West Pomeranian University
of Technology in Szczecin

POLYESTER ELECTRO CONDUCTIVE FIBERS WITH CARBON NANOTUBES AND GRAPHENE SHEETS

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OUTLINE

- **Introduction**

  Carbon nanostructures (1D, 2D) as promising nanofillers for multifunctional polymer nanocomposites

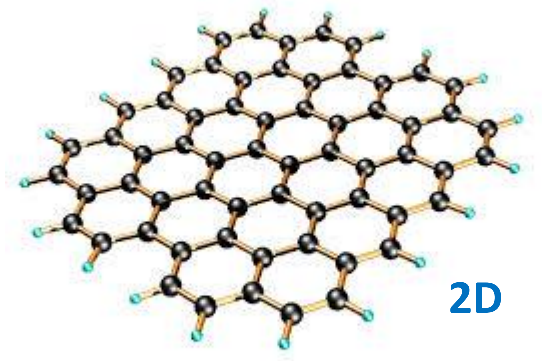
- **Materials used in the study**

- **Preparation of masterbatches and fibers**

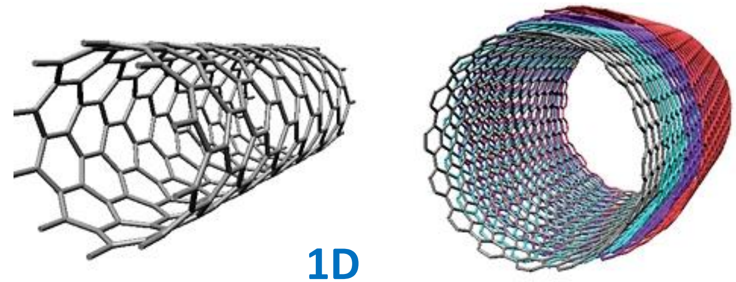
- **Electrical conductivity and microscopy analysis of prepared fibers**

- **Conclusions**

Carbon nanostructures



2D



1D

graphene | **carbon nanotubes (CNTs)**

Properties and Advantages

The exceptional properties of graphene/ nano graphene platelets (GNPs) include the following:

Conductivity	• A very high thermal conductivity of up to 5300 W/(mK) • High electron mobility at room temperature (theoretical limit 200 000 $cm^2V^{-1}s^1$); resistivity less than the resistivity of silver • GNPs have excellent in-plane electrical conductivity of up to 20 000 S/cm
Strength	• They have a very high Young's modulus 1 TPa, intrinsic strength of 130 GPa
Surface area	• GNPs have a specific surface area of up to 2 674 m^2/g, which is twice the surface area of CNTs
Density	• It is very light,with a 1-square-meter sheet weighing only 0.77 milligrams • NGPs have a low density of about 2.2 g/cm^3
Dimensions	• Single layer graphene is very thin with a thickness of just 0.34 nm • GNPs are available in a broad rage of platelet lengths of 1 to 50 μm and thickness range of approximately 0.34 nm to 100 nm
Optical	• Graphene's unique optical properties – transmittance 97.7 %
Barrier	• Complete impermeability to any gases

Nanocomposite performance

- Improvement of mechanical properties
- Improvement of electrical conductivity
- Nucleation effects
- Reduction of permeability of gases and vapours (when graphene added)
- Improved solvent resistance
- Improved surface properties (e.g. printability, smoothness)
- Reduced shrinkage
- Improved flame retardancy

Carbon nanofillers used in our study

- **single-walled CNTs** (KNT, Grafen Chemical Industries Co. Ankara)

purity : > 95 wt %

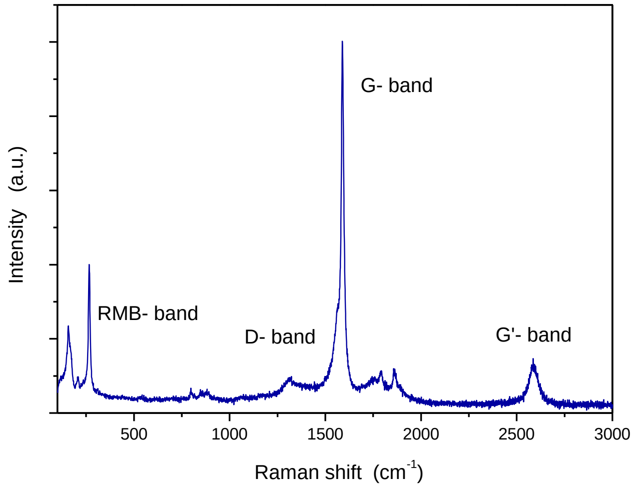
diameter: < 2.0 nm

length : 5 - 30 µm

electrical conductivity: > 100 S/cm

specyfic surface area : > 380 m2/g

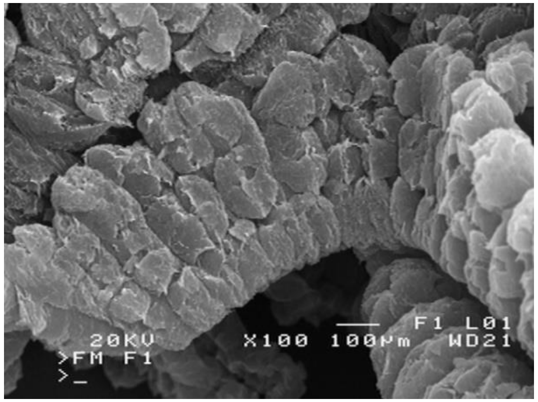
I_G/I_D (Raman) : > 20

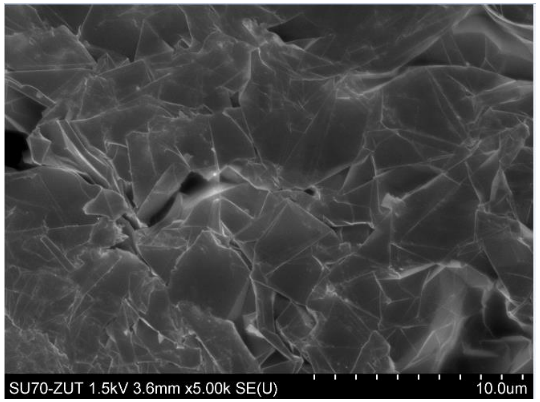


- **expanded graphite** prepared by thermal expansion (Slovak Academy of Sciences)

average thickness of the expanded agglomerates : 450-560 nm

average particle size of ranged from 16 µm to 50 µm (99%)





XPS analysis:

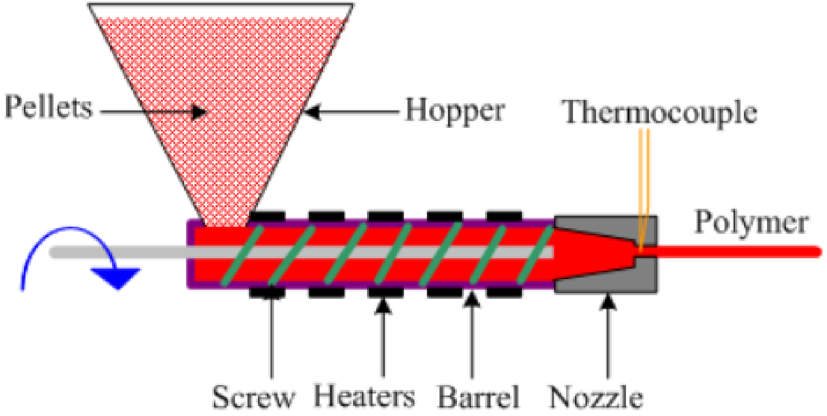
C1s 99.21 %

O1s 0.79 %

MASTERBATCH

In situ polymerization

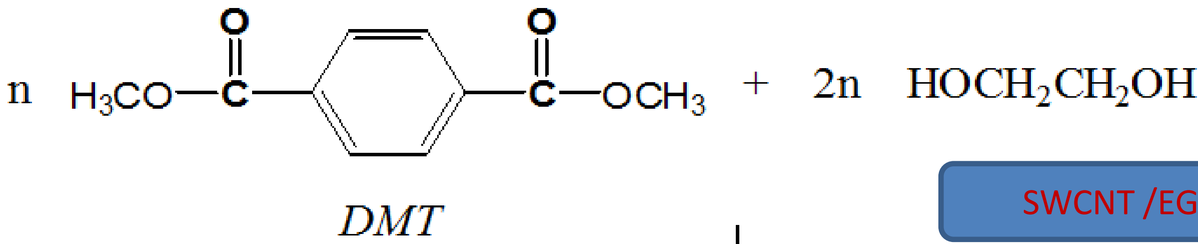
Melt blending under high pressure



PET/1.0wt % of SWCNT
PET/1.0 wt % of EG

PET/5.0wt % of SWCNT
PET/5.0 wt % of EG

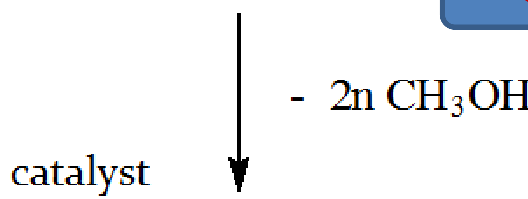
Preparation of PET/SWCNT(EG) nanocomposites

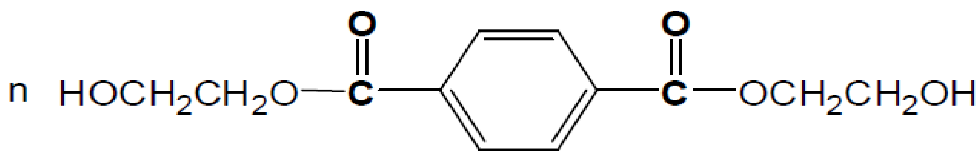


SWCNT /EG dispersion in ED

I step - Transestrification

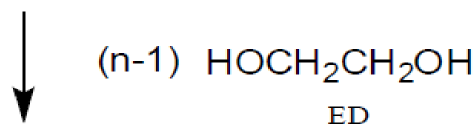
reaction between dimethyl terephtalate (DMT) and ethanediol to bis(2-hydroxylethyl) terephthalate

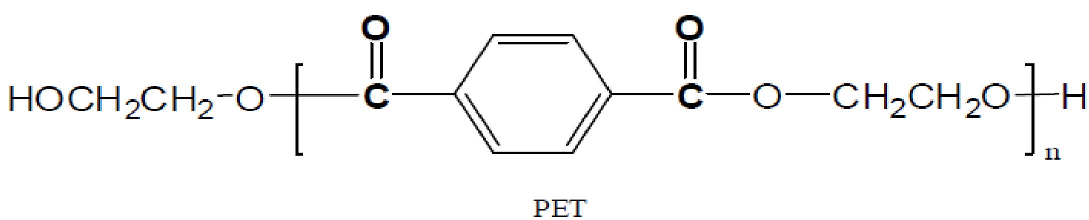


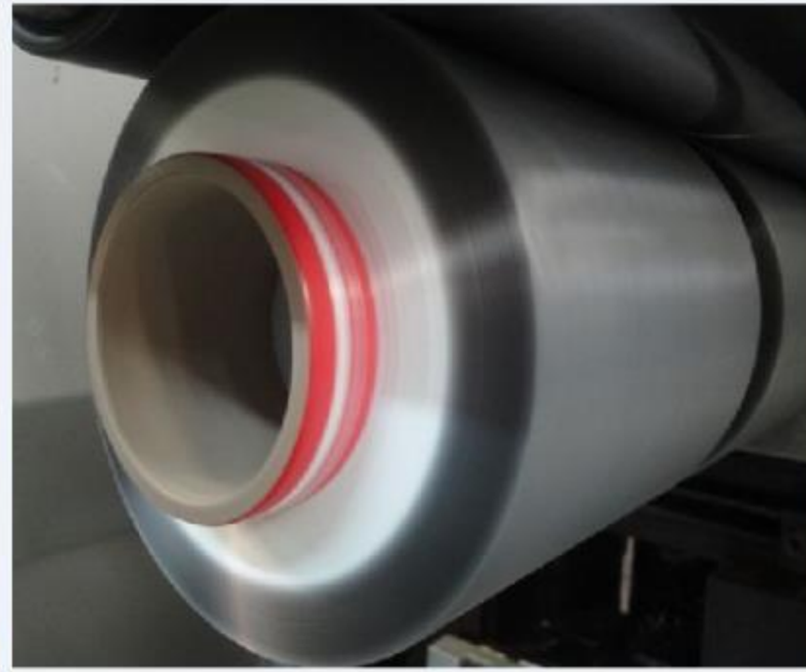


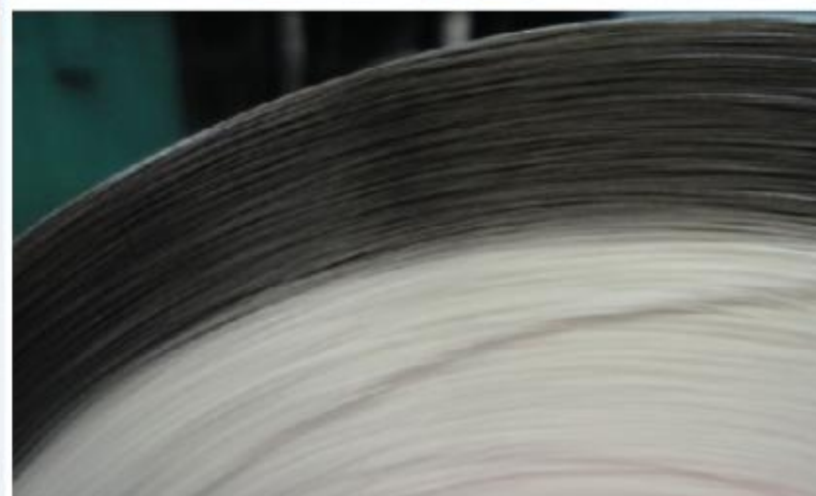
II step- Polycondensation

Polycondensation of bis(2-hydroxylethyl) terephthalate to poly(ethylene terephthalate)

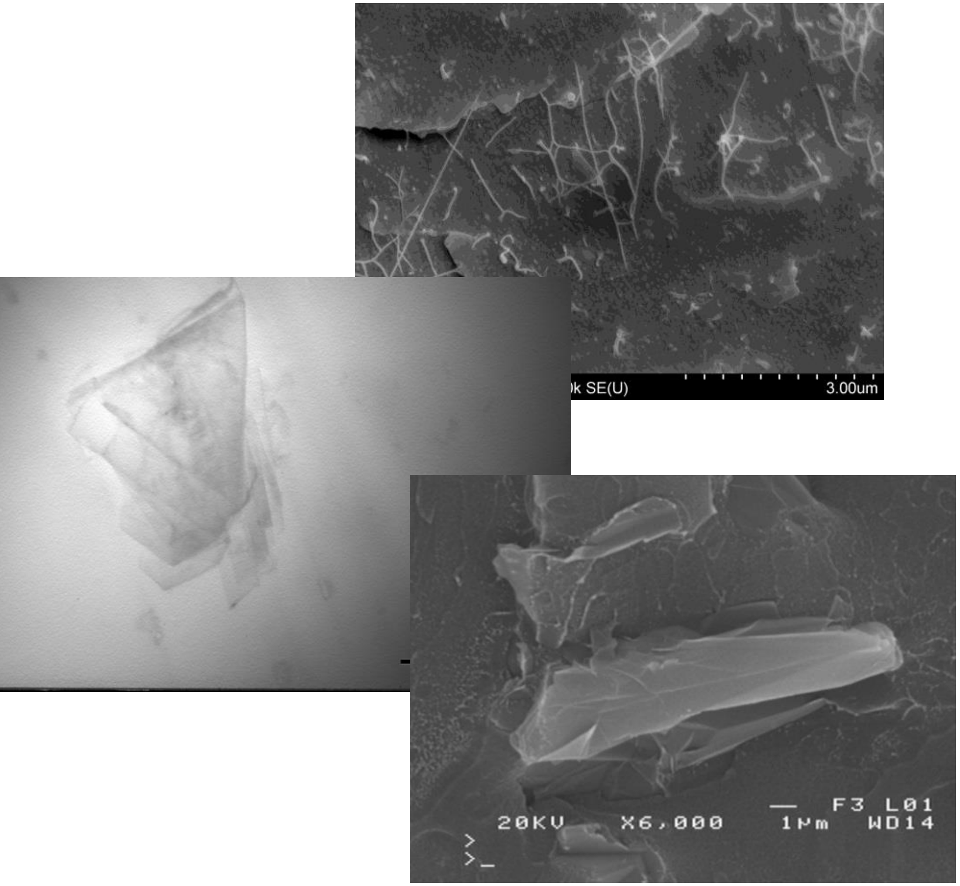






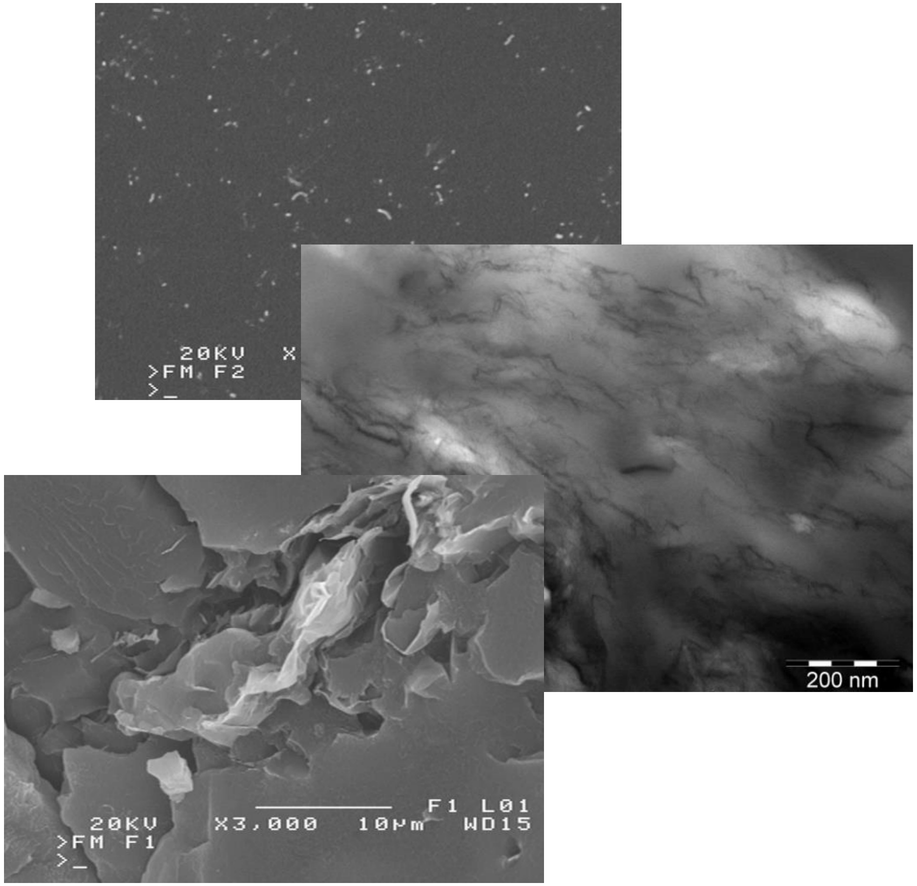


Samples prepared via *in situ* polymerization



SAMPLE	ELECTRICAL CONDUCTIVITY S/cm
PET	10^{-12}
PET/0.1 SWCNT	10^{-6}
PET/0.1 EG	10^{-5}

Samples prepared via melt blending



SAMPLE	ELECTRICAL CONDUCTIVITY S/cm
PET	10^{-12}
PET/0.5 SWCNT	10^{-10}
PET/0.5 EG	10^{-9}

CONCLUSIONS

- Two types of masterbatches were prepared in the Institute of Materials Science and Engineering WUT in Szczecin: via in situ polymerization and via melt blending under high pressure

- Masterbatches based on PET and prepared by in situ polymerization contained 1 wt.% of EG and 1 wt % of SWCNT. On the other hand masterbatches prepared by melt blending contained 5 wt.% of EG and 5 wt % of SWCNT

- Conducting fibers were prepared in Torlen Sp. z o.o. in Torun from the masterbatches. From the spinning points were collected PET fibers containing: 0.1 wt % of nanofillers (in situ) and 0.5 wt % (melt blending), respectively. Detailed description of the process is contained in the operating records of the company.

- Higher electrical conductivity was obtained for PET/EG fibers from masterbatches obtained by in situ polymerization.

- Values of electrical conductivity of SWCNT/EG PET fibers were very close to values obtained for neat PET fibers.

- SEM and TEM analysis of PET fibers obtained from masterbtaches prepared by *in situ* polymerization confirmed achievement of a good dispersion state of SWCNTs and highly exfoliated NGPs within PET matrix at low loading (0.1 wt%) of carbon nanofiller

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Thank you for your attention