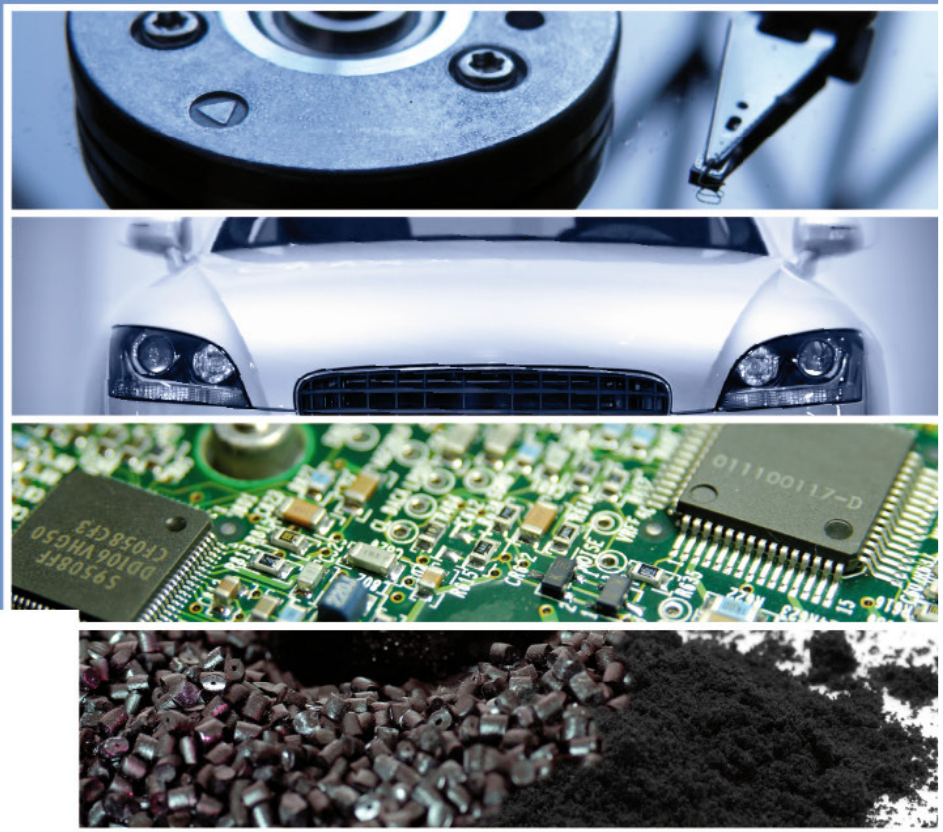
European Responsible Care Conference

Prague, 21-23rd Oct. 2009

NANO-ENGINEER YOUR FUTURE™



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www.nanocyl.com

Responsible Care and Nanomaterials Case Study Nanocyl

Dr. Frédéric LUIZI, R&D Director

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Bullet points

- Brief introduction about Nanocyl
- Toxicological, Exposure and Risk Assessment
- Examples of Benefits of Carbon Nanotubes (CNT)
- Risk communication

Nanocyl History & Milestones

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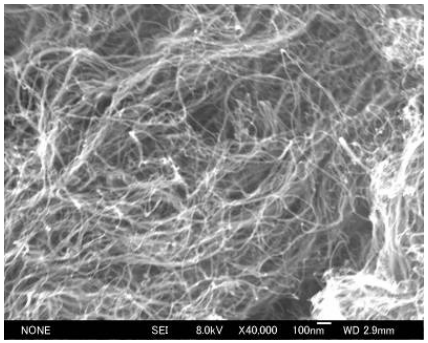
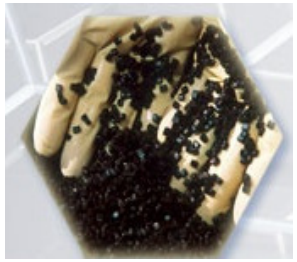
2002	2003	2004	2005	2006	2007	2008	2009
Nanocyl founded as a spin-off from the Universities of Namur and Liege	Contract to develop Flat Screens printing material	Investment in a CNT pilot plant unit	First commercial use of NC7000 in electronics	Demonstrated industrial production feasibility of CNT Move from the lab phase to the industrial phase for CNT Production Launch of Plasticyl product range	First commercial use of NC7000 in automotive	Completion of the construction of the industrial building (3000m²) Launch of Epocyl, Thermocyl & Aquacyl product range	Production of plastic compounds at industrial level

Nanocyl Product Lines



Industrial MWNT Powder - Nanocyl® 7000



Plastic Masterbatches and Compounds - PlastiCyl™

Dispersions - AquaCyl™, BioCyl™, ThermoCyl™ StatiCyl™ and EpoCyl™

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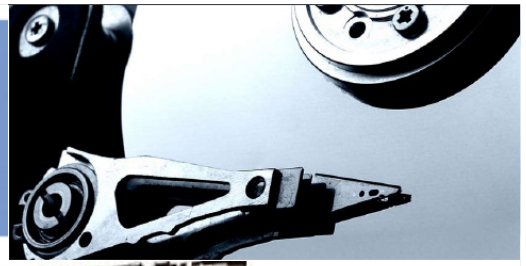
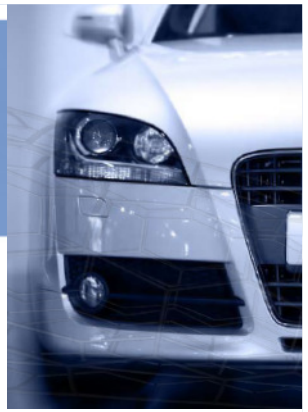
Electronic Packaging



IC trays and HDD components handling trays

- **ElectroStatic Dissipation** (ESD): Low loading required to reach the sufficient conductivity
- **Higher Cleanliness :** less outgassing and low particle count → decrease of the risk of contamination
- Elimination of Residual Voltage → more **homogeneous parts**
- **Better dimensional stability** and **recyclability**

Automotive Industry



- **ElectroStatic Dissipation** (ESD): Low loading required to reach the sufficient conductivity
- **Little impact on mechanical performances of polymeric parts**

Fuel System

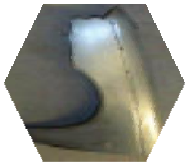
Electrostatic Painting

Fuel lines

Fuel Pumps

Mirror Housing

Door Handle



Fender

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- **Nanocyl cares for people**

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Toxicological overview

	Test Item	Test method	Test conclusion
In vitro	Cytotox.	Modified OECD 476	No tox.
	Dermal tox.	Modified OECD 431	No tox.
In vivo	Chronic Inhalation	OECD 403 and 413	LOEC at 0,1 mg/m³
	Ingestion tox.	Modified OECD 401	No tox.
Ex vivo	Impact on hemolysis	Referenced method	No tox.
	Impact on hemostasis	Referenced method	No tox.
Ecotox	Green algae inhibition test	OECD 201	On-going
	Daphnia mobility & reproduction test	OECD 202 & 211	On-going
	Fish mortality, growth & larval test	OECD 203, 210 & 215	On-going

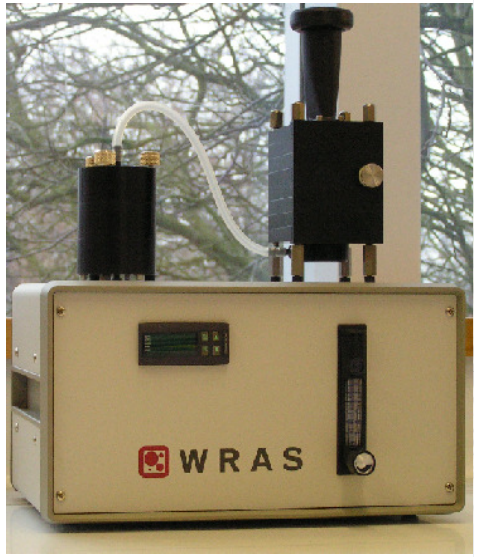
Risk assessment and management (1)

First : minimize exposure levels

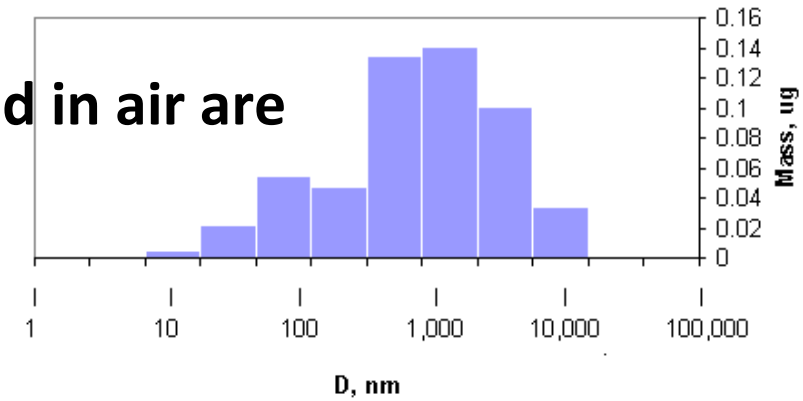
- Minimising workers exposure by technical measures (production in closed process, protective equipment and ventilation, information and formation)
- Regular exposure measurements in production and research
- No direct environmental exposure: closed process and CNTs embedded in polymer matrices for key applications
- MSDS and Code of conduct provided to customers
- Abrasion measurement for key applications: no free CNTs liberated

Risk assessment and management (2)

Second : measure exposure levels



- With the help of various organisations (Naneum Ltd.), the concentration in nanoparticles was measured with several methods at Nanocyl facilities
- There is limited evidence that a specific activity, i.e. taken samples and changing bags, resulted in an increase of particle number concentration and thus an additional emission of particles
- The CNT concentrations measured in air are
  - 1.45 µg CNT/m³ at the packaging
  - 1 µg CNT/m³ in extruder room
  - 0.25µg CNT/m³ in R&D offices



Risk assessment and management (3)

Third : assess the inhalation risk

- Starting from the LOAEC of 0.1mg/m³ resulting from the 90 days inhalation study (following OECD 413 guidelines – study performed in collaboration with BASF – published in Toxicological Science)
- Applying an assessment factor of 40
- A no effect concentration in air of 2.5 µg/m³ was estimated for an exposure of 8 hours per day.
- Measured concentrations are less than 1.5 µg/m³
- On top of that, personal protection equipments are used
- Conclusion, it is possible to minimize the exposure of workers in such a way that the health risk is negligible.

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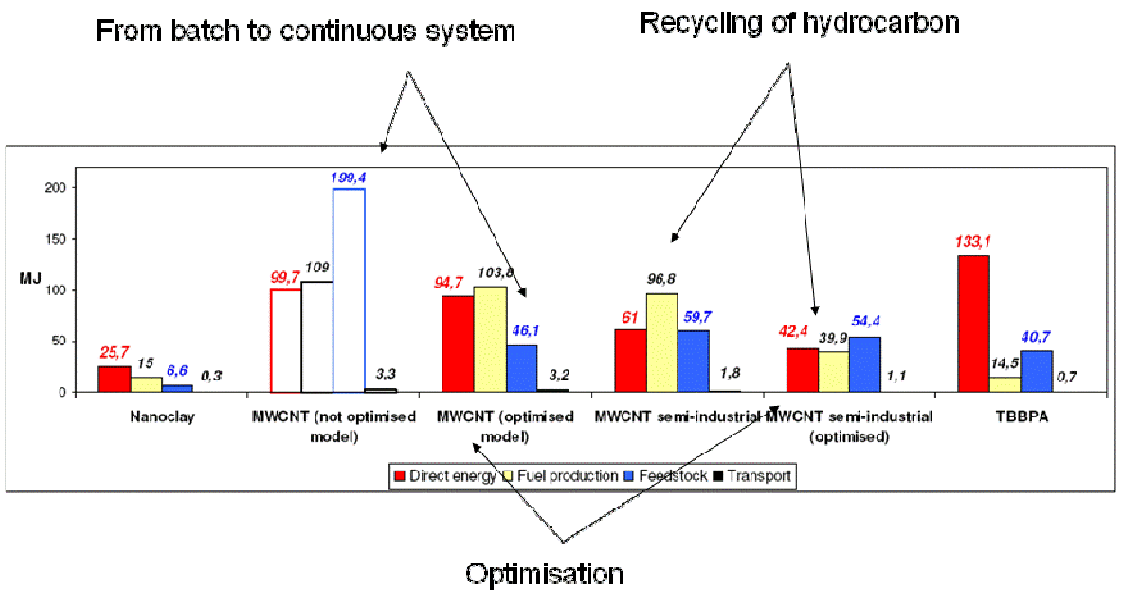
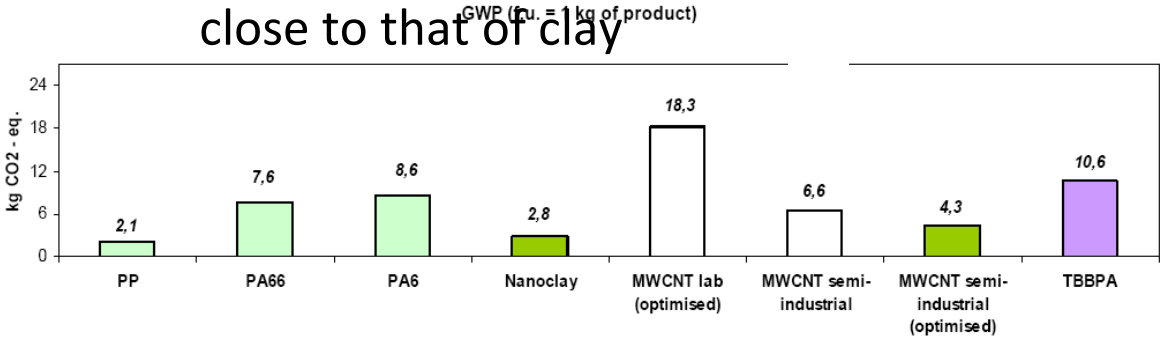
- **Nanocyl cares for the environment**

Optimisation of the environmental impact of CNT

- Improvement of the production process
  - Gross Energy Requirement (GER) below many polymers
  - Global Warming Potential (GWP) close to that of clay

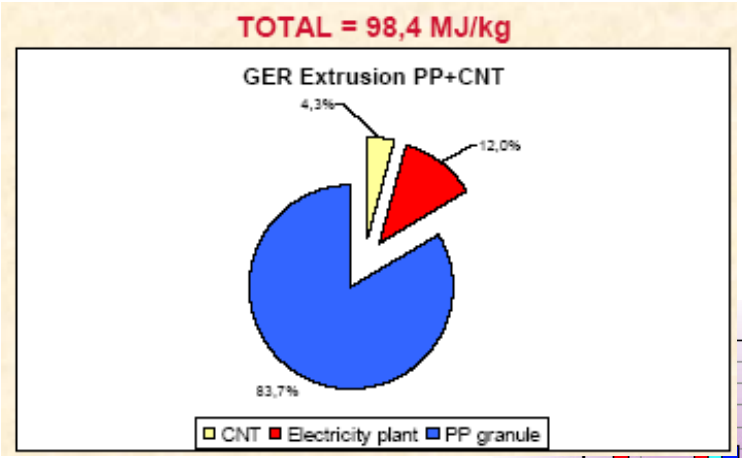




Courtesy of Prof. Camino (CDCMP – IT)

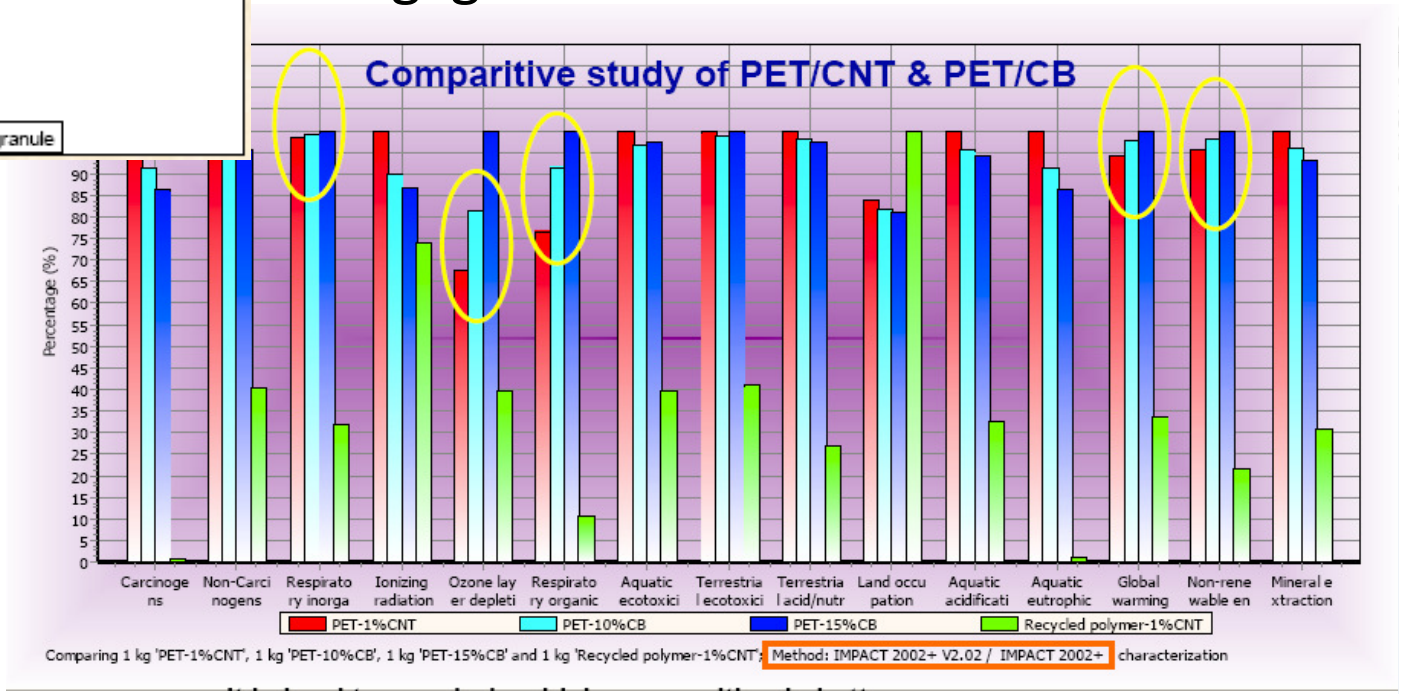
From CNT to nanocomposites

- Contribution of CNT and comparison



Courtesy of the Prof. Camino
(University of Turin – Italy)

- The beneficial impact of CNT on full part when comparing 1kg of existing materials with 1kg of new materials, is negligeable



• Courtesy of Prof. Jean-François FELLER – University of South Brittany (France)

Impact of CNT on the final products

- As the CNT represent so **little in weigth** in most products in which they are included, their beneficial environmental impact comes rather from the alternatives solutions they provide
- Hereafter, the real impact of the CNT as an enabling technology having highly beneficial impact on the environment is presented through 2 examples of CNT based coatings.

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Examples of applications in coating

- **Special focus of this presentation is on the applications of MWCNTs in high tech coatings**

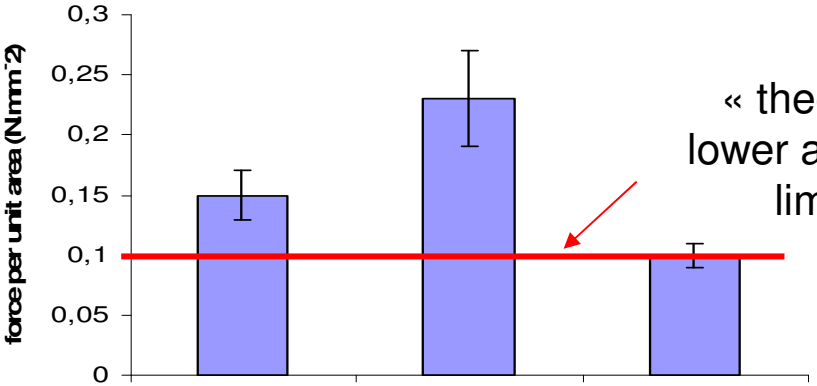
- **Application in fouling release coating**
  - **Nanocyl recently developed a new, solvent less, eco-friendly anti fouling coating for marine applications: BioCyl TM**

- **Application in fire protective coating**
  - **Protective thermal coatings containing on MWCNTs have been developed which can reduce insulation weight in automotive and aerospace applications.**

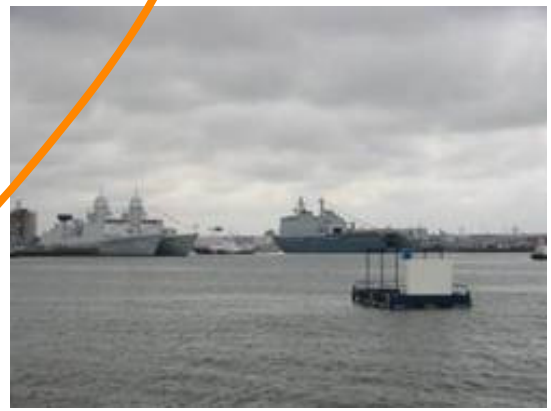
Anti-fouling application (1)

Various tests performed on algae and barnacles
- Short and long term settlement tests
- Removal tests
- Adhesion strength tests

Courtesy of Prof. Tony CLARE – UNEW (UK)



« theoritical lower adhesion limit »



Courtesy of Dr. Corne Rentrop – TNO.(NL)

Launch of BIOCYL

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Anti-fouling application(2)

- **BIOCYL™ does not harm marine organisms:** it does not contain any solvent, biocide, heavy metal or any other toxic substance.
- **BIOCYL™ could have a tremendous impact on the global warming:** the fouling release allows an annual reduction of 384 million tons CO_2 emissions and of 3.6 million tons of SO_2 emissions
- **BIOCYL™ preserves bio-diversity** by preventing invasive species and exotic diseases to invade foreign ecosystems.
- **BIOCYL™ has other industrial advantages:** easy to apply, short drying time, longer life

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Fire protection application (1)

- **CNT can be used as non halogenated flame retardant to improve the thermal stability of polymers**
  - Example : about 100°C gain of thermal stability for polyethylene in a classical test, with a lower filler content, a weight reduction and an easy processing
- **CNT can improve thermal protective coatings**
  - Example: Protection of metal and other substrate by a thin layer of plastic material containing less than 1wt% of MWCNTs, instead of commercial solutions containing 40 % of additive
  - This leads to weight reduction in insulation.

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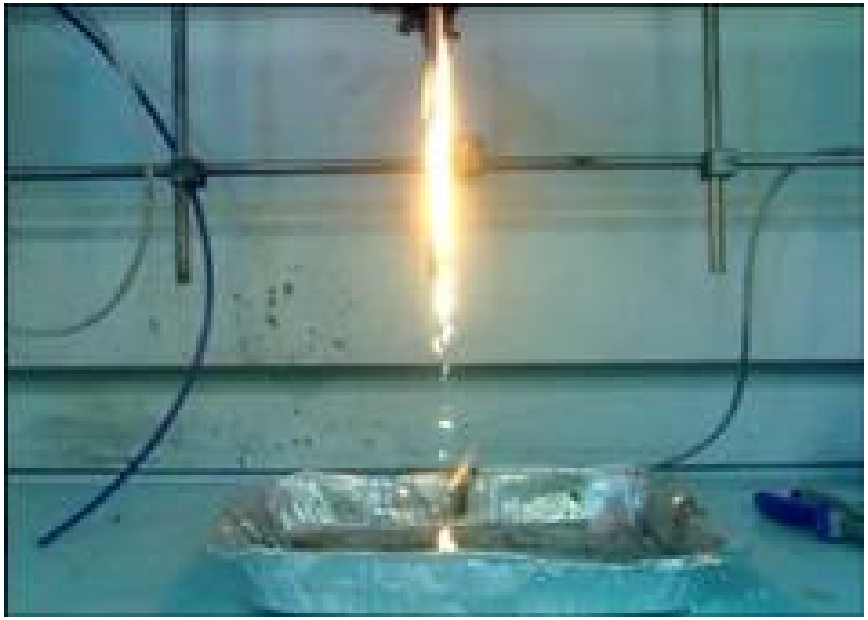
Fire protection application (2)

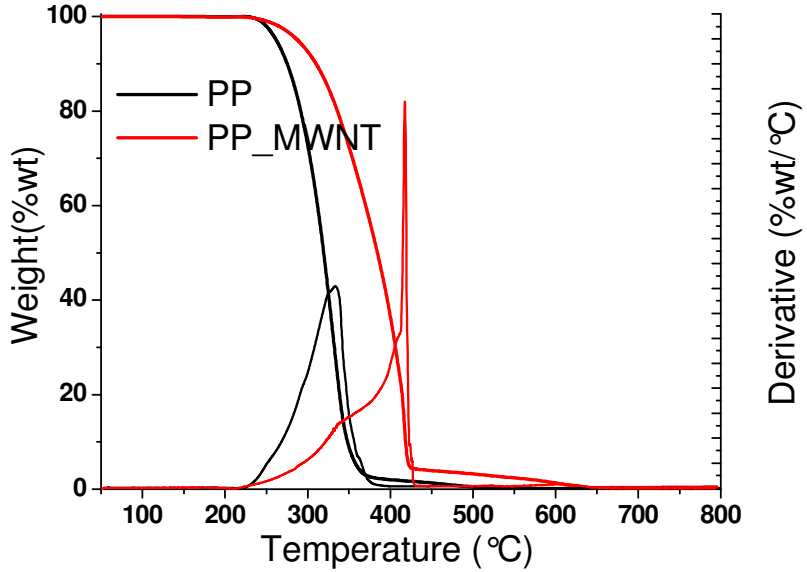


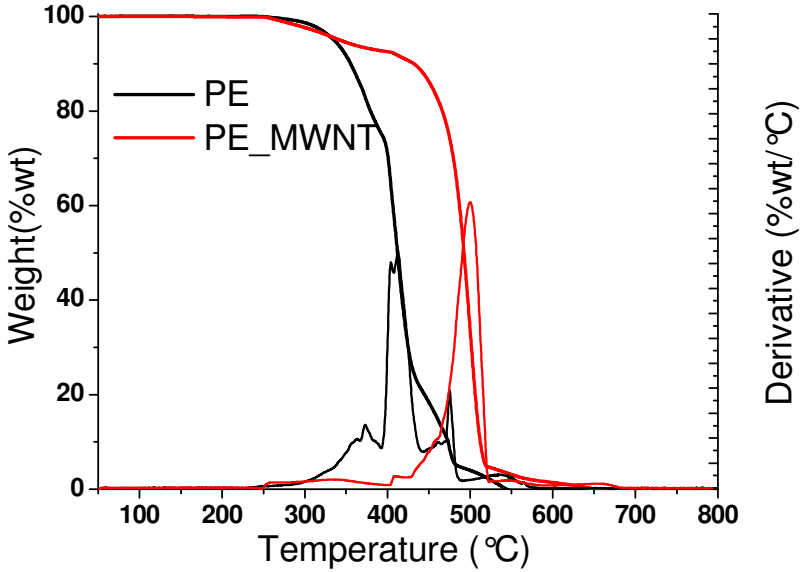
Fire Retardancy: Trading UL94 combustion test

- ✓ Pure PE: Fast burning and dripping (risk: flame propagation)
- ✓ PE with 1% MWCNTs :burns much more slowly, without dripping

Fire protection application (3)

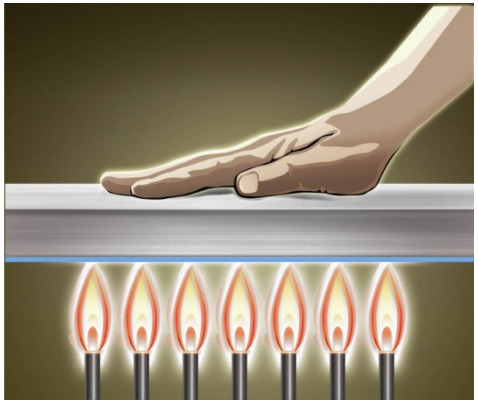
Stabilisation of polymer to thermal oxidation : example of poly-olefins

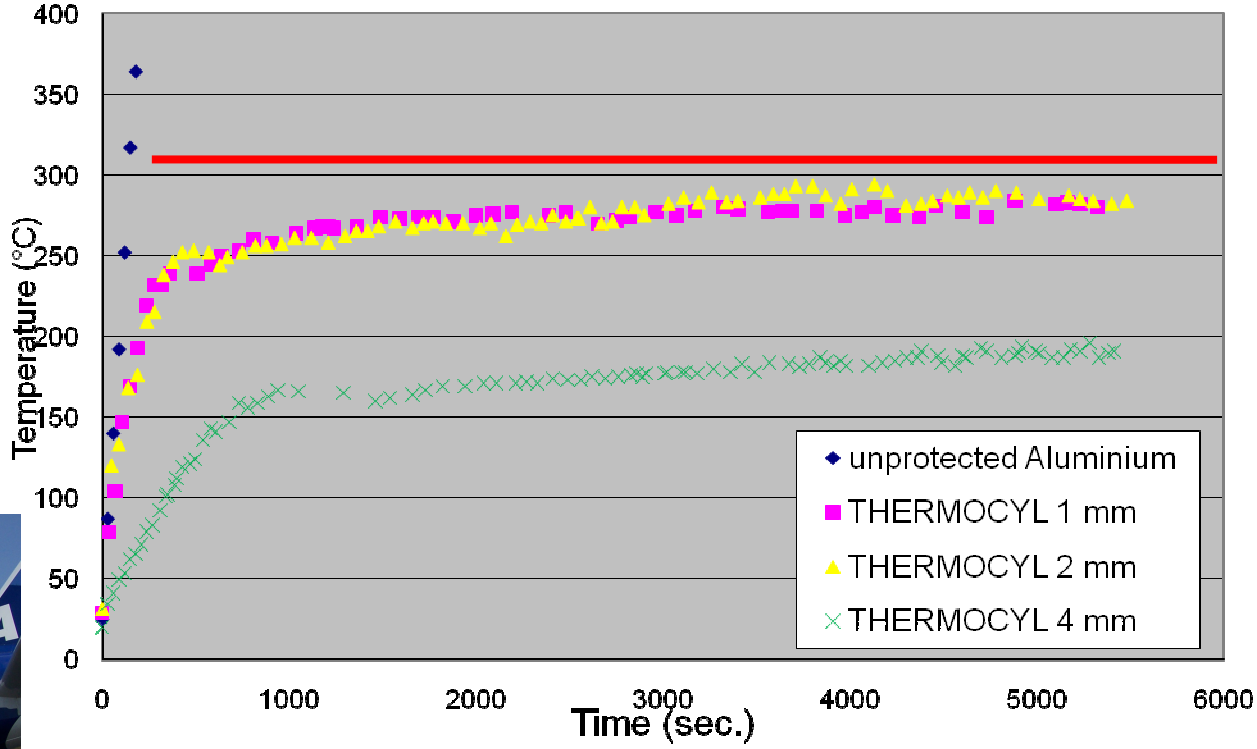




Thermal behaviour of nanocomposites in air (10 °C/min)

Fire protection application (4)





Thermal barrier coating ThermoCyl™

ISO 2685/ 1100°C / 116±10 kW/m2

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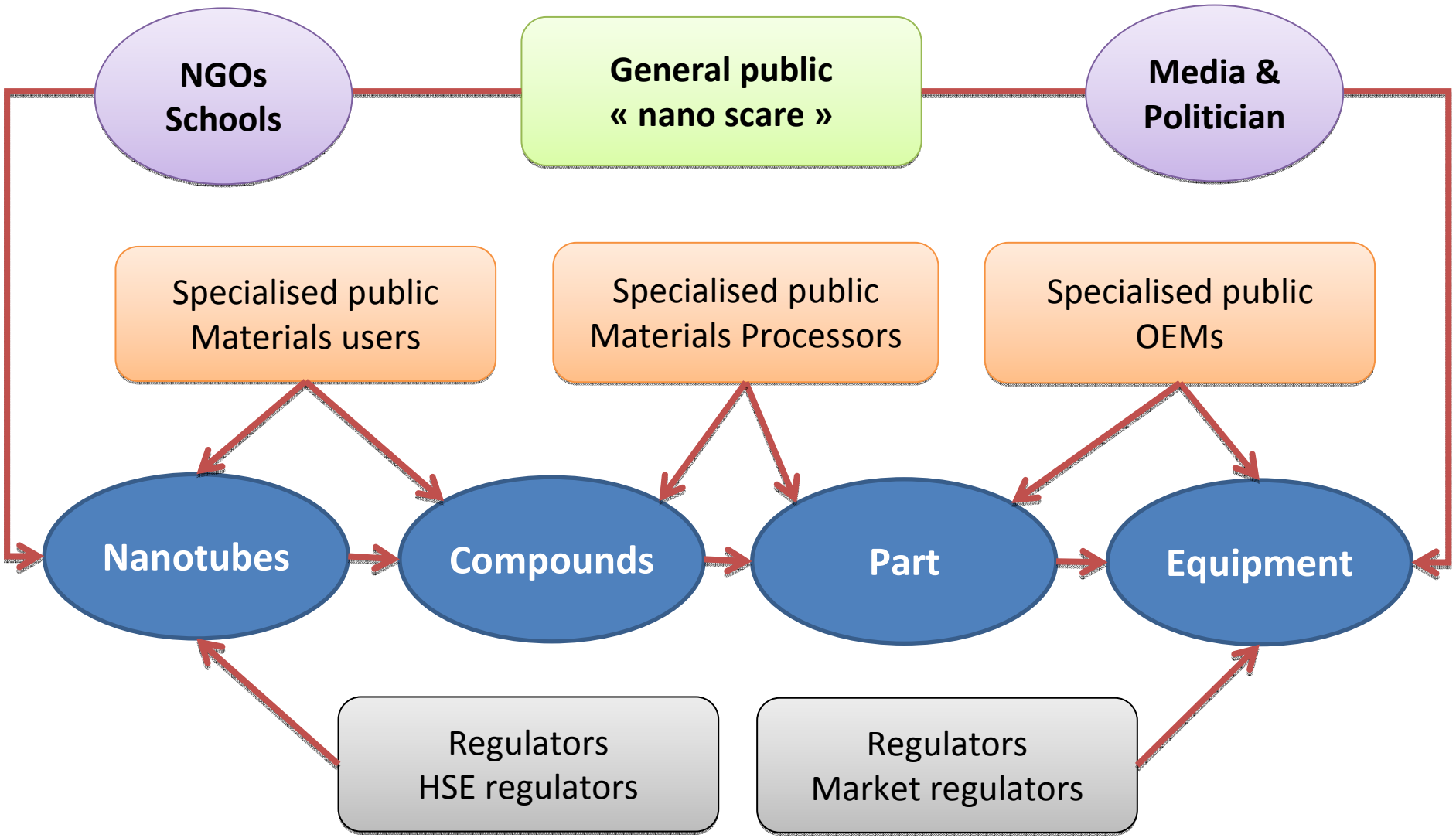
• Nanocyl's risk communication and public acceptance

Identification of stakeholders



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Risk communication

- **Establish routes of communication with all stakeholders**
  - Identify the right partner
    - Example: CEFIC, NIA, PACTE for communication with regulators
  - Communication on a regular basis
- **Clear, transparent messages**
  - There is no secret to hide. Let's be judged on facts rather than rumours and suspicion
- **Balance reaction about risks with pro-action about benefits**
  - On toxicological assessment and risk assessment, the demand for information anticipates what can be provided
  - On Life Cycle Analysis issues, there is little demand for information

Conclusions

- Carbon nanotubes can be thought of for their tremendous properties, but their are **more than just a filler**. They can allow a complete « rethink » of materials.
- In that process, Nanocyl will do its very best to ensure the **safety of workers, users** and **the general public**
- Nanocyl is largely engaged in the development of alternative solutions with signicant **beneficial impact on the environment**
- **Proactive communication** is essential

Thank you for your attention

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