Functional development materials of polymer protective gloves: a biomimetic perspective

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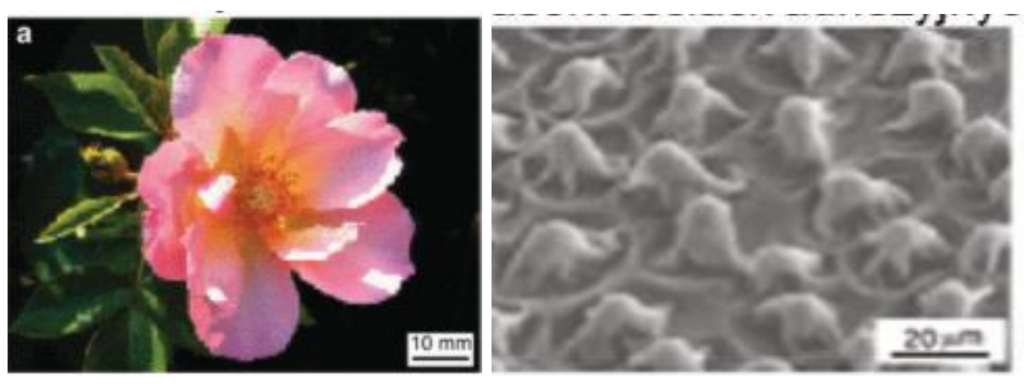
INTRODUCTION

Over the past years, the dynamic development of polymeric materials has fueled efforts to design new application solutions in personal protective equipment (PPE) [1]. In turn, the emergence of new hazards in the workplace and the necessity to better adapt PPE to the individual needs of users has motivated research focused on the implementation of innovative technologies and materials in that respect [2].

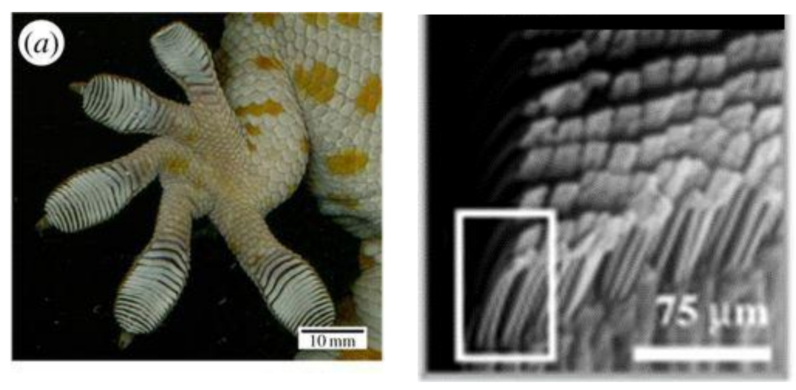
Of particular importance are the hydrophobic properties and adhesive properties of surfaces polymeric, protective gloves

Superhydrophobic properties inspired by rose petals



The hydrophobic properties of protective materials are particularly relevant for safety, as they decrease the risk of the accumulation of chemical and biological contaminants on the glove surface, preventing the hazards associated with the presence of noxious substances in the palmar region and alleviating impairments to hand dexterity.

Adhesive properties inspired by gecko's paw



Including reversible adhesion is important from the point of holding, carrying items to prevent them from falling out uncontrolled and out of the hand. .

MATERIALS

Commercially available polymeric protective gloves made of latex, natural latex, a mixture of natural latex with 2-chlorobuta-1,3-diene, nitrile butadiene rubber, butyl rubber, polyvinyl chloride, and 2-chlorobuta-1,3-dienewith various surfaces were selected for the tests.

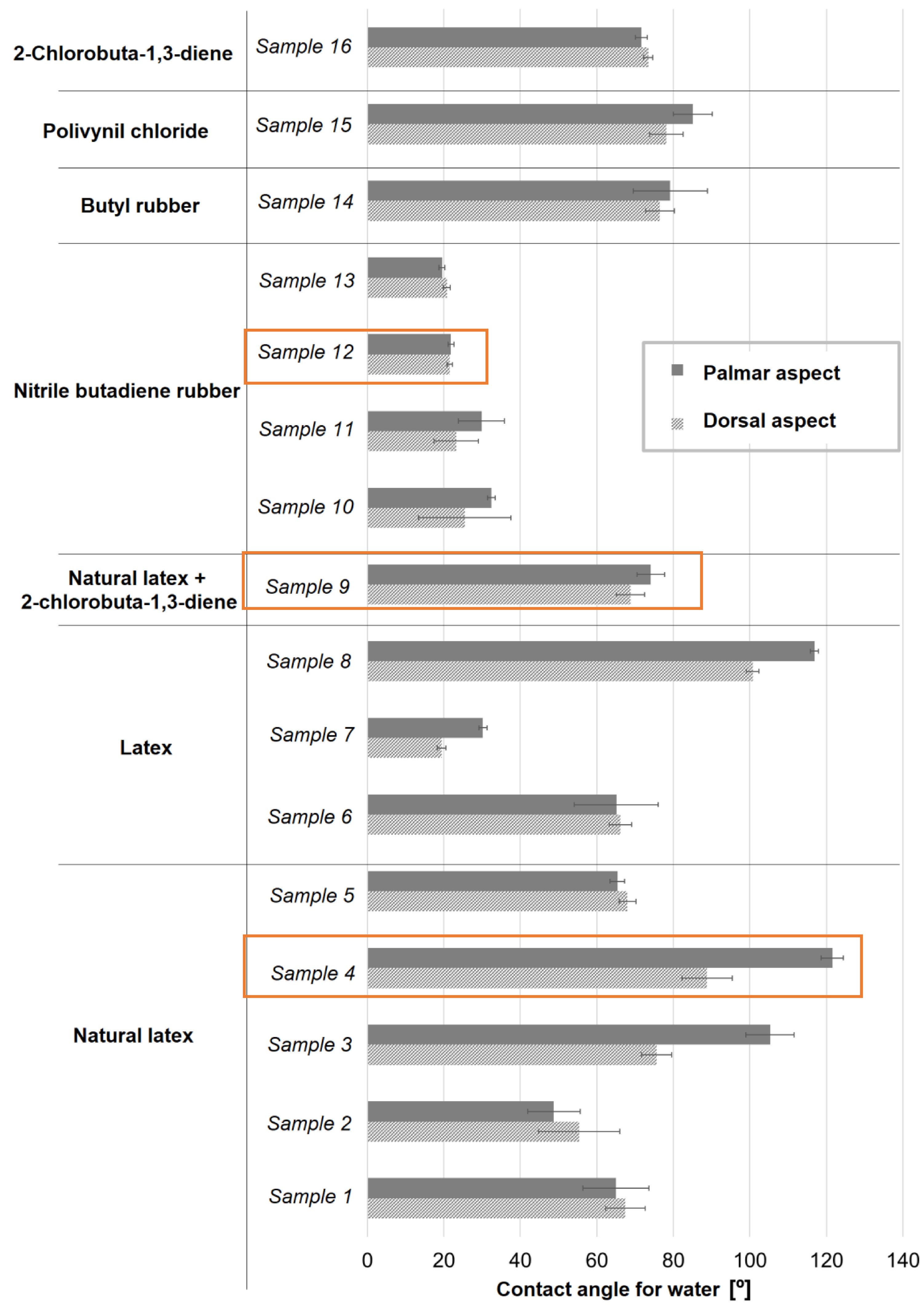
Material	Sample no., commercial name, manufacturer	Thickness [mm]	Palmar surface
Natural latex	Sample 1 (CHEM PROTEC 3250, NITRAS)	0.92 ± 0.01	
	Sample 2 (CPMBI LATEX, KCL)	0.96 ± 0.05	
	Sample 3 (LUDWIK, LARKIS)	1.09 ± 0.03	
	Sample 4 (CAMATEX 4517, KCL)	1.70 ± 0.08	
	Sample 5 (CAMAPREN 720, KCL)	0.73 ± 0.02	
Latex	Sample 6 (535 Jet Orange, POLYCO)	1.20 ± 0.01	
	Sample 7 (YETI GERIN)	1.06 ± 0.03	
	Sample 8 (3560 Soft Grip, NITRAS)	1.37 ± 0.04	
Natural latex + 2-chlorobuta-1,3-diene	Sample 9 (CAMA PREN 722, KCL)	0.74 ± 0.01	
Nitrile butadiene rubber	Sample 10 (743 Dermatril, KCL)	0.20 ± 0.01	
	Sample 11 (TEVUCHEM, KCL)	1.27 ± 0.04	
	Sample 12 (CAMATRIL 730, KCL)	0.46 ± 0.01	
	Sample 13 (3550, NITRAS)	1.32 ± 0.04	
Butyl rubber	Sample 14 (BUTOJECT 897, KCL)	0.67 ± 0.02	
Polyvinyl chloride	Sample 15 (CAMA ISO 6970. KCL)	1.54 ± 0.02	
2-Chlorobuta-1,3-diene	Sample 16 (3460, NITRAS)	0.78 ± 0.02	

METHODS

Analysis of the **surface wettability** of commercial protective gloves was performed using the drop-embedded method. The contact angle measurements were made on a Phoenix-Alpha apparatus from SEO (USA). An important element of the study was determination of **surface free energy** and **work of adhesion**. The values of the polar and dispersive components of the surface free energy of polymers and the values of the adhesion work (W_p - work of adhesion for a polar liquid, W_d - work of adhesion for a non-polar liquid, W_a - total work of adhesion) were calculated.

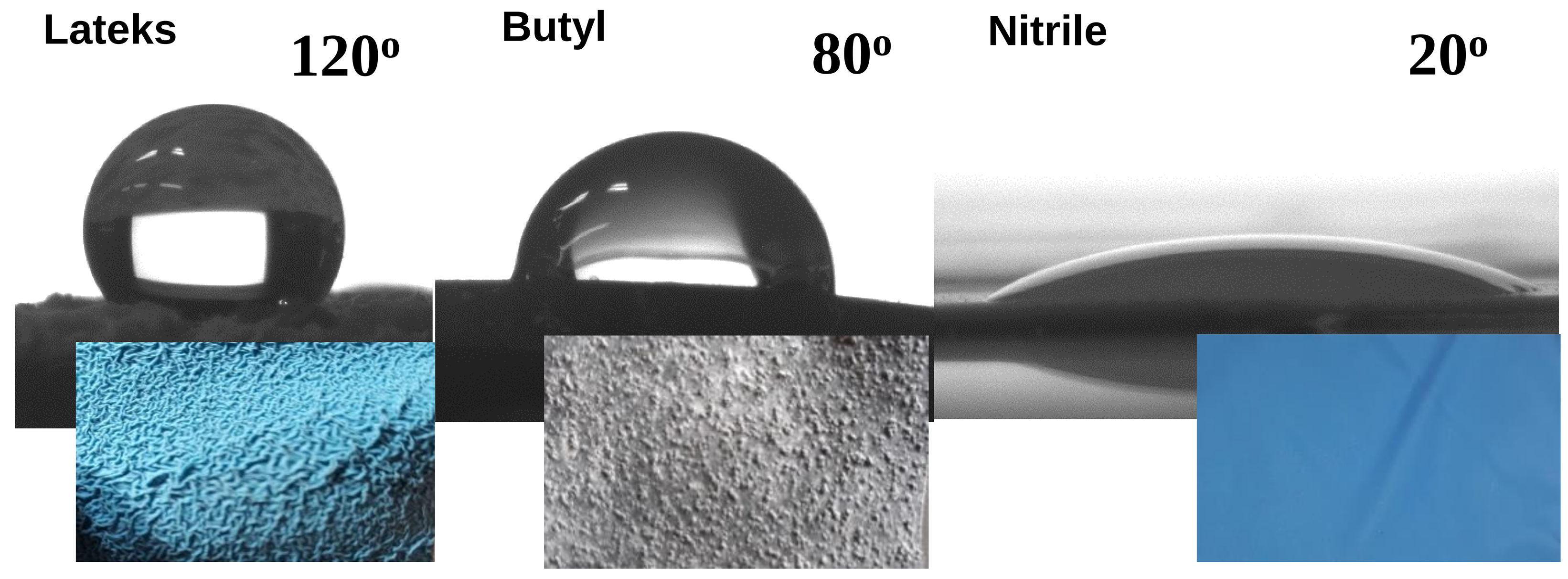
RESULTS

Water contact angle on the palm and dorsal surface of selected materials of protective gloves



RESULTS

The selected angle of contact with water of the protective glove materials



The selected work of adhesion of the protective glove materials

	[mJ/m²]	[mJ/m²]	[mJ/m²]	W_p [mJ/m²]	W_d [mJ/m²]	W_a [mJ/m²]
Nitril	48.60	1.13	**49,74**	77,43	10,71	**88,14**
Butyl	39.71	4.05	**43,76**	76,93	20,28	**97,22**
Lateks	29.95	33.84	**63,79**	93,68	58,64	**152,32**

CONCLUSIONS

- The geometric structures imparted to the surface led to different levels of hydrophobicity and surface free energy, improving adhesive properties and decreasing wettability.
- Most of the studied materials were characterized by good wettability properties, with only 2 latex samples exhibiting water contact angles of more than 90° (the only hydrophobic glove materials). On the other hand, gloves made of nitrile butadiene rubber were hydrophilic.
- The highest surface free energy was found for nitrile butadiene rubber materials (also characterized by high work of adhesion) which was four Times greater as compared to the other studied materials in the case of the nonpolar test liquid.

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