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Self-healing polymers - an innovative solution extending the service live of protective gloves

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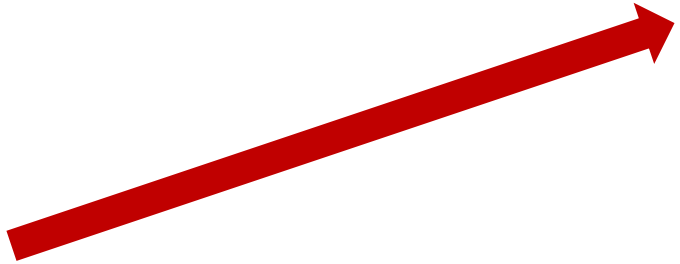
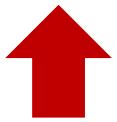
SELF-HEALING POLYMERS

artificial or synthetically-created material that is capable of repairing itself back to the original state.

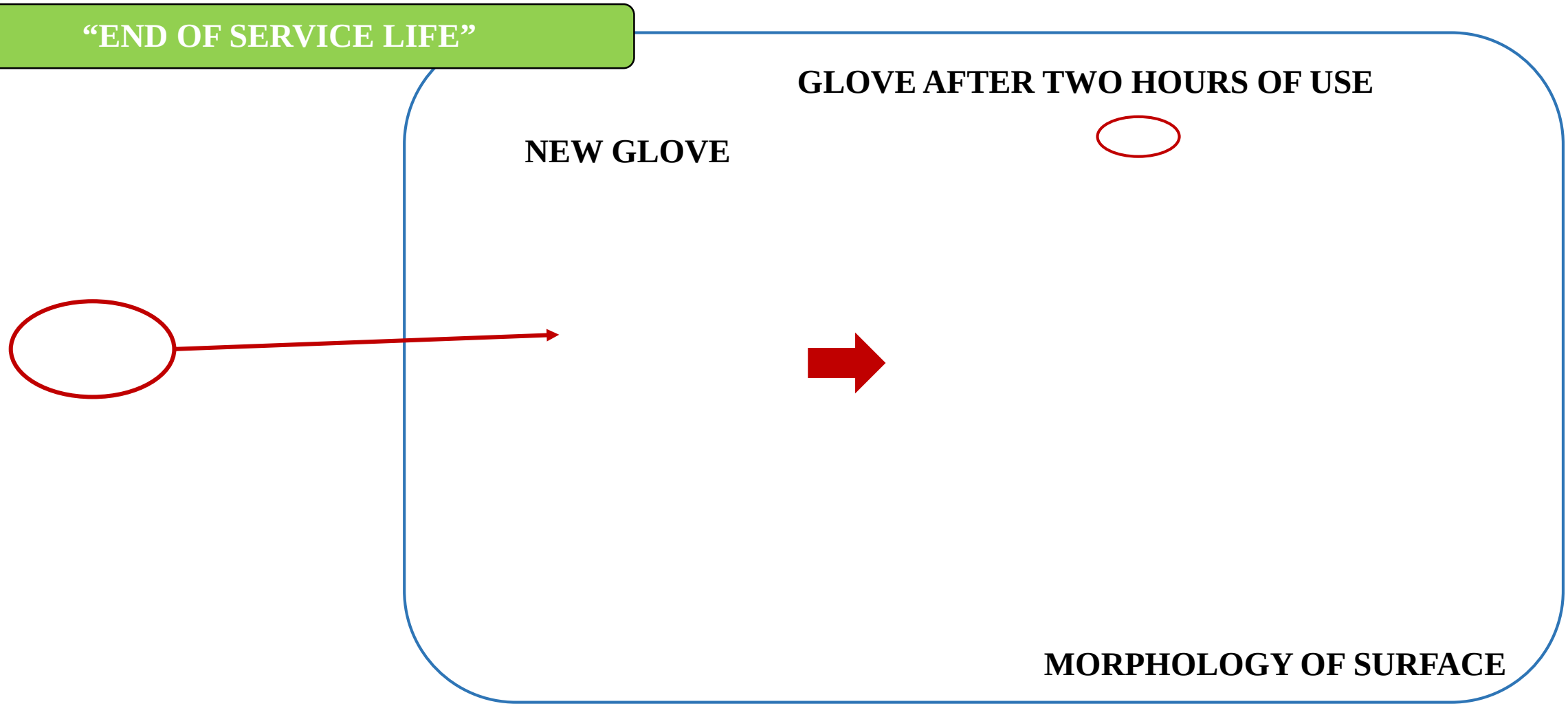


State of the art

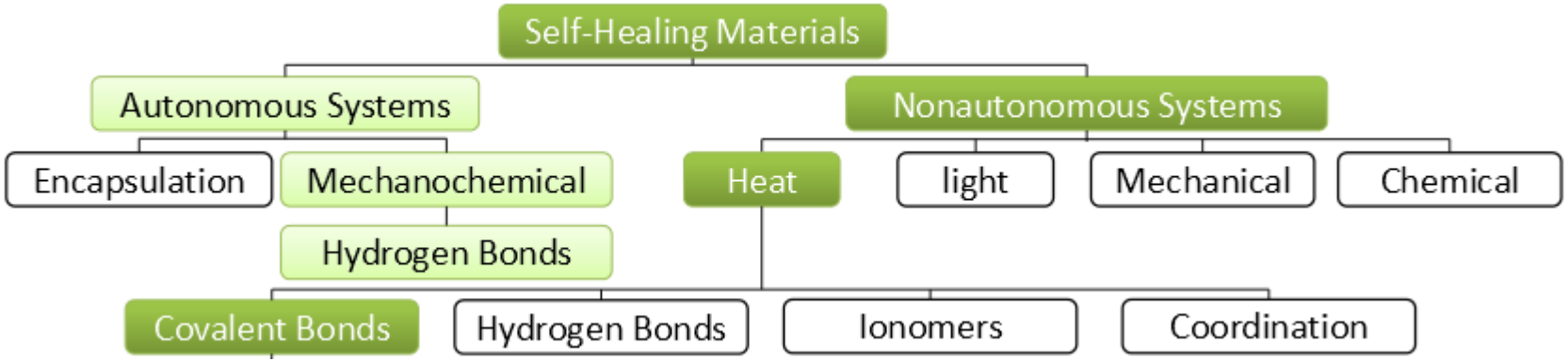


Application of self-healing polymers in personal protective equipment in the work environment

“END OF SERVICE LIFE”



MECHANISM OF SELF HEALING



CHOOSING THE HEALING SYSTEMS

Extrinsic healing systems, e.g.:

Micro-encapsulation of healing agent

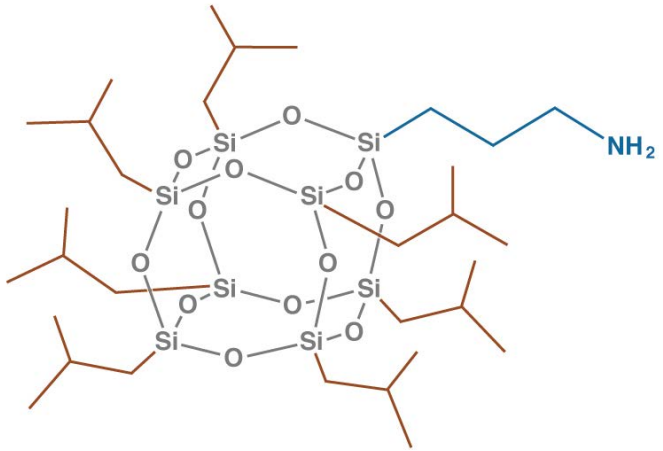
Micro vascular network

Intrinsic healing systems, e.g.:

Intrinsic mechanism -reversible bonding

SELECTED SELF-HEALING POLYMER MATERIALS

Aminopropyl (isobutyl) -POSS (AP-POSS) is a hybrid molecule with an inorganic silsesquioxane at the core, organic isobutyl groups attached to seven corners of the cage and an aminopropyl group attached to the eighth.



The methylvinylsilicone rubber containing 0.07 % of vinyl groups cross-linked with dicumyl peroxide (DCP) and the filler was fumed silica Aerosil 380 with containing 5 parts by weight AP-POSS.

*The detailed information of the elastomer composition has been described in the patent number **PL 218804 (B1**) (Zaborski M.; Strąkowska A., Kosmalska A., Lodz University of Technology, Institute of Polymer and Dye Technology).*

EXPERIMENTAL

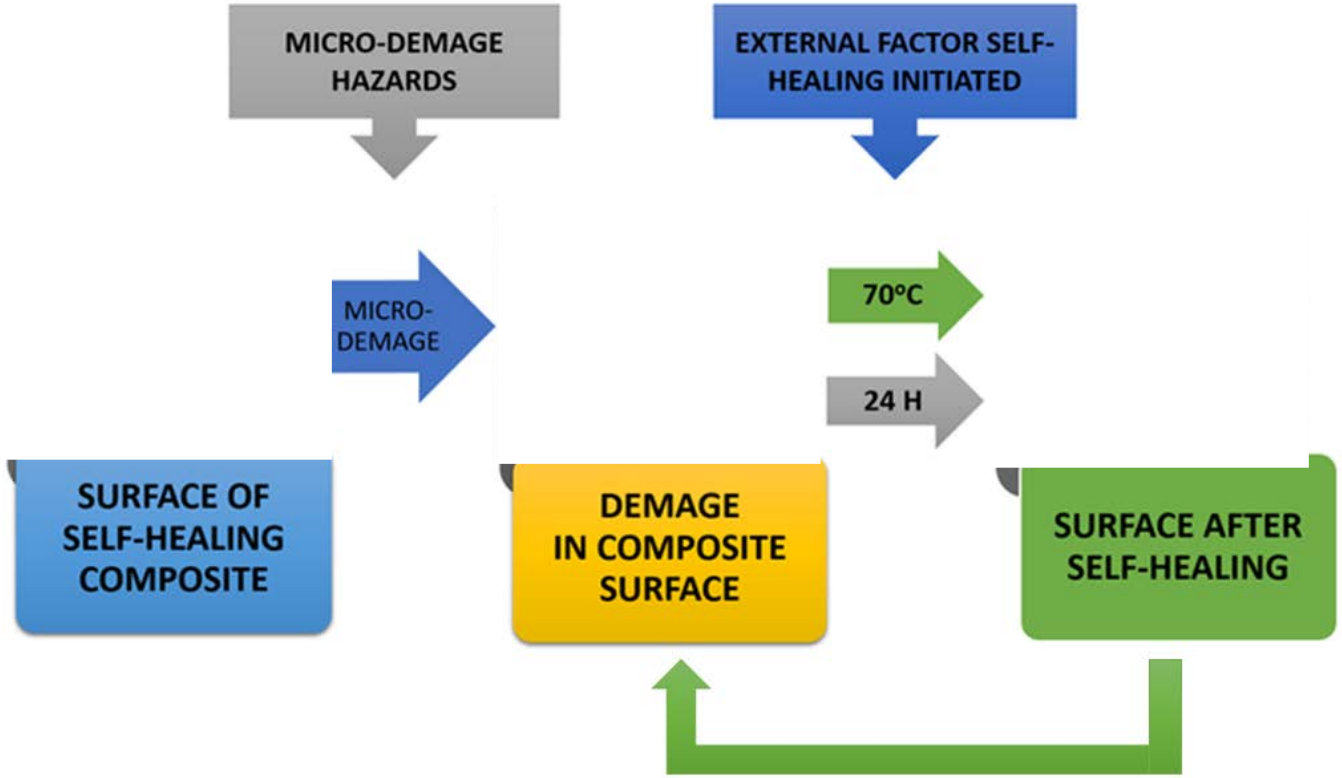
***Simulation of micro-damage*:**

- Puncture

- Cut

- Abrasion

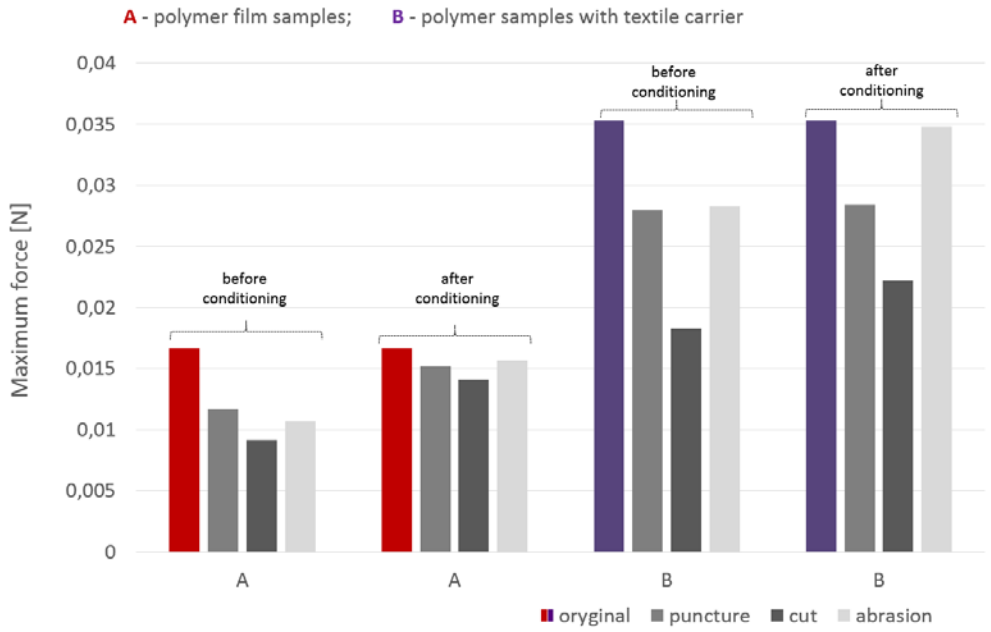
Parameters of the self-healing process



RESULTS - EFFICIENCY OF SELF-HEALING

	PUNCTURE	CUT	ABRASION
Surface morphology of **subjected to simulated micro-damage**.			
Surface morphology of subjected to simulated micro-damage **after the self-repair process.**			

SELF-HEALING POLYMER – resistance to mechanical damage



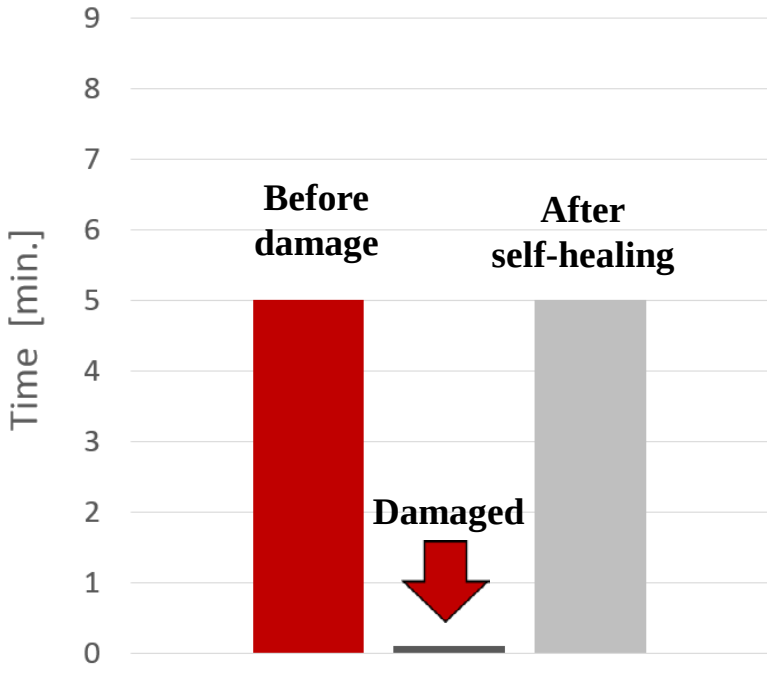
Mechanical properties		Results	Performance level
Resistance to puncture	Against damage	29	1
	after the self-repair process	30	1
Resistance to abrasion	Against damage	2000	3
	after the self-repair process	2200	3

Conditioning of damaged samples resulted in the increase of the maximum force value at breakage which indicates that the process of self-healing and regeneration of damaged bonds occurred (due to the increased mobility of damaged chains caused by increased temperature).

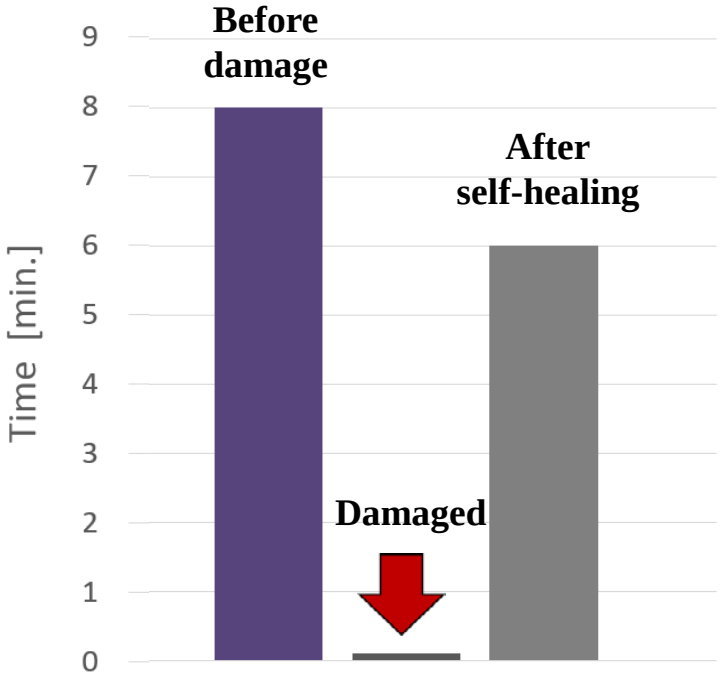
CONCLUSION:

Damaged chains were able to reconnect and increase the density of the network, which resulted in the recovery of mechanical parameters close to the initial parameters.

SELF-HEALING POLYMER - permeation of chemical substances.



Polymer film sample



Polymer sample with textile carrier

Gloves protecting against chemical substances should meet the requirements of PN-EN 374-1: 2017-01

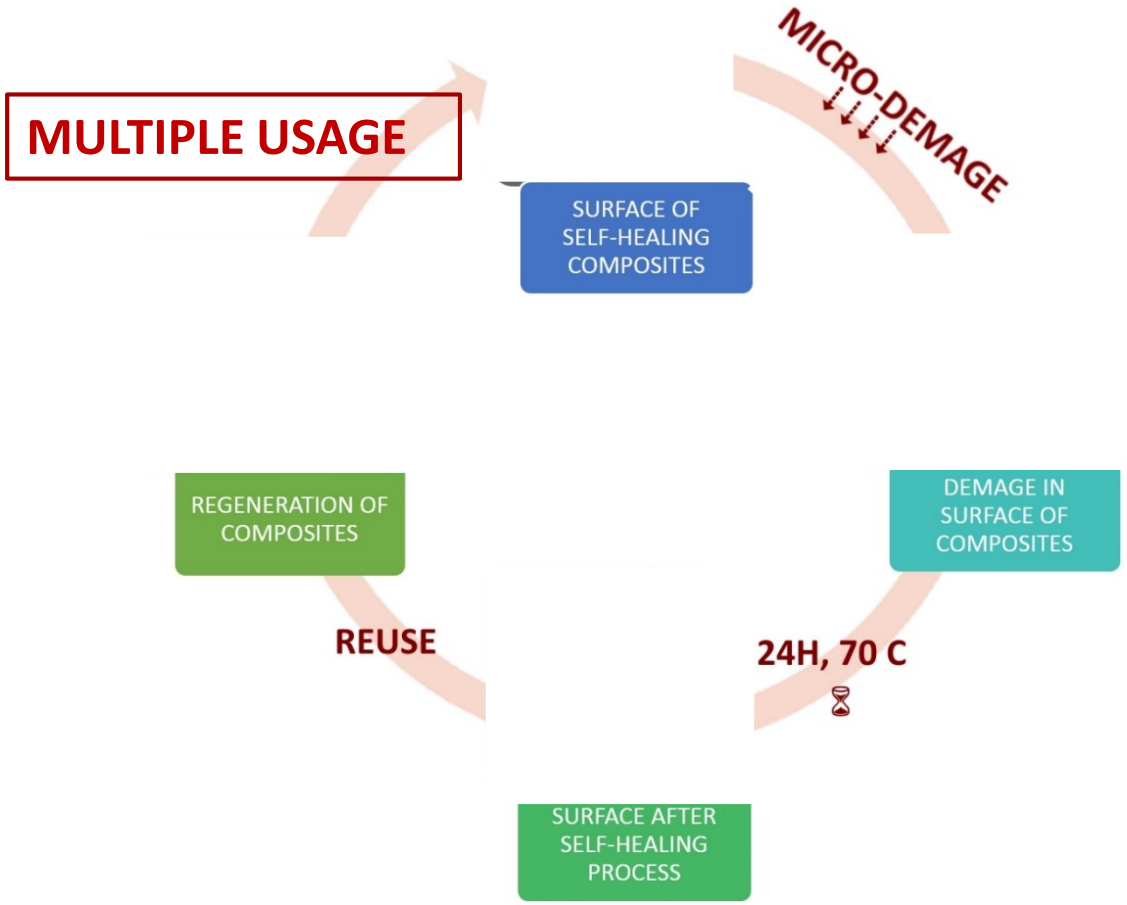
The assessment of resistance to penetration of chemical substances was carried out for samples:

- before damage,
- damaged
- subjected to the process of self-healing (24 hours at 70°C).

CONCLUSION:

- damaged samples **did not provide any protection against selected solvent.** The breakthrough occurred immediately after the contact of the polymer with isopropanol,
- permeation times for samples subjected to the process of self-repair returned to the initial values.

"END OF SERVICE LIFE" CYCLE OF THE SELF-HEALING POLYMER



For what? For whom?

The interest in the subject of self-healing polymers in protective materials is related to **ensuring better work safety during their use as well as extending their service life**.

This is of great importance not only in **economic terms, but also ecological**, as it translates into a reduction of polymer waste.

CONCLUSIONS

- Gloves protecting against chemical substances should meet the requirements of **PN-EN 374-1:2017-01**, which relate to minimum resistance to permeation of chemical liquid substances.

- In this standard, resistance to permeation of a liquid chemical substance is determined by the level of performance: that is, a number defining a specific category or degree of performance according to which the test results can be classified. Permeation itself is the process of chemical agent passing through the material of the protective glove at the molecular level (absorption of molecules of chemicals, their diffusion and desorption on the other side of the glove)

CONCLUSIONS

- On the basis of preliminary results of self-healing polymer materials used to improve safety in the work environment, it is reasonable to undertake efforts to develop new test procedures, different from those previously used and described in normative documents.

- In the proposed test procedure, it is recommended to take into account the problem related to:
  - developing a method of repeatability of simulation of material damage,
  - assessment of liquid chemicals penetration before and after the self-healing process,
  - as well as the assessment of multiple self-healing process possibility.

- All of this involves the inclusion of additional methods in the assessment of protective parameters, other than those included in the standard on the resistance of protective gloves to permeation of chemicals.

Acknowledgements

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