

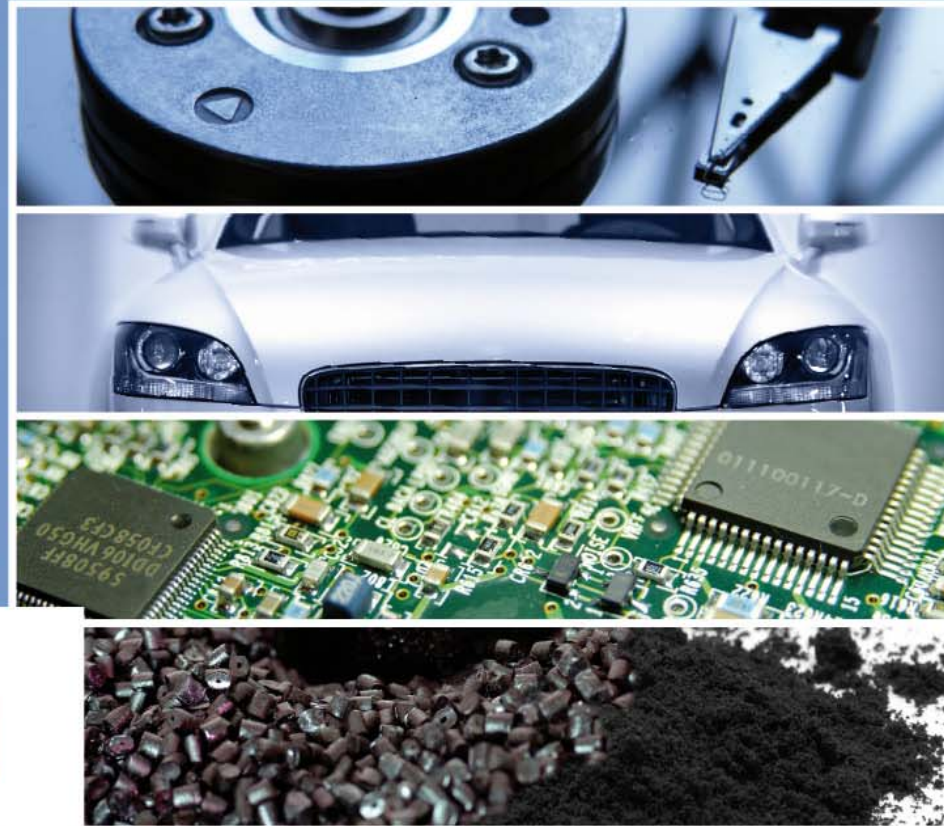
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NANO-ENGINEER YOUR FUTURE™



THE CARBON NANOTUBE SPECIALIST

www.nanocyl.com



The safe use of carbon nanotubes in coating applications
Prof A. J. Lecloux, HSE Manager
Dr. F Luizi, R&D Executive Director

Nanocyl at a Glance

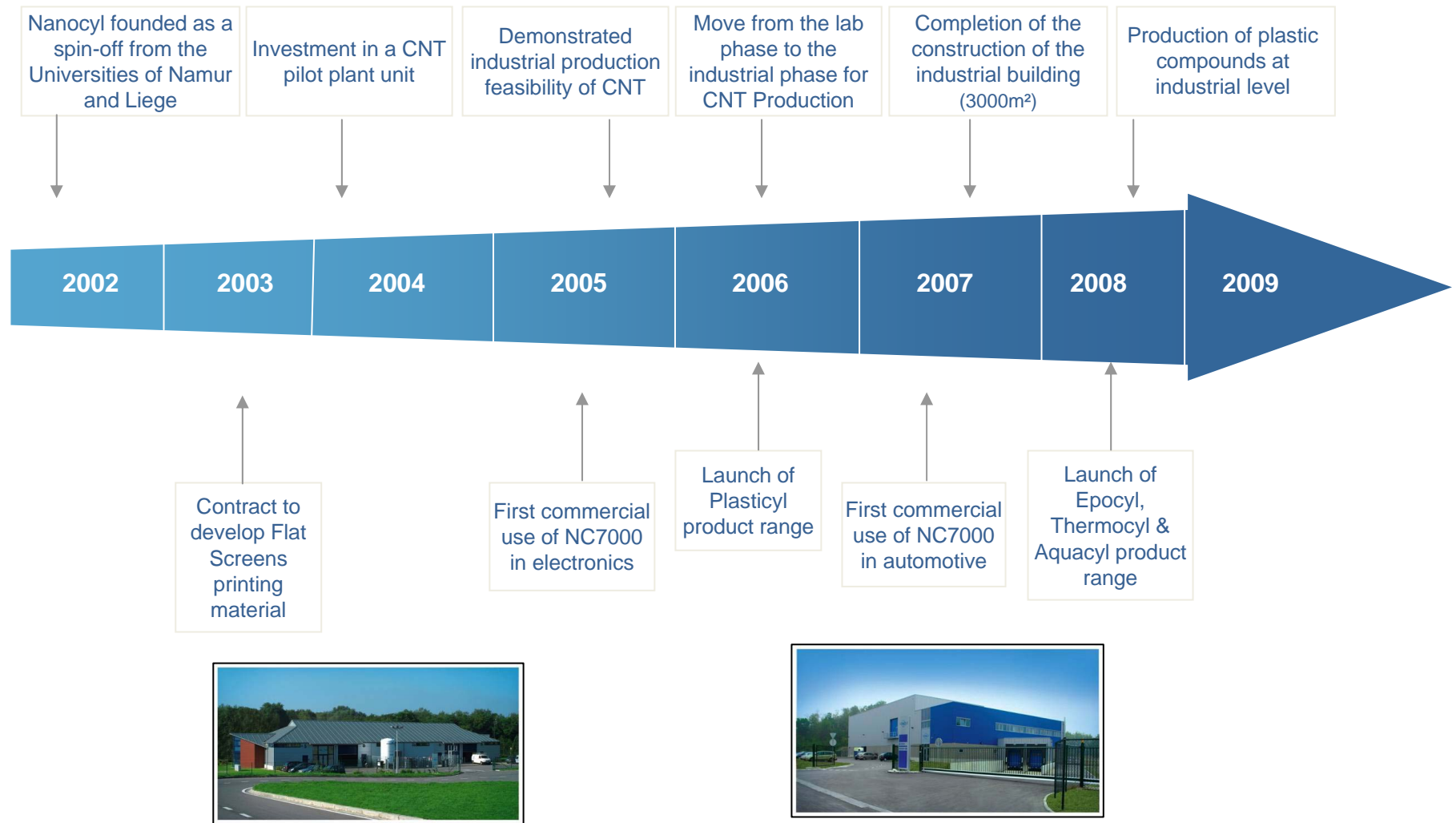
- Founded in 2002, privately owned

- 45 employees



- Headquarters in Sambreville, Belgium
Office representatives USA , Japan and South-Korea
- Distributors in South Korea, Taiwan, Japan, Europe, India, China
- Member of PACTE - **P**roducers **A**ssociation of **C**arbon nanotubes in **E**urope and CEFIC (European Chemical Industry Council)

Nanocyl History & Milestones



Benefits of CNTs as filler in plastic materials

- **Multi-walled carbon nanotubes (MWCNTs) are characterised by very high mechanical strength, very good electrical conductivity and very good thermal conductivity.**
- **They can be easily dispersed in plastic materials and improve their mechanical properties in such a way that significant weight reduction can be achieved at equal mechanical performances.**
- **When used in automotive or aircraft applications, this will lead to fuel saving and consequently to a reduced ecological burden and lowering of CO₂ emissions**
- **These performances allow energy and resource saving.**

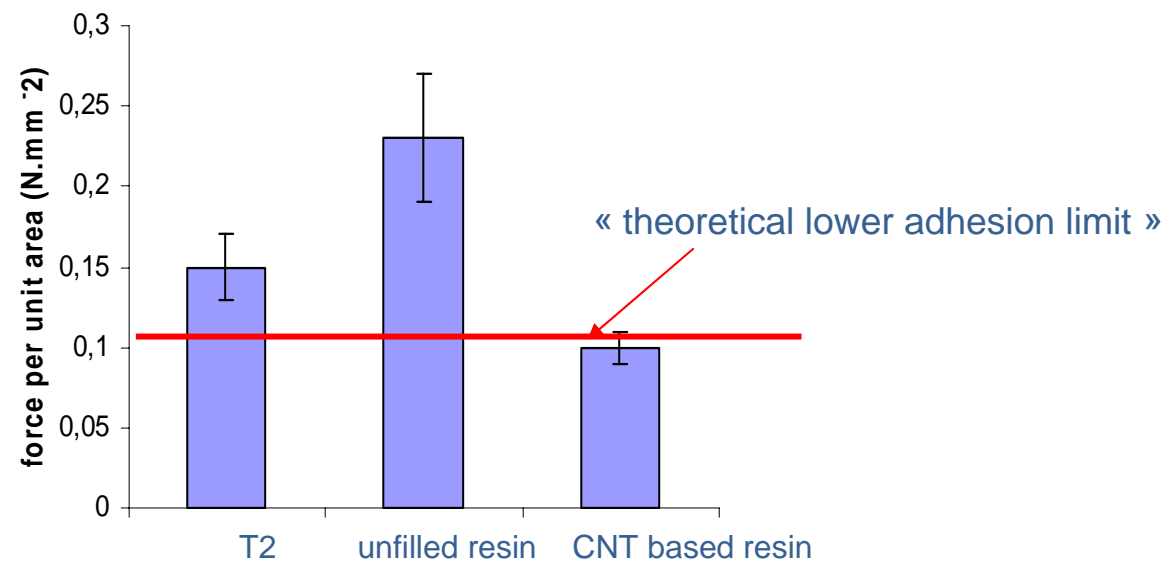
- **Special focus of this presentation is on the applications of MWCNTs in high tech coatings**
- **Application in anti fouling coating**
 - Nanocyl recently developed a new, solvent less, eco-friendly anti fouling coating for marine applications: BioCyl™
- **Application in fire protective coating**
 - Protective thermal coatings containing on MWCNTs have been developed which can reduce insulation weight in automotive and aerospace applications.

Biological evaluation of BioCyl™, CNT based resin

Adhesion strength of young adult barnacles

Results:

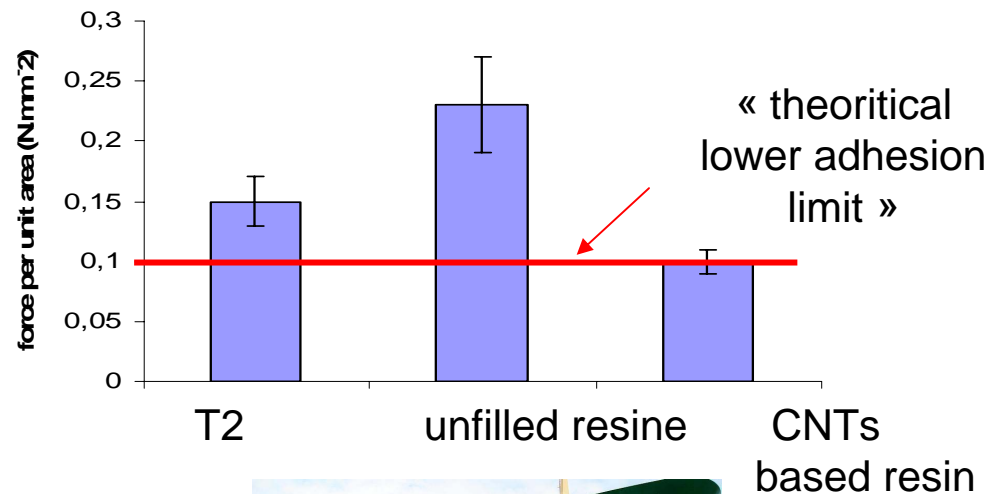
Much lower adhesion strength than the commercial paints
No more trace of basal plate remaining attached to the surface



Anti-fouling application (2)

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)



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



Launch of BIOCYL

Anti-fouling application(3)

- **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 CO₂ emissions and of 3.6 million tons of SO₂ 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

Real life trial



Fire protection application (1)

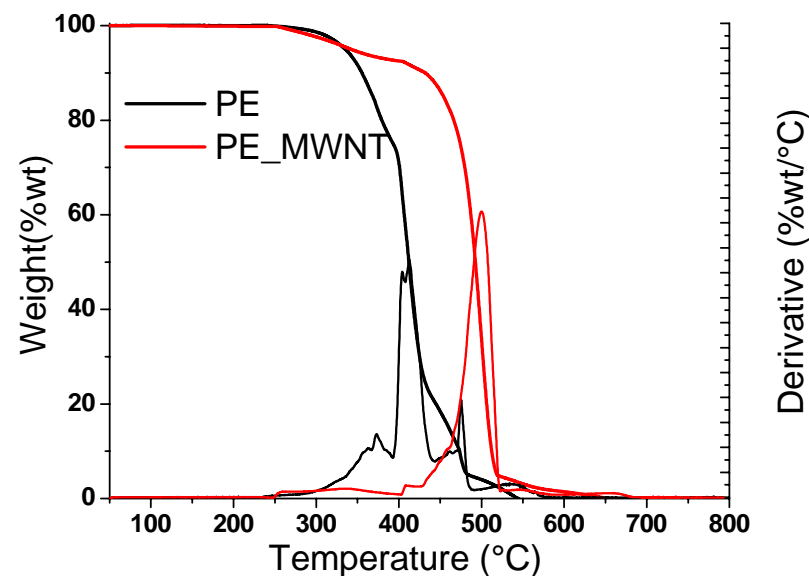
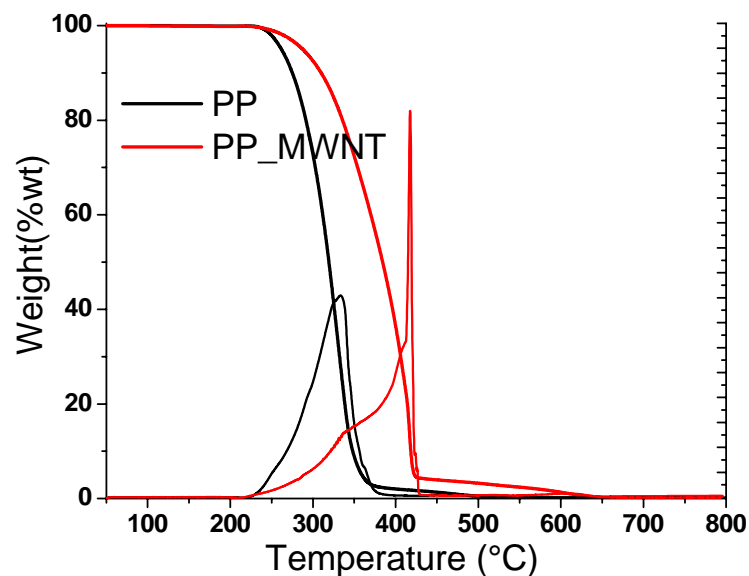
- **CNT can be used as non halogenated flame retardant to improve the thermal stability of polymers**
 - Example : about 100°C gain of thermal stability for polyethylene in a classical test, with a lower filler content, a weight reduction and an easy processing
- **CNT can improve thermal protective 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.



Fire Retardancy: Trading UL94 combustion test

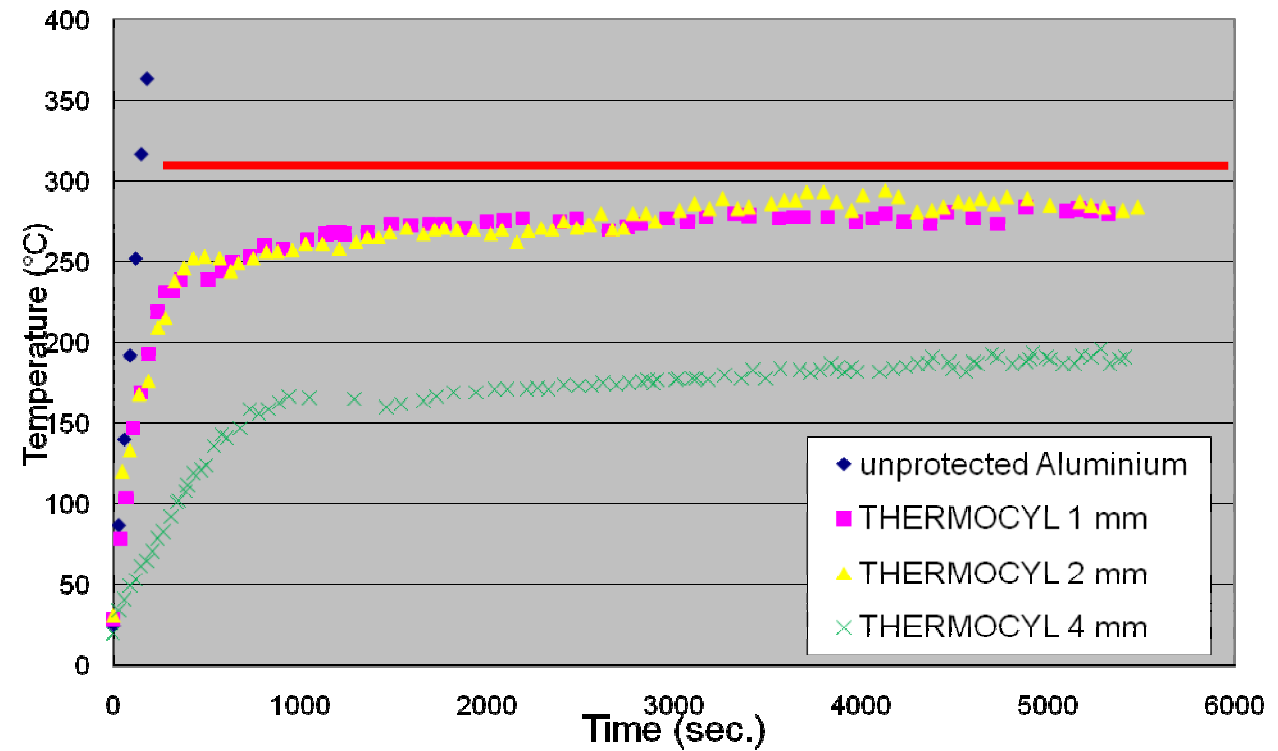
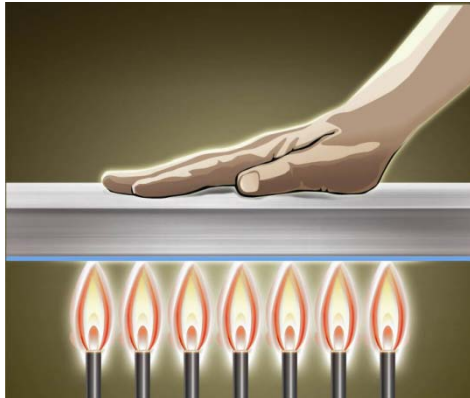
- ✓ Pure PE: Fast burning and dripping (**risk: flame propagation**)
- ✓ PE with 1% MWCNTs :burns much more slowly, without dripping

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



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

Fire protection application (4)



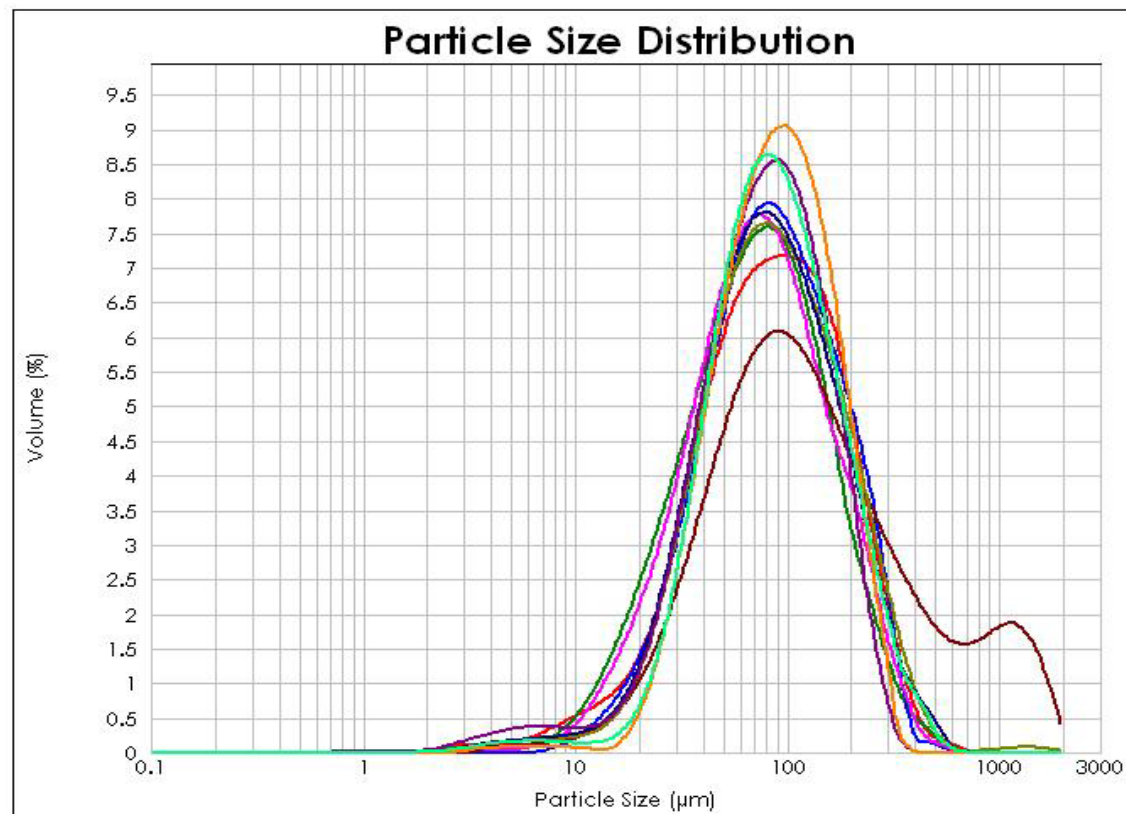
Thermal barrier coating ThermoCyl™

ISO 2685/ 1100°C / 116±10 kW/m²

Nanocyl responsible risk approach

- **To carry out toxicological studies according to OECD protocols in cooperation with other EU research teams**
 - No dermal acute toxicity, no toxicity by ingestion in rats and 90 days inhalation toxicity recently published
 - Eco-toxicological testing in progress
 - Negative carcinogenic test in rats during 2 years (published)
- **To work on the exposure assessment in cooperation with Naneum**
 - to develop detection devices
 - to measure exposure levels in production and research facilities
 - to help our customers to assess exposure and risk

Only a small fraction of CNTs is inhalable



Assessment of exposure to CNTs (2)

- Need to define the exposure level and the nature of the particle to which workers are exposed
- But difficulties in measuring particle size distribution in the nano range
- To solve this problem the Naneum company (UK) developed portable sampling devices covering particle sizes from 3 nm up to 30 microns
- Need to distinguish CNT from the background
- Nanocyl is cooperating with Naneum to develop CNT specific detectors

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

Second : measure exposure levels

- With the help of various organisations, 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 $\mu\text{g CNT}/\text{m}^3$ at the packaging
 - 1 $\mu\text{g CNT}/\text{m}^3$ in extruder room
 - 0.25 $\mu\text{g CNT}/\text{m}^3$ in R&D offices

Third : assess the inhalation risk

- Starting from the LOAEC of $0.1\text{mg}/\text{m}^3$ resulting from the 90 days inhalation study
- Applying an assessment factor of 40
- A no effect concentration in air of $2.5\text{ }\mu\text{g}/\text{m}^3$ was estimated for an exposure of 8 hours per day.
- Measured concentrations are less than $1.5\text{ }\mu\text{g}/\text{m}^3$
- 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.

- **Willingness to be transparent: LCA and risk benefits analysis**
- **Definition of an OEL for workers**
- **Systematic measurements of nanoparticles concentration and particle size distribution in air and comparison to background both in Nanocyl and when needed at customer facilities**
- **Cooperation to OECD programmes on CNTs**
- **Registration under REACH and TSCA in 2010**



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Nanocyl S.A.

Rue de l'Essor 4 Tel. +32 71 750 380
B-5060 Sambreville Fax +32 71 750 390
BELGIUM sales@nanocyl.com

Sales & technical

Tel. +32 71 750 386
Fax +32 71 750 390
sales@nanocyl.com

R&D

Tel. +32 71 750 671
Fax +32 71 750 390
r-d@nanocyl.com

www.nanocyl.com



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