Self-healing systems in polymeric materials of protective gloves and footwear

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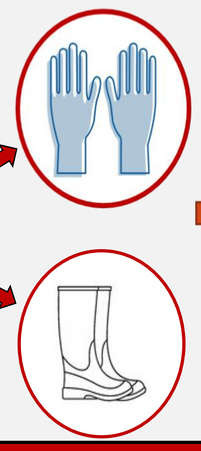
INTRODUCTION

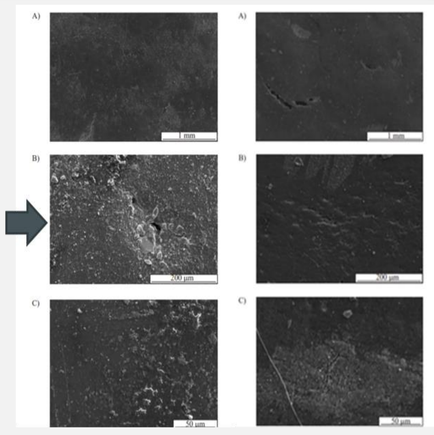
New solutions in the field of materials engineering now allow the production of innovative polymer materials with the ability to self-repair and the application of these solutions to Personal Protective Equipment (PPE) used in the work environment, e.g. polymer elements used for the soles of protective footwear and protective gloves to increase its the end of service life and improve its safety performance in the workplace. Some mechanical defects naturally occur in the structure of PPE in the course of its normal use. While initially those defects are often not visible and difficult to detect, they may compromise polymeric materials and over time lead to permanent damage and the end of service life.

Mechanical factors during use

Degradation of materials during use



MICRODAMAGES

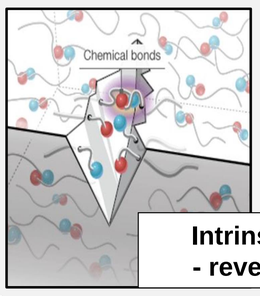


BASIC ASSUMPTIONS

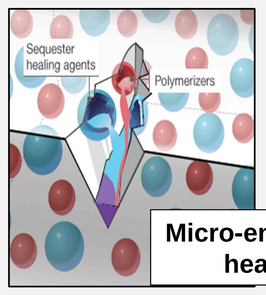
In the literature, there is a division of polymer composites with the ability to self-repair due to the method of its initiation defined by the chemical structure and the self-healing mechanism: autonomous self-healing materials (AMS), where the self-healing mechanism starts automatically in response to damage/fracture in the material and non-automatic self-healing materials (NMS) requiring an external stimulus, e.g. temperature, pressure [1-3].

SELF-HEALING SYSTEMS

Intrinsic self-healing systems (AMS)

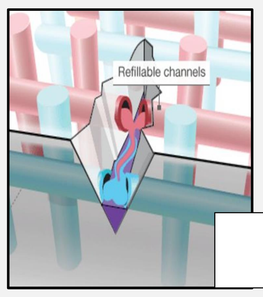


Intrinsic mechanism - reversible bonding



Micro-encapsulation of healing agent

Extrinsic self-healing systems (NMS)



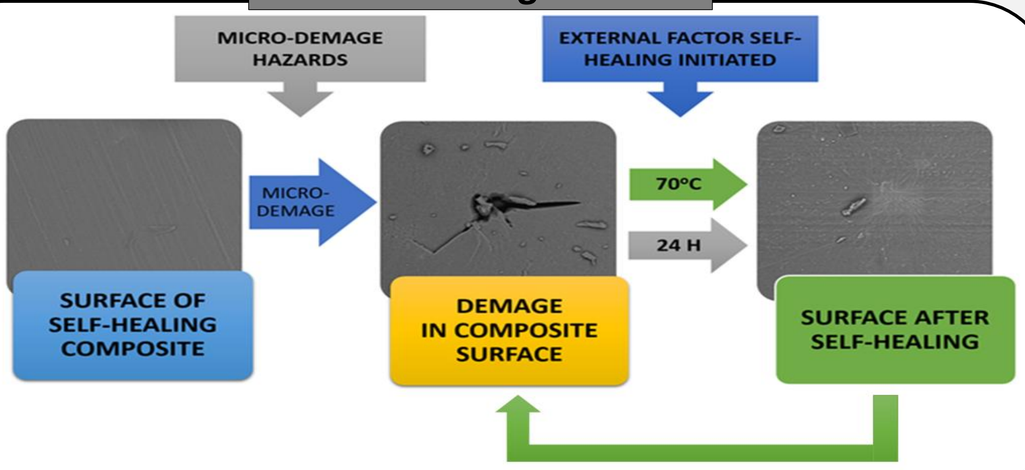
Micro vascular network

In terms of PPE:

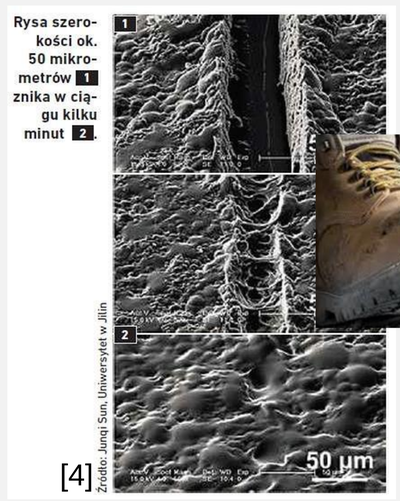
- The material must be self-healing throughout its the end of service life
- The polymer should maintain high resistance to external factors
- The price of the product and its use should be as low as possible

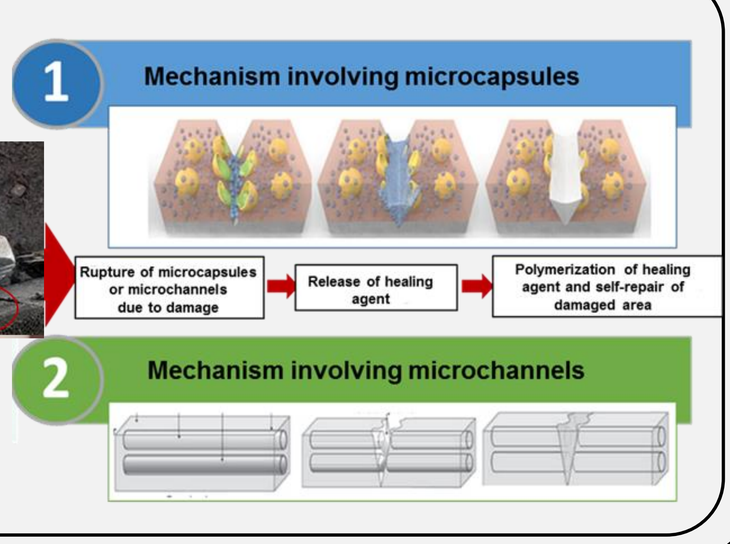
CONCEPTS OF SELF-HEALING SYSYEMS IN PPE

Protective gloves



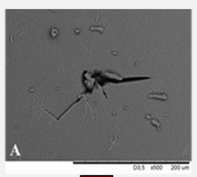
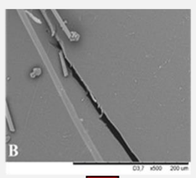
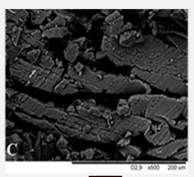
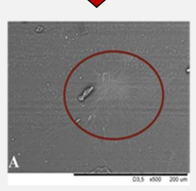
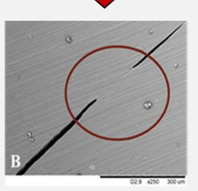
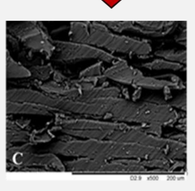
Protective footwear

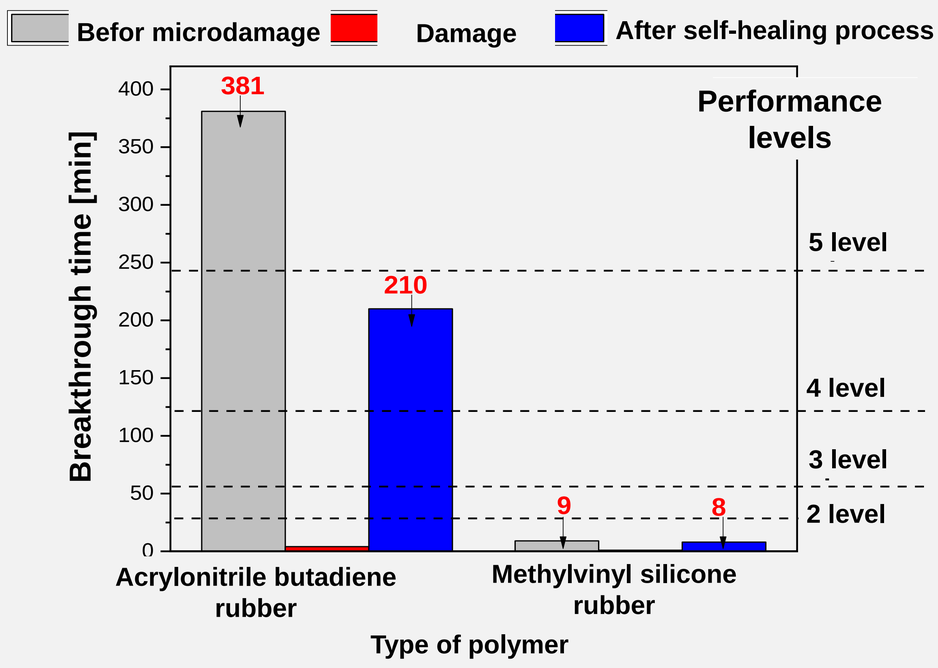




PRELIMINARY TEST RESULTS FOR SELF-HEALING GLOVES

Selected symulation of microdamage in all-ruber protective gloves.

	PUNCTURE	CUT	ABRASION
Surface morphology of elastomeric composites with self-healing properties **subjected to simulated micro-damage**.			
Surface morphology of elastomer composites with self-healing properties subjected to simulated micro-damage **after the self-repair process.**			



CONCLUSIONS

Self-healing materials can be used to make protective gloves and footwear. Preliminary research was conducted for gloves made of methylvinylsilicone rubber containing hybrid molecules with an inorganic silsesquioxane in the protective gloves then simulated with microdamage. The protective properties were confirmed by analysis of permeation resistance and assessment of the surface morphology before and after self-healing process. [5] The obtained results confirm the possibility of using tested elastomeric composite in the construction of protective gloves and showed an effectivity of the self-healing process. There were also promising preliminary results for footwear made of polyurethanes with self-healing properties.

Acknowledgements

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References:

[1] B.J. Blaiszik, S.L.B. Kramer, S.C. Olugebefola, J.S. Moore, N.R. Sottos, S.R. White, “Self-Healing Polymers and Composites”, Annual Review of Materials Research, 40, 179-211, 2010

[2] H. Tan-Phat, S. Prashant, H. Hossam, “Advanced Materials for Use in Soft Self-Healing Device”, Advanced Materials, 29, 1604973, 2017

[3] A. Adamus-Włodarczyk, A. Bacciarelli-Ulacha, E. Irzmańska, A. Strąkowska, M. Masłowski, „Evaluation of the Elastomeric Composite Self-repair Process for the Construction of Protective Gloves”, Fibres & Textiles in Eastern Europe, 4, 104-110, 2018

[4] B.J. Blaiszika, M.M.Carusob, D.A. McIlroyc, J.S. Moorebce, S.R. Whitede, N.R.Sottos “Microcapsules filled with reactive solutions for self-healing materials”, Polymer, 50 (4), 990-997, 2009

[5] A. Adamus-Włodarczyk, E. Irzmańska “Assessment of the chemical resistance of a polymer with self-healing properties for use in protective gloves – case study”, Polimery, 6, 458-467, 2020