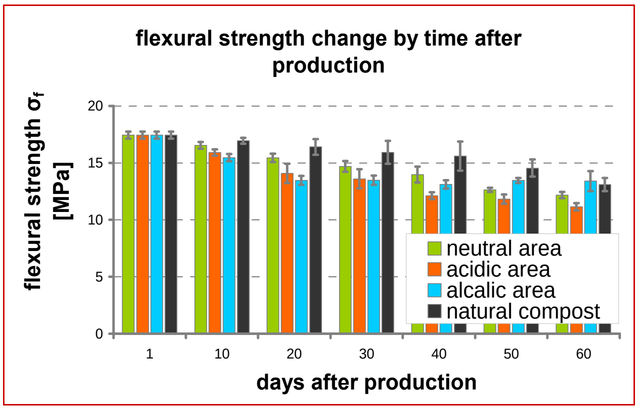

Fig. 3 Flexural strength results

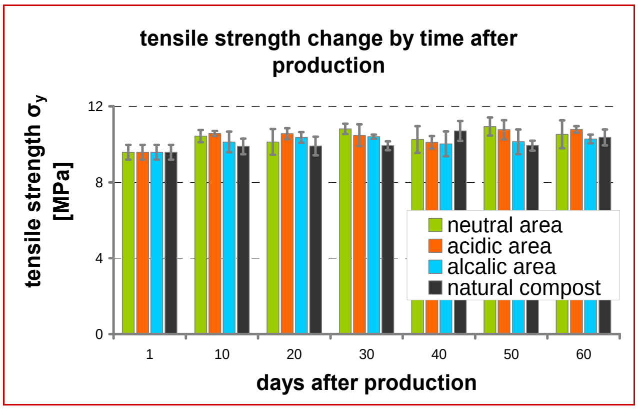

Fig. 4 Tensile strength results

Flexural strength values are virtually without some change regardless area, where is just specimen placed. Second property which is not sensitive to placement in biodegradable area (in chosen time interval) is SHORE D hardness. Is possible to say that changes in this case are in statistical deviation. See fig. 5. Light change was observed in case of IZOD impact strength. This dependence is shown on fig. 7.

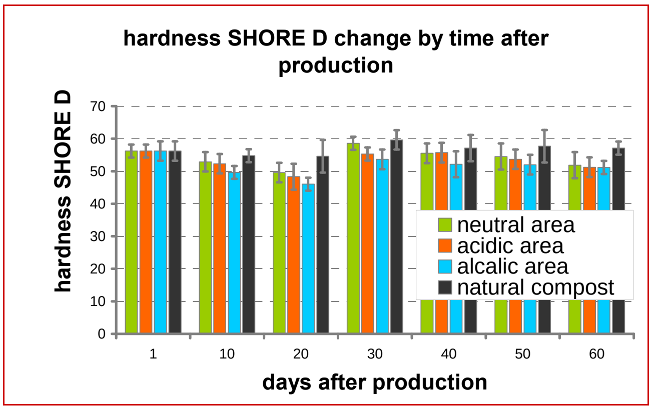

Fig. 5 Hardness SHORE D results

During whole experiment was also specimen surface analyzed. In case of water solution was observed same changes with increasing time after production in each area regardless water pH. These changes of surface are shown on fig. 7, fig. 8., fig 9 and fig. 10.

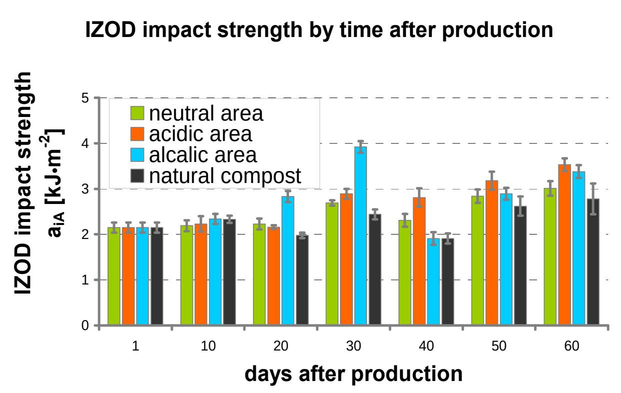

Fig. 6 Hardness SHORE D results

For better clearness were fig. 7 and fig 9. graphically exposed a color saturated. Result of this graphic changes sharpening is fig. 8 (based on fig. 7) and fig. 10 (based on fig. 9). Specimen surface placed in water solution (neutral/acidic/alcalic) is by time after production turning to light. Final surface after 60 days is absolutely white. This is caused by gradual starch separation. After 30 days period was also observed surface change to surface similar to chalk surface. Fig. 11 shows gradual specimen degradation in nature compost. Surface changes in this case are obvious.

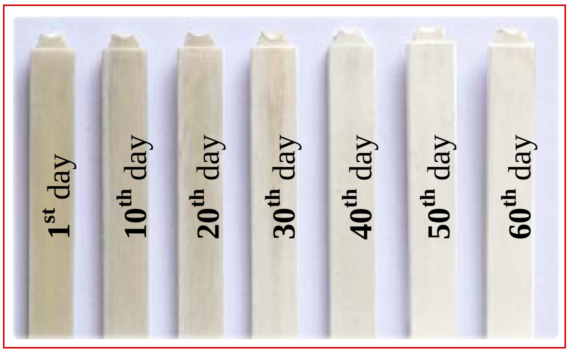

Fig. 7 Specimens biodegradation in ACIDIC/ALCALIC area.

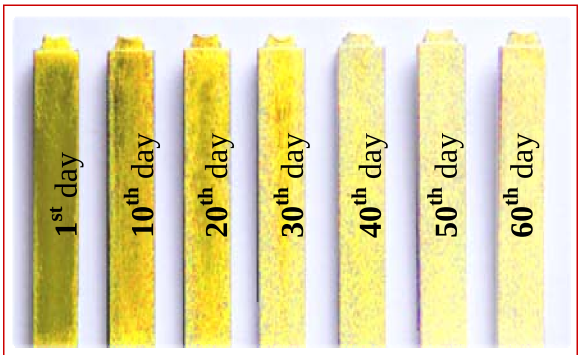

Fig. 8 Specimens biodegradation in ACIDIC/ALCALIC area – graphically exposed

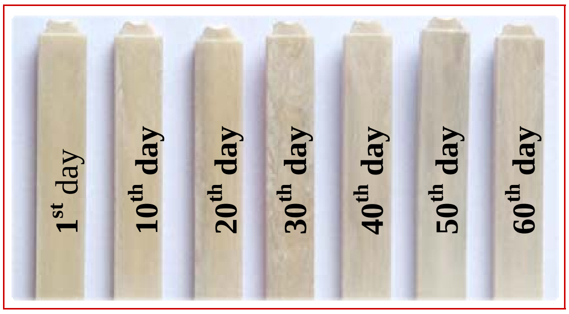

Fig. 9 Specimens biodegradation in NEUTRAL area

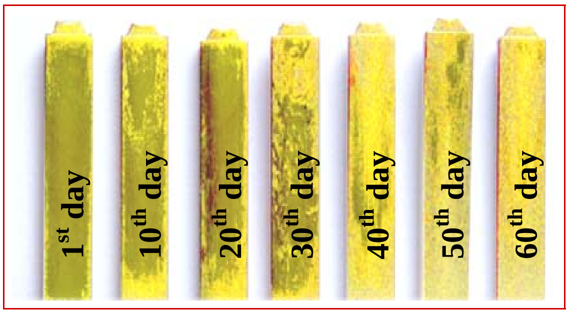

Fig. 10 Specimens biodegradation in NEUTRAL area - graphically exposed

Fig. 11 Specimens biodegradation in NATURE COMPOST

CONCLUSIONS

Getting knowledge of behavior biodegradable plastic PSM HL 103 in different areas is main goal of this paper. Just this knowledge is important to material selection during plastic part proposal or construction. Is obvious that exists plastic parts where is acceptable significant flexural modulus and flexural strength change without any significant change of tensile properties, hardness or light impact strength as same as probably exists parts, where this is not acceptable. Is necessary to remind, that mentioned dependences are valid for mentioned 60 days period after specimen / part production. Probable application of observed biodegradable material as same as of all fully biodegradable materials is application where is plastic part life cycle very short. As mentioned above it is the *most probably application in packaging field, where goods are using (are performing function) only for some days and after it is problem "WHAT WITH THEM"? This problem in case of PE and PP materials is very complicated and never could not be absolutely solved. Biodegradable plastics advantage in this case is obvious. Due to their comfortable (for unpretentious applications as packaging etc.) properties can perform plastic part function without any problem and after end of part life cycle (where conventional petrolic polymers becomes problem) is able to resolve to nature component without any "ecologic print". In next studies will be observated technological parameters influence to degradation behavior of the material HL-103. Because of relatively high price of this material, next studies will be also focused to price decreasing possibilities. The simplest way is to fill this basic material with another biodegradable material which is much cheaper than basic polymeric material. For example it could be wood powder. It is question, how can this filler affect mechanical properties and properties during biodegradation. Probably wood powder will decrease mechanical properties of specimen made of compound HL-103 and wood powder, but on other side will be decreased time of complete degradation. Rate of these influences is of course in volume percentage of added wood powder. And this is the question will be solved in next studies, where will be used various wood powder percentages in basic HL-103 and similar properties observated in this study will be observated for each compound.*

REFERENCES

[1] *ČSN EN ISO 527-1,2 (640604). Plasty – Stanovení tahových vlastností. Praha: ČNI Praha, 2003.*

[2] *ČS N EN ISO 178 (640607). Plasty – Stanoveni ohybových vlastností. Praha: ČNI Praha, 2003.*

[3] *ČSN EN ISO 180 (640604). Plasty – Stanovení rázové houževnatosti metodou Izod. Praha: ČNI Praha, 2001.*

[4] *ČSN EN ISO 868 (640624). Plasty a ebonit – Stanovení tvrdosti vtlačováním hrotu tvrdoměru (tvrdost Shore). Praha: ČNI Praha, 2003*

AUTHOR & AFFILIATION

[1.] *JIŘÍ BOBEK*

[1.] *KATEDRA STROJÍRENSKÉ TECHNOLOGIE, ODDĚLENÍ TVÁŘENÍ KOVŮ A PLASTŮ, TECHNICKÁ UNIVERZITA V LIBERCI, CZECH REPUBLIC*

ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

ISSN: 2067-3809 [CD-Rom, online]