SAFEPROTEX - Newsletter 3

High protective clothing for complex emergency operations

May 2011

Introduction

The objective of SAFEPROTEX is to develop highly effective protective clothing for people who operate under complex emergency situations. The garments shall (1) provide protection against multiple hazards, (2) present extended useful lifetime and (3) ensure the physiological comfort of the wearer.

For the implementation of the innovative features, the project has taken a bottom-up approach, starting at the nano-scale and encompassing the entire value chain (spinning, weaving, surface treatment technologies and design) up to the prototyping of the actual protective uniforms. This approach covers a multi-step development scheme, with contributions from several partners in each case.

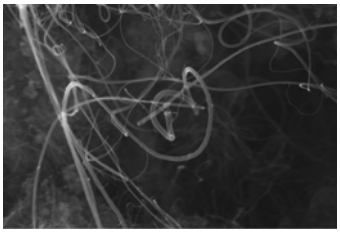
During the first months of the project, preparatory work has been conducted, aiming to:

- *Verify the initial assumption on user requirements and develop technical specifications of the uniforms.*
- *Develop and appropriately modify functionalizing nanoparticles.*
- *Optimize the procedures of master-batches preparation.*
- *Develop smart fibers and yarns.*
- *Establish surface treatments for textiles functionalization.*

SAFEPROTEX follows a bottom-up approach, starting with the development of raw materials and additives and encompassing the entire value chain (spinning, weaving and knitting, surface treatments and design), up to the prototyping of the actual protective garments.

Development & Functionalization of MWCNTs

Multi-walled carbon nanotubes (MWCNTs) of different diameters and purities were produced using the Catalytic Chemical Vapor Deposition (CCVP) method.



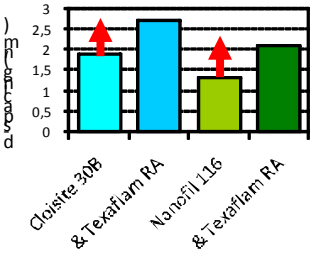
Functionalization of CNTs with –OH groups followed to facilitate their dispersion in polymer matrices. The diameter and the functional groups content were estimated using SEM, TGA and Raman spectroscopy.

	Diameter (nm)	Functional groups (%)
MWCNTs (97 % purity)	20-40	8
Thin-MWCNTs	6-15	12

Introduction of FR compound in the galleries of layered silicate

In order to develop synergistic FR systems, alternative, halogen-free FRs were introduced in the galleries of montmorillonite clays (MMT), kindly supplied by Rockwood, using solution blending.

XRD and FTIR analyses indicate the successful intercalation of Texaflam RA (FR compound supplied by the partner INOTEX) in the galleries of both pristine and organically modified MMT.



Increase of d-spacing upon addition of the FR, indicating its successful intercalation in clay galleries

Preparation of master-batches

PA6.6 based master-batches incorporating nanoparticles (CNTs, LSs, TiO_2) have been prepared and test samples are being developed.

PP based master-batches incorporating CNT have been obtained with good conductivity results even though electrical performance is still under study.

Nanocomposite master-batches of different PP-g-MA incorporating Perkalite F100 (LS) were prepared by melt-blending.

Concerning the incorporation of thermochromic dyes in polymers, nine master-batches have been prepared combining three polymers (PP, PLA, EVA) with three thermochromic pigments (colour change at 42ºC, 47ºC,50ºC) and first samples of thermochromic PP, PLA and EVA yarns were spun.

Thermochromic EVA plates (color change at 63ªC)

Bi-component fibers incorporating non-encapsulated PCMs

Two organic hydrocarbons (PCMs, Tm= 28 and 32 °C) were compounded with high MW HDPE at 70 % content. The blends were used as core components in the extrusion of bi-component fibers with PA6 and PET in the sheath (core/sheath ratio ca. 50/50).

Filament yarns (48 filaments of 240-480 dtex) with heat of fusion in the range of 50-75 J/g have been produced and knitted fabrics prepared to be used as intermediate layer.

In the next step, PP-based nanocomposites will be used to form the sheath of bi-component fibers in order to endow FR properties and to simultaneously suppress the migration of PCMs.

The proposed approach allows the incorporation of higher amounts of PCMs, compared to the microencapsulation approach, and constitutes a cheaper procedure.

So far PP/ Perkalite yarns containing less that 1 % clay have been spun, showing similar mechanical properties to neat PP and improved thermal stability.

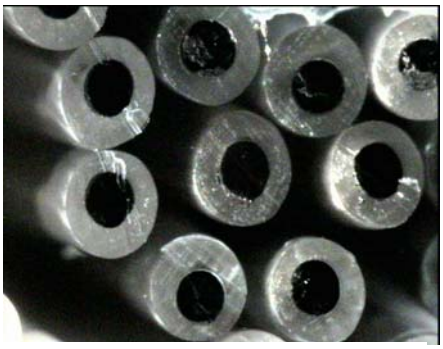


Image of bi-component fibers incorporating non-encapsulated PCMs

Feasibility trials concerning the production of PEEK fibers

Poly(ether ether ketone) (PEEK) processing conditions have been optimized and good quality fibers were spun.

Alternative routes towards modification of PEEK are being explored to induce anti-pollution, antibacterial and self-cleaning properties.

Modified PEEK fibers would exhibit self-cleaning & antimicrobial properties.

Two modified polymers have been synthesized and characterized, namely sulphonated and nitrated PEEK:

Sulphonated PEEK

Nitrated PEEK

Development & application of PCM-containing microcapsules

Based on the state-of-the-art and preliminary trials:

- Paraffin waxes were selected as core materials, due to their high heat of fusion, heat capacity and thermal stability.
- Natural polymers were found suitable as shell materials due to their non-toxicity and stability.
- The coacervation technique was selected to be used for microcapsules preparation.
- Appropriate binding systems were selected for microcapsules fixation on textile substrates.

As a result, gelatine/arabic gum microspheres of paraffin were obtained by coacervation. These microspheres exhibit very good thermal resistance and good heat capacity and particle size distribution for two different temperature range:18°C and 37°C.

Development & application of chitosan microparticles

Dissolution of chitosan in acetic acid solution

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Drop wise addition to NaOH solution

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Filtration & washing of recovered microparticles

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Addition of glutaraldehyde aqueous solution

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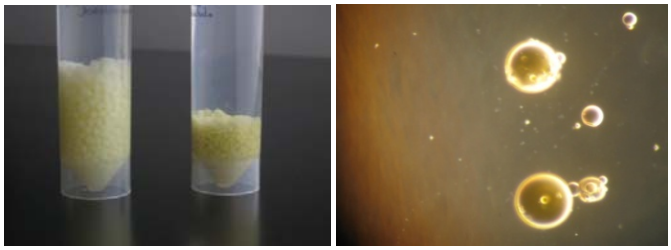
Filtration and washing



Pictures of chitosan microparticles, exhibiting antimicrobial

Development & application of alkoxysilane nanosols

1st series of trials

Preparation of a 1:1 distilled water/ethanol solution at pH 3.5-4.0

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Drop wise successive addition of methyltriethoxy-silane

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Fabrics treatment with the solution

↓

Padding, drying and curing

The treatment resulted in hydrophobic and antimicrobial properties, without affecting the handle of the fabric.

An optimum formulation of precursors was established. Addition of an accelerator led to uncontrolled polymerization and precipitation.

2nd series of trials

Mixing basic precursors (GPTES, GPTMS, ASB) in solution

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Controlled hydrolysis in acidic environment, leading to the formation of linear oligomers

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Application on textiles by padding, drying and curing

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www.safeprotex.org

Beneficiaries:

- **INOTEX spol,s.r.o. (CZ)**
- **RESCOLL Technical Centre of Materials (FR)**
- **TDV Industries (FR)**
- **De Montfort University (UK)**
- **Tampere University of Technology (FI)**
- **GAIKER Technological Centre (ES)**
- **Swerea IVF AB (SE)**
- **Next Technology Tecnotessile Societá Nazionale di Ricerca (IT)**
- **LEITAT Technological Center (ES)**
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- **CALSTA Work Wear S.A. (GR)**
- **NANOTHINX S.A. (GR)**
- **Suministros Iruñako S.V. (ES)**
- **CETEMMSA Technological Center (ES)**
- **SAR-ESPAÑA (ES)**
- **RESCUE GR (GR)**

SAFEPROTEX Public Releases

1. Informative poster of SAFEPROTEX . INTERPROTEC 2010 – 10th International Fair of Personal Protective Equipment, Czech Republic, October 14 - 17, 2010.
2. Papaspyrides CD. The European research project SAFEPROTEX – short overview. 4th Annual Public Conference - From EU Research to Industrial Innovation, Brussels, Belgium, April 2009.
3. 1st newsletter of SAFEPROTEX
4. Press release in Swedish published (www.swereaivf.se)
5. Sol-gel hybrid polymers for surface coating of textile materials, DMU Research Technology Showcase, September 9, 2010.
6. www.dmu.ac.uk/faculties/art_and_design/research/team/safeprotex/index.jsp
7. Announcement of 1st workshop http://www.basqueresearch.com/ekitaldia_irakurri.asp?Ekitaldi_Kod=2744&hizk
8. Monen tieteen yhteinen hanke. Textiili 6/2010: p. 14-15
9. Pavlidou S, Kotzia F. High protective clothing for complex emergency operations (2 articles in Greek). GreekFashion magazine; 94: p 40-42
10. Shen J, Smith E, Dogra N. Development of hydrophobic and antibacterial cotton fabric by sol-gel based surface coating. 7th International Conference on Polymer and Textile Biotechnology, Milan, Italy, March 2-4, 2011
11. PPE Conference of EURATEX, Brussels, 1-2/02/2011
12. Paul R, De la Fuente M, Martinez-Palau M, Garcia A, Gonzales-Vidal N, Brouta M. Thermal stress Sensoring system in personal protection equipments for emergency situations. 1st SMARTEX - Egypt 2011, Kafrelsheikh University, Egypt, May 23–25, 2011 *(upcoming conference)*.
13. Paul R, Serret A, Crespo L, Surribas A, Bautista L, Esteve H. Chitosan microspheres for antibacterial finishes. AUTEX 2011, Mulhouse – France, June 8-10, 2011 *(upcoming conference)*.