CARBON NANOMATERIALS FOR FUNCTIONALIZATION OF PROTECTIVE LAYER IN TEXTILE COATING TO IMPROVE MECHANICAL PROPERTIES

Emilia Irzmańska[1], Anna Boczkowska[2], Magdalena Jurczyk-Kowalska[2], Kamila Strycharz[2], Paulina Kropidłowska[1], Olga Olejnik[1]

[1] Central Institute for Labour Protection - National Research Institute, Department of Personal Protective Equipment, Czerniakowska 16 Street, Warsaw, Poland
[2] Faculty of Material Science and Engineering, Warsaw University of Technology, 141 Woloska, 02-507 Warsaw, Poland

INTRODUCTION

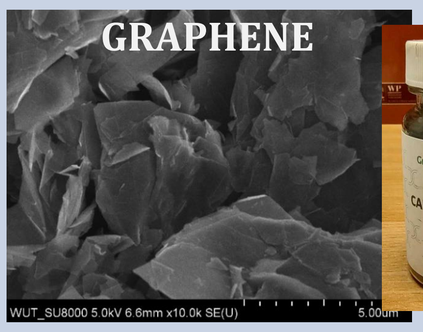
The minimum value required based on the standard	The Average Tearing Force Obtained During the Test Based on the PN-EN ISO 13937-2:2002 standard
EN 469:2020 (protective clothing for firefighters)	30 N
EN ISO 11611:2015 (protective clothing used during welding and related processes)	15 N—level 1 of performance 20 N—level 2 of performance
EN ISO 11612:2015 (clothing for protection against heat and flame)	10 N

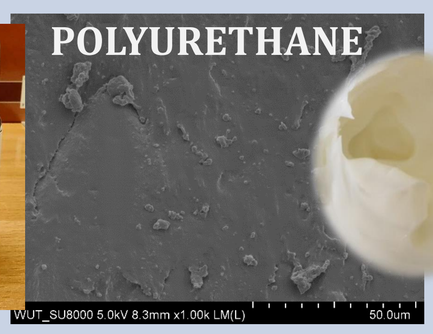
An interesting area of research is the evaluation and verification of the impact of using **graphene as a modifier in a coating paste for textile materials**, focusing on its mechanical properties, particularly tear resistance, in the context of its **application in PPE.** The authors conducted experiments applying graphene to the coating paste to analyze the effect of its weight content on the mechanical properties of hybrid textile materials.

This study involved three variants of hybrid textile material samples, consisting of a textile substrate and a coating material, which included a polyurethane paste and graphene at two different weight contents. The research was conducted with a focus on the material's potential use in PPE.

MATERIALS AND METHODS

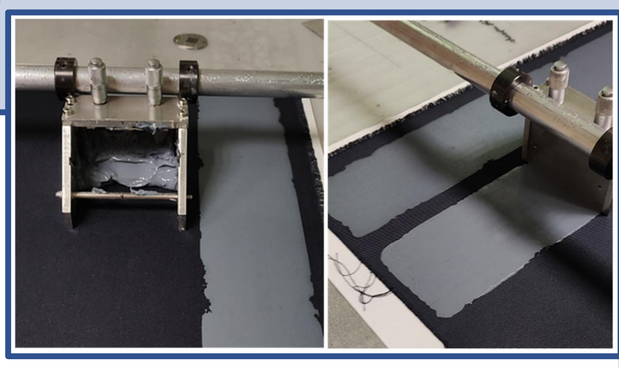
Sample	Material Description
textile/PU	meta-aramid textile carrier with an addition of 2% antistatic fibres coated with polyurethane
textile/PU/ 0.25%G	meta-aramid textile carrier with an addition of 2% antistatic fibres coated with polyurethane containing 0.25 wt.% of graphene
textile/PU/ 0.5%G	meta-aramid textile carrier with an addition of 2% antistatic fibres coated with polyurethane containing 0.5 wt.% of graphene



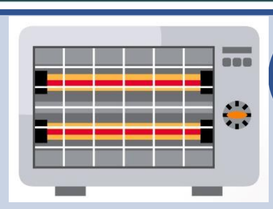


1 MIXING AND HOMOGENIZING

2 TAPE COATING METHOD



3 CROSS-LINKING:
1st heating: 120°C/15 min
2nd heating: 170°C/1 min



4 TESTING:
a) Tear Resistance
b) Microstructure Assessment (SEM Analysis)

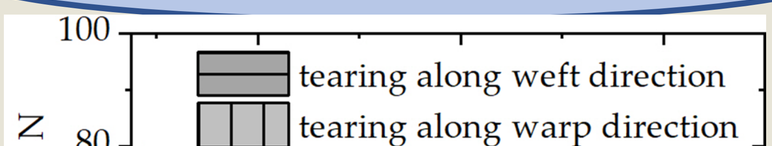
In the first stage, the mixture components, including polyurethane and graphene nanofiller with different mass content (0,25 wt% and 0,5 wt%) were mixed and the obtained two types of paste were homogenized via high-energy mixing using a planetary homogenizer. Subsequently, the prepared pastes were formed into coatings by implementing pastes into the textile via tape-coating method. Next, the prepared coatings were crosslinked. The cross-linking process was performed using a laboratory dryer at a temperature of 120°C for 15 minutes and then at 170°C within 1 minute. The hybrid materials were tested by means of tear resistance and their morphology was analysed using Scanning Electron Microscopy.

POLYURETHANE (PU) based on a commercially available reagent under the tradename TUBICOAT PU 60 (CHT Germany) was applied as a polymer matrix.

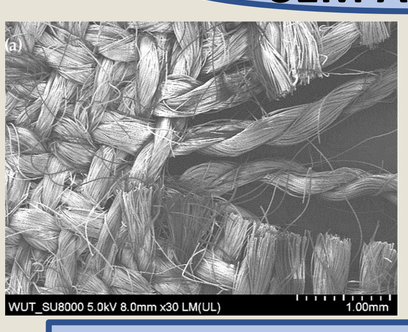
GRAPHENE (CARBON 4LAB) with 99,9% of purity provided by Institute of Carbon Technology (Poland) was used as a nanofiller (flake size: 1,5 µm, thickness: 3 nm, specific surface area: 800 m2/g, purity: 99,9 %).

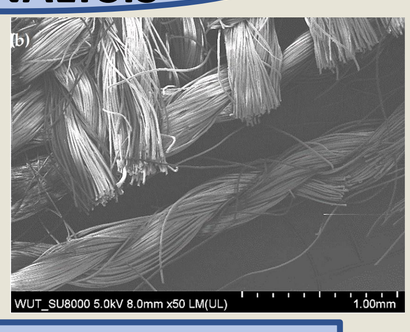
RESULTS AND DISCUSSION

TEAR RESISTANCE RESULTS



SEM ANALYSIS

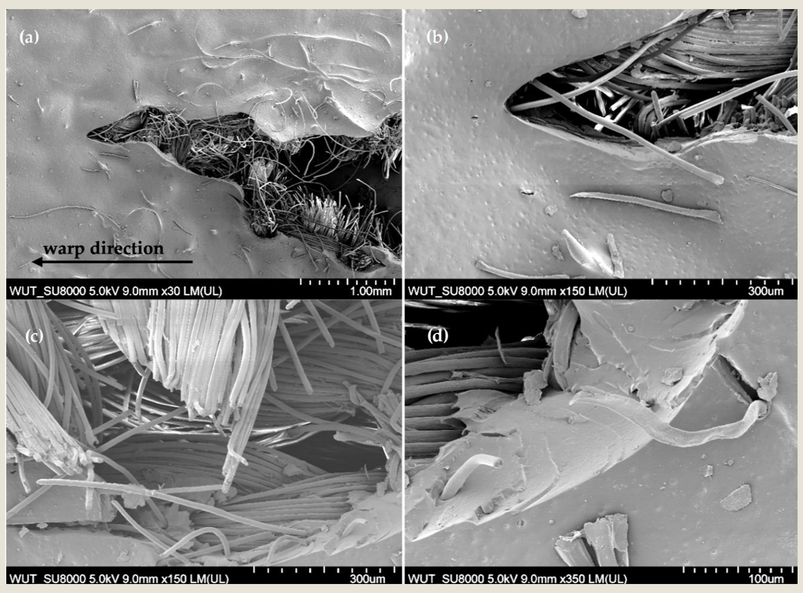




TEXTILEAFTER TEAR RESISTANCE

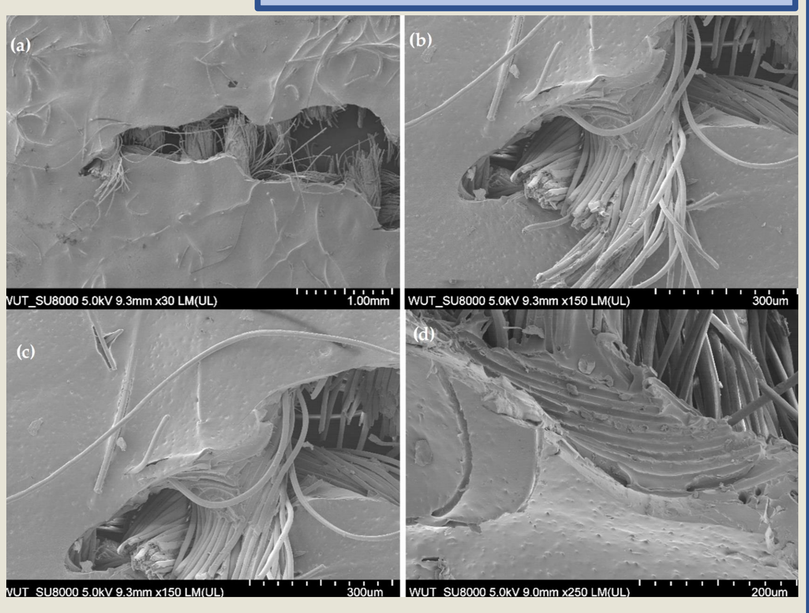
TEXTILE/PU AFTER TEAR RESISTANCE TEST

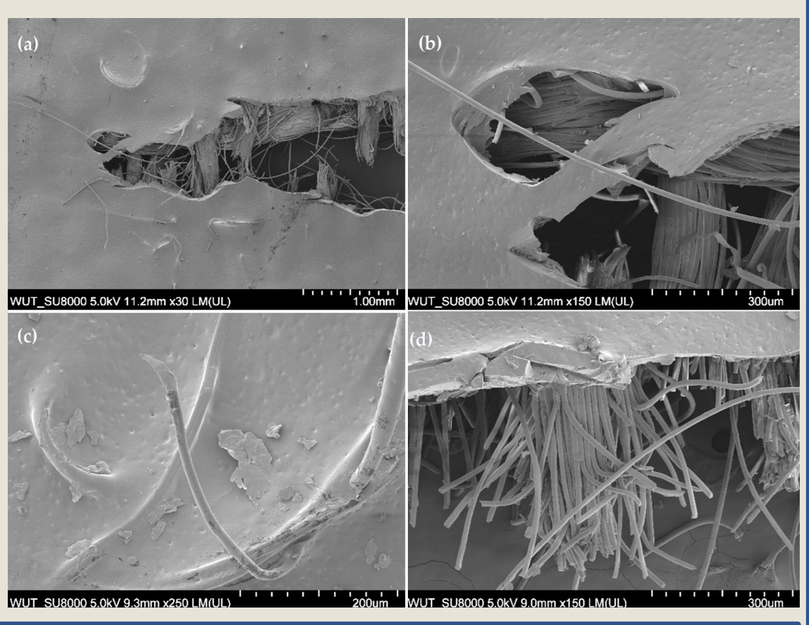
SEM ANALYSIS



The application of 0.5 wt.% of graphene in the polyurethane coating caused an increase in tearing force measured when tearing along the weft direction of **more than 30%** compared to the coated textile with no graphene. However, the same parameter measured as a result of tearing the material along the warp direction was reduced by about 6%. Nevertheless, according to different PPE standards, the obtained materials are characterized by various performance levels and therefore these hybrid textile materials **may be used in personal protective equipment (PPE).**

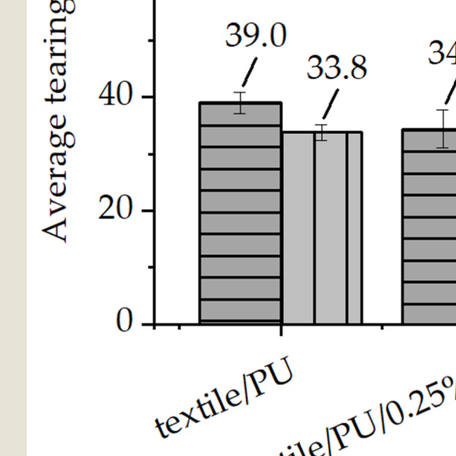
TEXTILE/PU/0.25%G AFTER TEAR RESISTANCE





TEXTILE/PU/0.5%G AFTER TEAR RESISTANCE

CONCLUSIONS



Currently, it is of considerable importance to develop materials dedicated to personal protective equipment. The presented studies were focused on hybrid textile materials dedicated to PPE, consisting of a polyurethane coating containing graphene and of a textile carrier. The hybrid materials were tested by means of tear resistance and morphology. The hybrid material coated with polyurethane (textile/PU) and the hybrid material with a PU coating with 0.5 wt.% of graphene met the tearing force requirements for protective clothing for firefighters according to EN 469:2020. The only material which did not meet these requirements was a textile coated with polyurethane with 0.25 wt.% graphene (textile/PU/0.25%G), but it may meet other requirements, including the minimum value required based on the EN ISO 11612:2015 (clothing for protection against heat and flame).

epf GRONINGEN 2025

CIOP PIB 75 YEARS

This task was completed on the basis of results of research carried out within the scope of the 6th stage of the National Programme "Governmental Programme for Improvement of Safety and Working Conditions" funded by the resources of the National Centre for Research and Development task no.: I.PN.05 „Graphene-modified hybrid textile materials for firefighter gloves". The Central Institute for Labour Protection – National Research Institute is the Programme's main co-ordinator.