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# INVESTIGATION OF WETTABILITY MEASUREMENTS OF PROTECTIVE GLOVES MATERIALS

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## ABSTRACT

Wettability measurements of the polymeric materials that are designed to be used for protective gloves are the key aspect in the evaluation of their potential safety of use. The gloves made of polymeric materials that will be resistant to chemical or biological contamination should exhibit low wettability and good adhesive properties to reduce the possibility of accumulation of hazardous substances on the surfaces of the gloves together with losing dexterity of hand movement during work. Currently, in laboratory practice, there is no method to investigate thoroughly the wetting properties of polymeric surfaces taking into consideration parameters like water permeability index, non-wettability index, and absorption index. The presented research concerns the novel way of measuring the wettability of polymeric protective gloves, and the validation of the proposed method. Based on the series of performed measurements, a thorough assessment of the uncertainty budgets for individual components of performed metrological analysis of obtained results was performed. Based on these findings, the measurement errors that could affect the reliability, repeatability, and quality of the performed investigation have been identified.

## KEYWORDS

Wettability, protective gloves, validation, polymers.

## INTRODUCTION

During the use of personal protective equipment, improvement of safety and durability of the used equipment might serve as a key aspect to consider by the designers of such products. Especially in the case of protective gloves, their safety against chemical and biological hazards is crucial. To avoid the threat of contamination of surfaces of protective gloves, they must exhibit properties such as high wettability connected with good adhesive properties so that they will be able to transfer hazardous substances off the glove. Currently, there is no method in laboratory practice that evaluates the wettability properties of polymeric protective gloves in terms of simulating real-life working conditions.

Based on this, the method has been proposed to evaluate the surface wettability of polymeric protective gloves in terms of investigation of three parameters, i.e.: water permeability index IP (permeability being considered as the process of chemical traveling through e.g. porosities), non-wettability index IR (being ability of the surface to get rid of the liquid) and absorption index IA (where absorption has been considered as the process of penetration of the one substance to another).

## MATERIALS AND METHODS

Based on these parameters investigation, the presented method of wettability measurement has been validated. For the sake of this evaluation, measurements on three types of commercially available polymeric protective gloves have been performed. These included natural latex, nitrile rubber, and butyl rubber gloves.

A protocol of investigation of the wettability of these polymeric materials taking into consideration measurement of the three indices has been proposed. The invented method is based on the PN-EN ISO 6530:2008 standard describes the way of investigation of the resistance of materials to penetration by liquids. The setup scheme is presented in Figure 1.

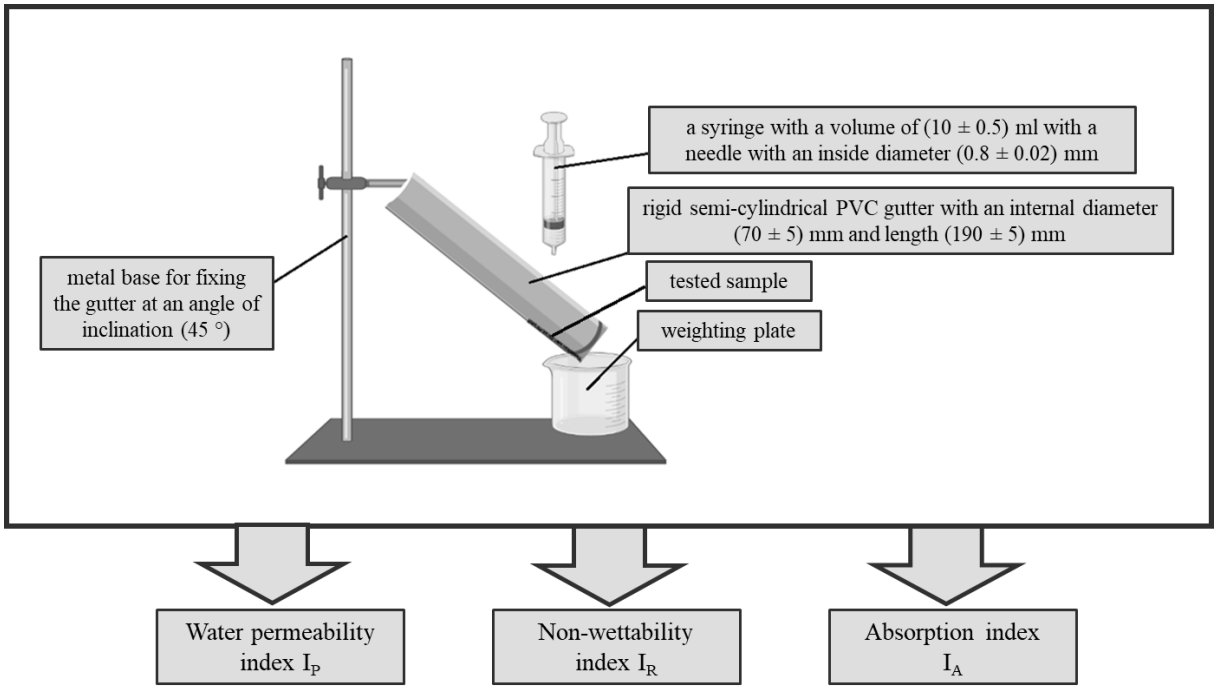


**Figure 1. The setup for the measurement of polymeric protective gloves surfaces' wettability.**

Validation of the method of measurements for surface wettability was based according to the three ISO standards: PN-EN ISO 6530:2008; PN-ISO 5725-1; PN-ISO 5725-2. Parameters that have been considered after the series of performed measurements were: precision, measurement accuracy, and uncertainty. Following components of uncertainty were taken into account when the estimation of the uncertainty of the measurements has been performed:

- The standard deviation of repeatability and limit of repeatability;
- The within-laboratory standard deviation of reproducibility and reproducibility limits.

Moreover, important aspects taken into consideration were accuracies of:

- the diameter of the sample,
- the angle of the gutter,
- weight of the liquid applied onto the sample,
- weight of the liquid collected after the test,
- dispersion of measurements' results.

## RESULTS AND DISCUSSION

When designing the Personal Protective Equipment (PPE), one of the most important aspects to be considered is the improvement of the safety of the final product [1–4]. A PPE for which issues of safety

are extremely important are protective gloves, especially when considering the durability and long-time protection in everyday work-related actions. Among them, polymeric gloves are one of the most often used groups, that can be applied in many different working environments and conditions. Particularly important from the point of view of the protective properties of these types of gloves are their hydrophobic properties. When these materials' surfaces exhibit hydrophobic character, the possibility of risks of accumulation of chemical and/or biological contaminants over the surface is highly reduced. It is most important in case of not only the negative effect of these harmful substances for the palm, but their presence might highly reduce the dexterity of movements of equipped with the contaminated glove. Based on these findings, it has appeared crucial that a thorough investigation of the wettability properties of polymeric protective gloves in terms of possible interactions of the liquid with these gloves' surfaces need to be performed.

The method of wettability measurements considering three correlated parameters (water permeability index, non-wettability index, and absorption index) has been proposed. It is important to notice that the correlation between those three parameters describing the interactions of liquid with the surface. The material might serve well when trying to simulate the real-life working conditions with different types of chemicals and other harmful liquids that get in contact with the investigated surfaces.

Based on performed measurements, it was possible to calculate the uncertainty budgets [5] expressed as the percentage contributions of the components of selected parameters to the compound measure of relative uncertainty, as presented in Table 1.

**Table 1. Results of the uncertainty budgets for investigated polymeric protective gloves.**

| | NATURAL LATEX | NITRILE RUBBER | BUTYL RUBBER |
|---|---|---|---|
| UNCERTAINTY BUDGET FOR REPEATABILITY OF MEASUREMENTS | 1.319 % | 0.300 % | 0.306 % |
| REPEATABILITY LIMITS | 3.70 % | 0.84 % | 0.86 % |
| UNCERTAINTY BUDGET FOR REPRODUCIBILITY OF MEASUREMENTS | 1.108 % | 0.348 % | 0.276 % |
| REPRODUCIBILITY LIMITS | 3.10% | 0.97 % | 0.77 % |
| UNCERTAINTY BUDGET FOR DISPERSION OF MEASUREMENTS | 0.2605 % | 0.2472 % | 0.1174 % |
| RELATIVE DISPERSION LIMITS | 0.002650 % | 0.002490 % | 0.001185 % |

The relative uncertainty budgets for studied polymers considering the components of measurements uncertainty are presented in Table 2.

**Table 2. Results of the relative uncertainty components of undertaken measurements.**

| | RELATIVE UNCERTAINTY |
|---|---|
| SAMPLE DIAMETER | 0.0015 |
| THE ANGLE OF THE GUTTER | 0.000593 |
| WEIGHT OF THE LIQUID BEFORE TESTING | 0.0021 |
| WEIGHT IF THE LIQUID AFTER TESTING (COLLECTED FROM THE SAMPLE) | 0.0021 |

In current laboratory practice of measurements of wettability of polymeric protective gloves, there is no such method that allows to broadly investigate the possibility of interaction of the examined surfaces with potentially hazardous substances at the possible workplace – oils, biological contamination, chemical substances. It is also worth noticing that conventional, static ways of measuring contact angle and surface wettability might not be enough when mimicking real-life working conditions of protective gloves – that is also a strong argument for the proposed method to be considered as a useful investigation tool [6–10].

## CONCLUSION

The performed measurements and the conducted metrological validation of obtained results proved that the invented procedure to study the wettability of polymeric protective gloves allows obtaining repeatable, reproducible results of high precision and quality. Based on the performed investigation, it may be possible to better select polymeric protective gloves for certain applications, taking into account the possible ways of interaction of their surfaces with potential chemical or biological contamination.

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