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Microindentation Assessment of Climatic Loading Impacts on Polymer Sealants

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Abstract: Sun light, especially the short-wave ultra-violet part of the sun spectrum, together with influence of moisture, are the most enlarged and the most effective sources of climatic damage of polymers. The effects of the both influences became stronger with enhanced temperature. Sun light on the one hand supports the forming of transverse chemical bonds between macromolecules and on the other hand results in their breakdown. This causes a strengthening or softening of polymers. The amount of changes and the dominant process depends on the radiation dose and on the influencing wave length. Every kind of chemical bond has its own critical wave length, which, with sufficient amount of energy, brings a reaction. Ageing, as a result of climatic loading, is therefore very closely connected with a structure of a real material.

Microindentation is one of possible methods for assessing influences of a climatic loading on mechanical properties of polymers. Indentation test is checked by the history either of a power or an indent depth. The information about the hardness, Young modulus and viscoelastic properties of the investigated material can be received afterwards from measured data. The investigated materials were tested in their native standard form and also after four model types of physical-chemical ageing. Time-dependent properties of the sealants were assessed by the method of indentation creep. One hundred indentation creep tests were conducted for each sealant and type of ageing. A motivation for this work was a requirement to assess an influence of a climatic loading on the basic mechanical properties of sealants, used for a creation and a repair of mosaics.

Investigated materials

A group of six polymer sealants was selected for measurements. Their commercial names, production plants, compositions and their short marks for distinguishing are given in Table 1.

Tab. 1: Investigated materials

Commercial name of the sealant	Production plant	Composition	Mark of the sealant
Akryl Exterier	Den Braven	One-component sealant on the basis of acrylate dispersion	A
Mapeflex AC4	Mapei	One-component acrylate sealant in water dispersion	B
Mapeflex MS45	Mapei	One-component quickly hardening elastic thixotropic sealant on the basis of hybrid silan polymer	C
Multisil	Remmers	Silicone- caoutchouc sealant	D
MS 150	Remmers	Elastic sealant on the basis of hybrid polymers	E
MultiSil NUW	Remmers	Silicone- caoutchouc sealant	F

The investigated materials were tested in their native standard form (STAND) and also after several model types of physical-chemical ageing:

a) after one month placement in the conditions of enhanced temperature, moisture influence and ultra violet radiation (UV)
b) after three month placement in the temperature 60 °C (60)
c) after three month placement in the temperature 60 °C with the relative humidity 80 % (60M80)
d) after one month cycle of 2 hours soaking in water with subsequent freezing (VM).

Methods of measurements and results

The system Hysitron TI 750D TriboIndeter™, equipped by the Berkovich indenter, was used for testing. The basic mechanical characteristics were measured using quasi-static mode Basic QS Trapezoid. Its output represent reduced Young modulus and hardness. Indentation creep is defined by the history of loading $P(t')=P_o*H(t')$, where $H(t')$ represents the Heaviside function. The equation for viscoelastic compliance $D(t)$ has a form dependent on the history of the indent depth $h(t)$.

$$D(t) = 2\, h^2(t) / [\pi(1-\nu^2)\, P_c \tan \alpha] \quad (1)$$

ν is the Poisson´s coefficient, α is the effective angle of the Berkovich indenter. The average viscoelastic compliance values of the sealant with the smallest influence of the climatic loading on the investigated mechanical characteristics are presented in Fig. 1.

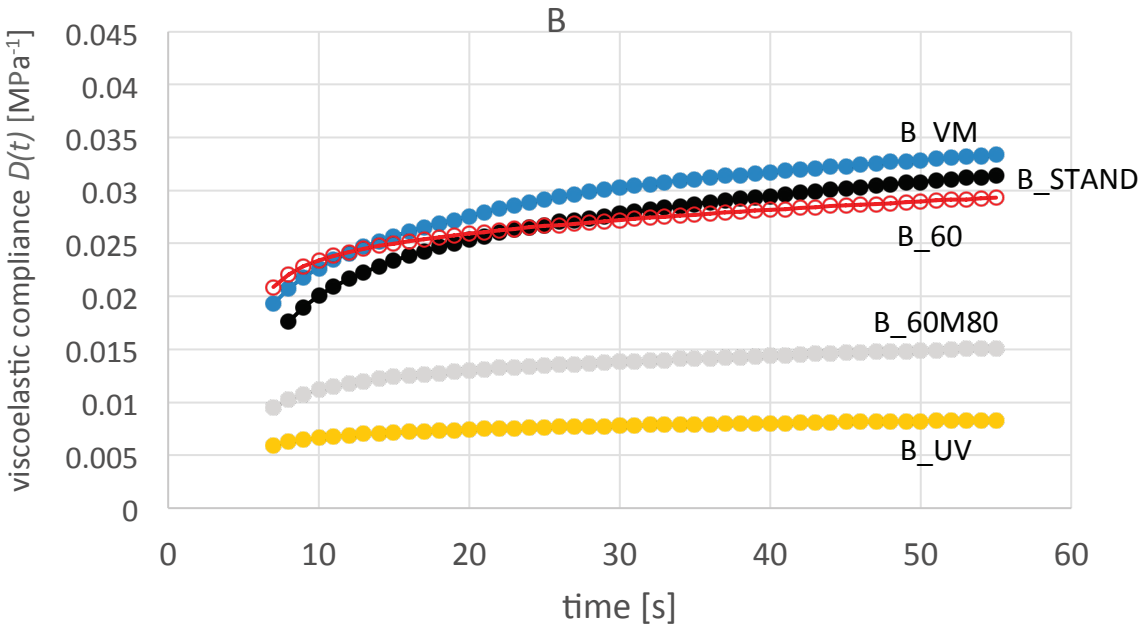

Fig 1: Viscoelastic compliances of the B sealant

Conclusion

Present results have confirmed microndentation technique to be a suitable methodology to assess changes of basic mechanical properties of sealants caused by photo-degradation processes and climatic influences.

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