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Adhesion Improvements of functional nanofibrous layers

E. Fatarella[1*], M. Ruzzante[1], S. Savi[2]

[1] Next Technology Tecnotessile, Società Nazionale di Ricercal rl (Italy)
[2] Department of Chemistry and Industrial Chemistry, University of Pisa (Italy)

[*]chemtech@tecnotex.it

REAPower

NEXT TECHNOLOGY TECNOTESSILE SOCIETÀ NAZIONALE DI RICERCA R. L.

Main facts

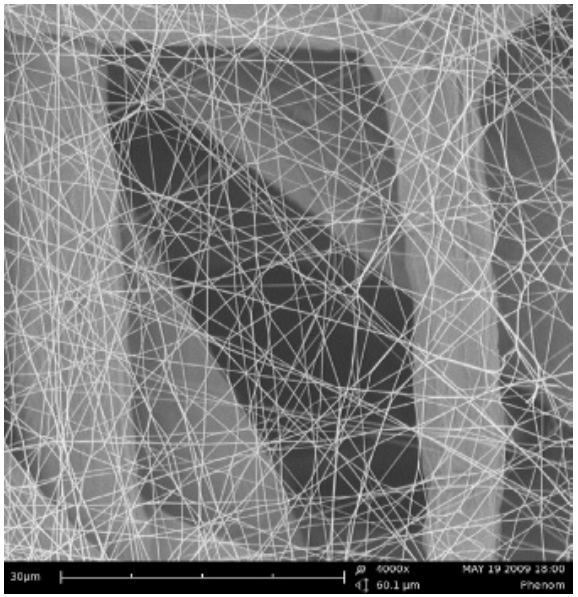
- Legal name: **Next Technology Tecnotessile** *Società Nazionale di Ricerca r.l.*
- Legal address: Via del Gelso, 13 – 59100 Prato (Italy)
- Year of establishment: 1972
- Mission: Research and technological innovation in the textile and textile machinery sectors

  - Consultancy services on textile technologies, from raw materials to final products
  - Modification of materials, surface functionalisation, development of novel chemical processes
  - R&D on treatment and reuse of industrial wastewaters
  - Design of mechanical devices and machinery development
  - R&D on process automation and control systems
  - Laboratory tests on fibres, yarns and fabrics
  - Experimental testing of textile machines and processes

Introduction

When the diameter of the polymer fiber is reduced from micron to nanometer level it has the appearance of different characteristics

- High Porosity
- High surface/volume ratio (ratio rise by a factor of 10^3 compare to micro fiber
- Wide range of polymers capable of spinning
- Different additives can be embedded
- Good breathability
- Small and uniform pore size
- Nearly imperceptible amount of mass added



Introduction

Polymer nanofibers

Cosmetic Skin Mask
- Skin cleansing
- Skin healing
- Skin therapy with medicine

Application in Life Science
- Drug delivery carrier
- Haemostatic devices
- Wound dressing

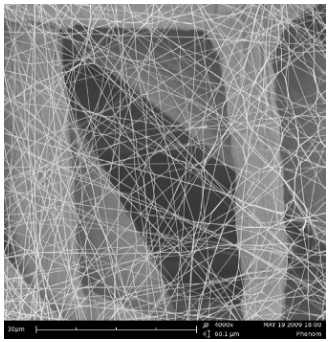
Tissue Engineering Scaffolding
- Porous membrane for skin
- Tubular shapes for blood vessels and nerve regenerations
- Three dimensional scaffolds for bone and cartilage regenerations

Military Protective Clothing
- Minimal impedance to air
- Efficiency in trapping aerosol particles
- Anti-bio-chemical gases

Filter Media
- Liquid filtration
- Gas filtration
- Molecule filtration

Nano-sensors
- Thermal sensor
- Piezoelectric sensor
- Biochemical sensor
- Fluorescence optical chemical sensor

Other Industrial Applications
- Micro/nano electronic devices
- Electrostatic dissipation
- Electromagnetic interference shielding
- Photovoltaic devices (nano-solar cell)
- LCD devices
- Ultra-lightweight spacecraft materials
- Higher efficient and functional catalysts

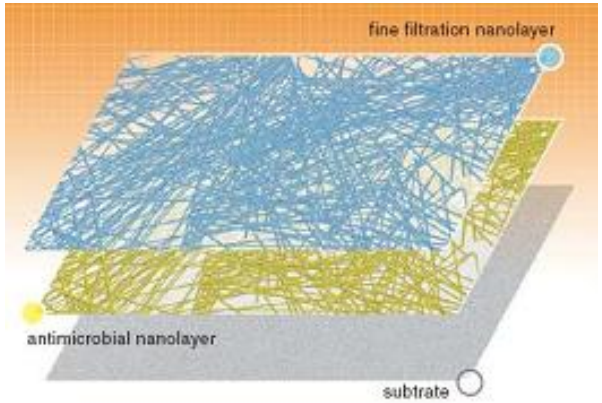


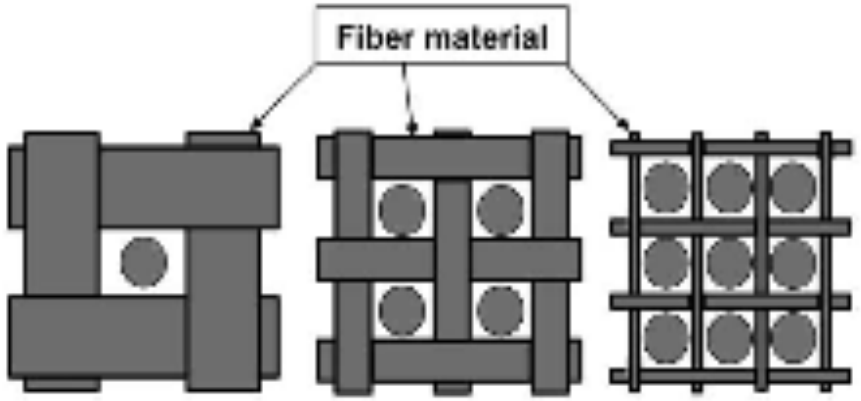
Zheng et. al., 2003

Introduction

Nanofibers for filtration applications

Advantage	Limitations
High filtration efficiency	Necessity to provide appropriate mechanical properties
Low pressure drop	Adhesion of the nanofibrer layer

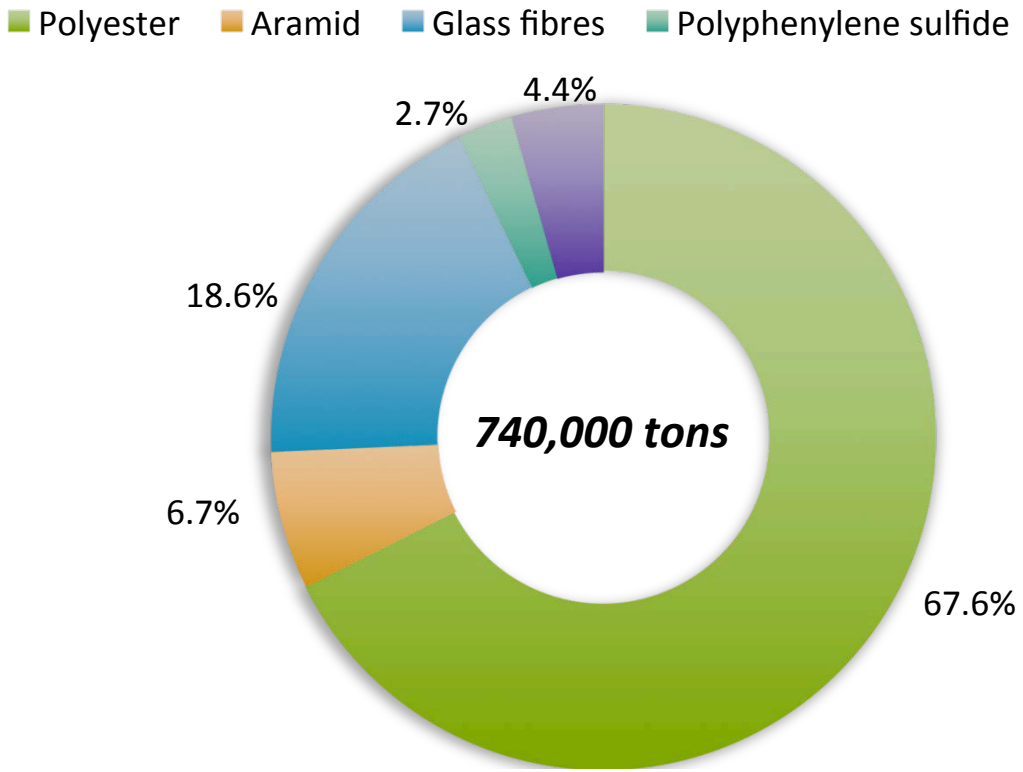




Zheng et. al., 2003

Introduction

Nanofibers for filtration applications



International filtration News, 2013

Materials and Methods

Number of spinning electrodes	1
Spinning electrode width	200 mm
Effective nanofiber layer width:	200 mm
Spinning distance:	70 – 190 mm
Substrate speed	0.13 – 1.57 m/min
Process air flow	20 – 150 m^3/h
Spinning voltage	0 – 80 kV
Batch volume	20 – 200 ml
Power	0.45 kW
Total footprint	0.64 m^2

A ***thermoplastic polyurethane*** has been used and combined with polyesters since it can assure proper sealant properties according to its Glass Transition Temperature

Process and System Parameters

Spinning solution		Collector substrate material		Equipment setting	
Polymer	PET PET/PU PU	Composition	PET net	Electrode	Yarn/Drum
Solvent	TFA:DCM (7:3)	Thickness	0.5 mm	Electrode rotation speed	0 – 16 rpm
Concentration	5-20%wt.	Resistivity	10^{13}	Distance of the electrodes	7 – 19 cm
Additive	None			Voltage	20 – 80 kV
				Collector electrode	Yarn/Drum

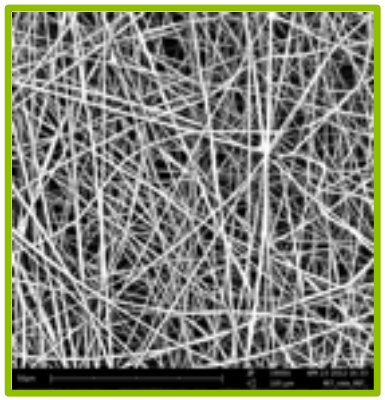
Optimisation of the solution **viscosity**

Optimisation of **the electrical field**

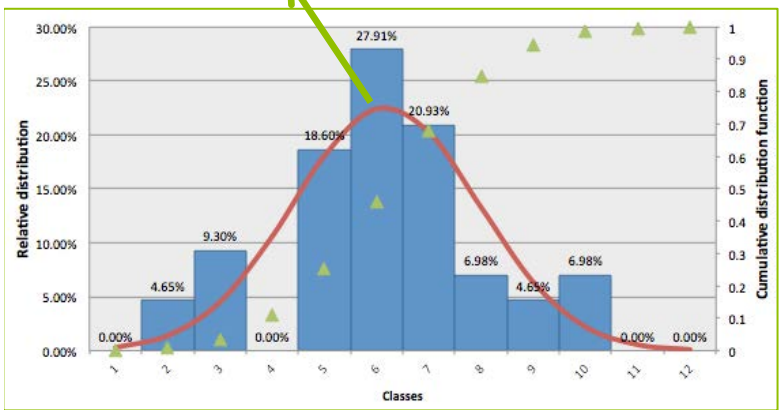
Polymer	Concentration	Voltage	Electrode	Distance
PET	10%wt.	70 kV	Yarn	16
PET-PU (3:1)	7.5%wt. – 2.5%wt.	73 kV	Yarn	15
PET PU (1:1)	4%wt. – 4%wt.	76 kV	Yarn	14
PU	7% wt.	80 kV	Yarn	12

Results

PET nanofibres

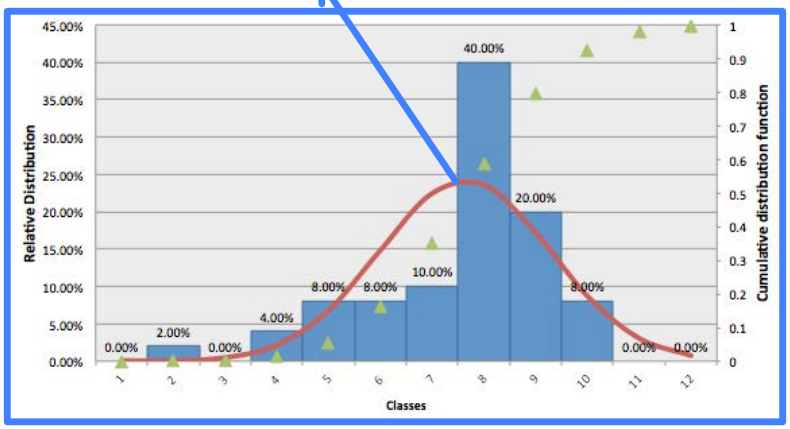


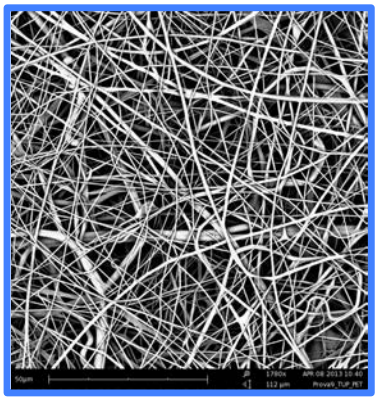
348 nm



PET:PU 1:1 nanofibres

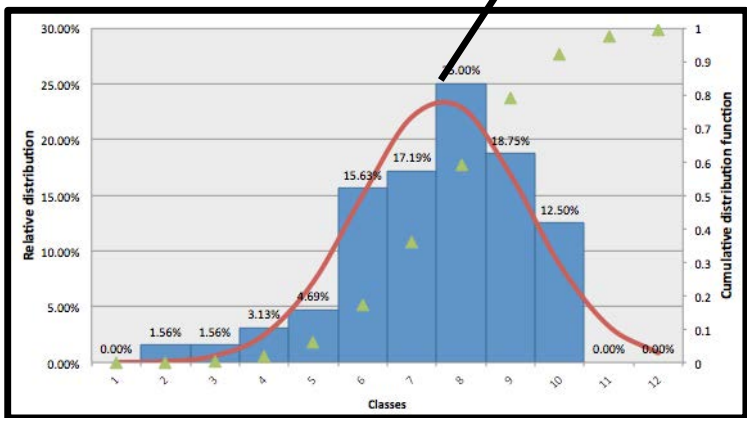
553 nm



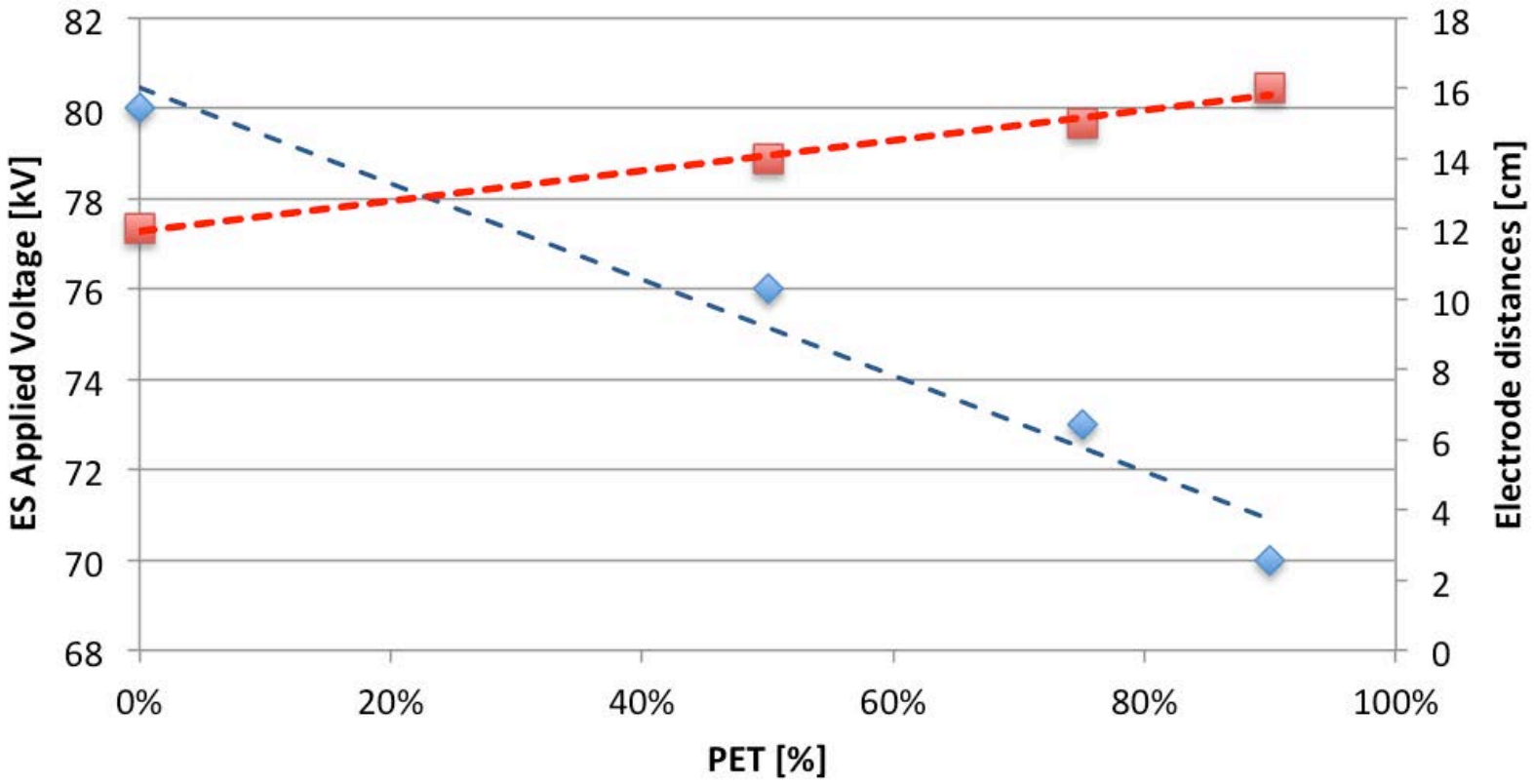


PU nanofibres

620 nm



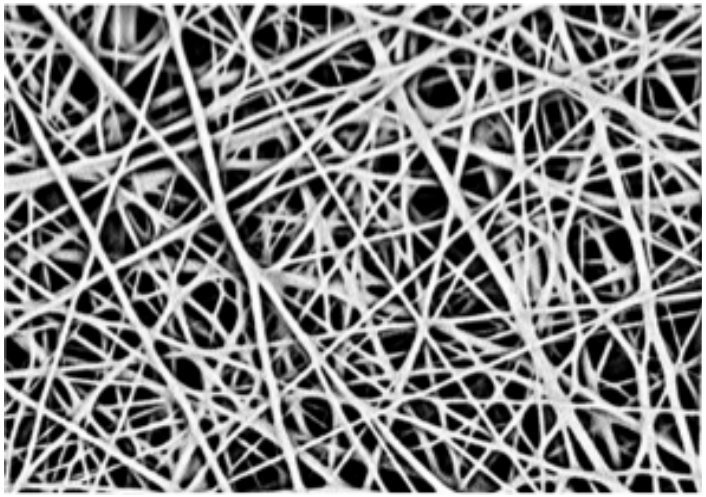
Results



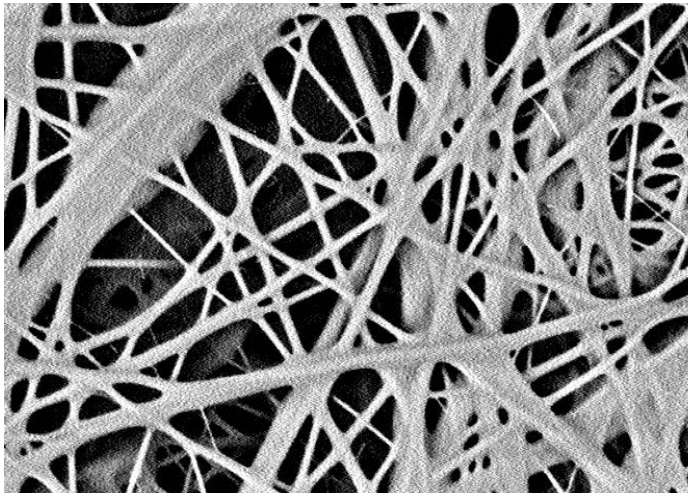
At hgher viscosity, a larger electrical field strengh is required

Results

PU nanofibres



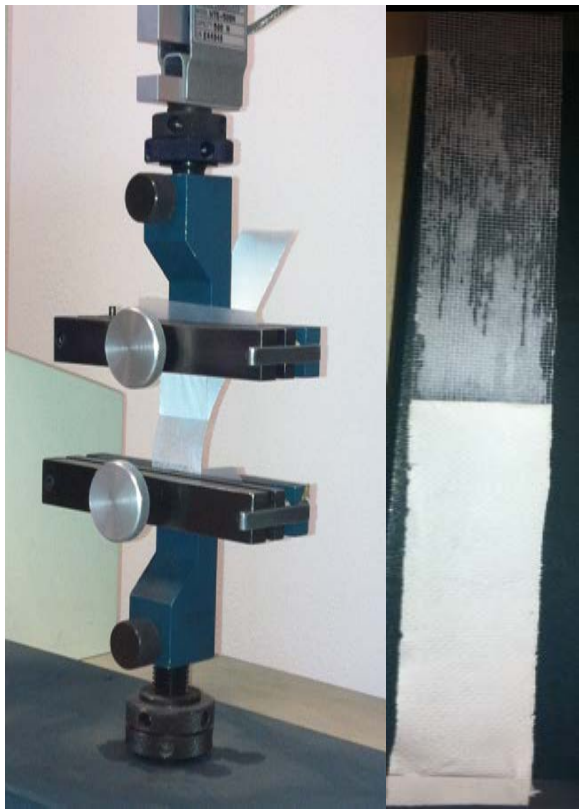
PU nanofibres heated @ 150°C for 5 minutes

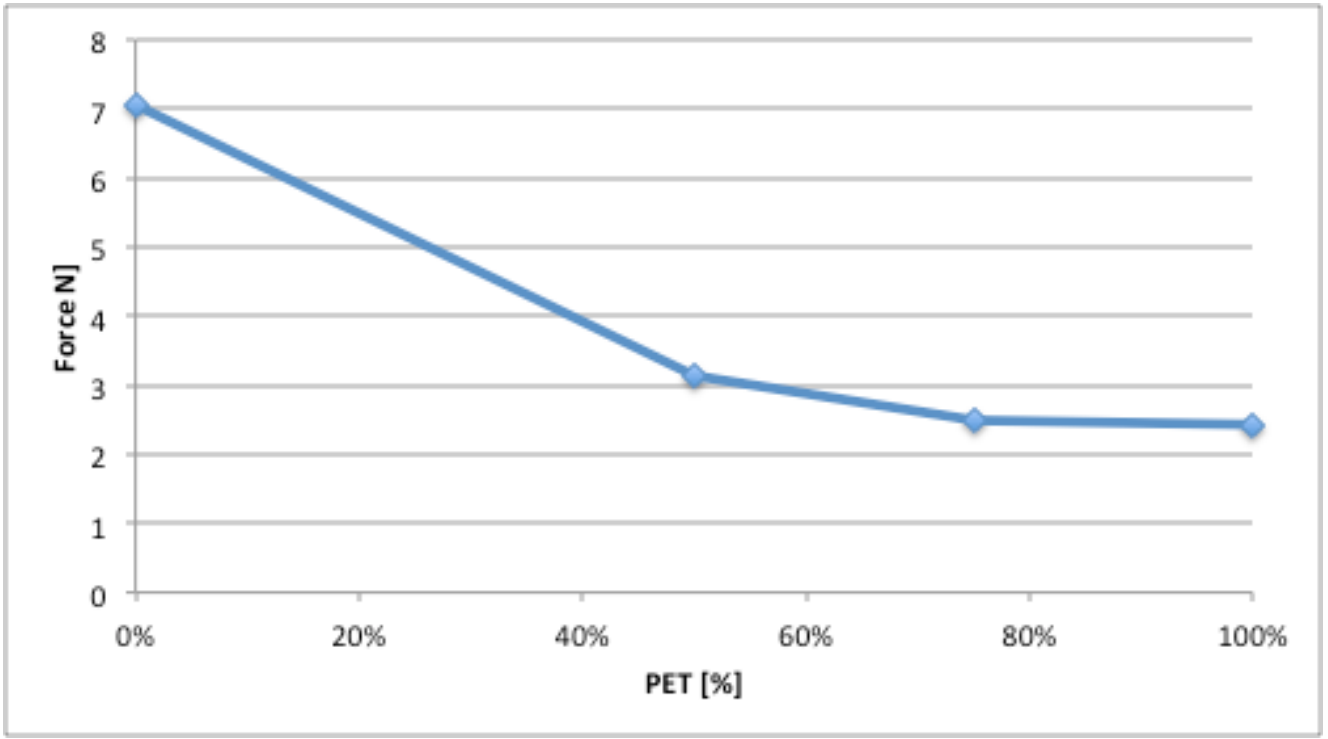


- Point bonded structure is generated by PU melting
- Increase of the fiber diameters up to 800 nm
- Decrease of the superficial area

Results

Peel test similar to the ISO 10373





Conclusions

- The addition of the PU sealant is significantly improving the adhesion of the nanofibres onto the support
- Homogeneous nanolayer can be produced by increasing the electrical field when PU is added to the electrospinning solution
- By increasing the amount of sealant an increase in the fiber diameters is recorded
- The improvement of the adhesion is allowing to spread out the application of nanofibres in filtration.

Acknoledgments

THANK YOU FOR YOUR KIND ATTENTION

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www.**reapower**.eu/

SEVENTH FRAMEWORK PROGRAMME