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HSE manager



NANO-ENGINEER YOUR FUTURE™



Risk management of multi-walled carbon nanotubes (MWCNT - NC7000™) along the life cycle

Forum 2016- « Mesurer l'exposition des personnes au travail » - Lille Grand Palais
10 juin 2016



Nanocyl: A dynamic company



Founded in 2002, BELGIUM



HIGHLY SKILLED STAFF: <50 people



✓ 2 facilities: R&D and Production, Sambreville
✓ 1 warehouse



✓ 400 tons of industrial MWCNT capacity
✓ 3500 tons of thermoplastic compounds capacity



Provide the most **electrically conductive** multiwall carbon nanotube (MWCNT) in the world



✓ **International certification:** ISO 9001
✓ **NC7000 MWCNT registration:** REACH (EU), TSCA PMN granted (USA), CEPA NSN Schedule 5 (CANADA)

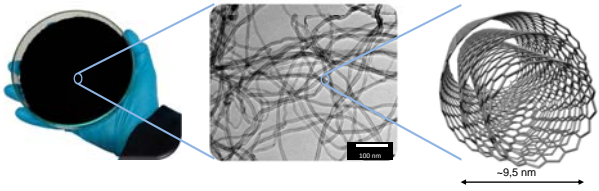
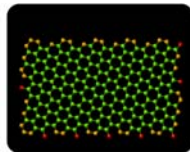
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Short entangled multi-walled carbon nanotubes produced by Nanocyl: NC7000™

Properties	Values	Units
Average Diameter	9,5	nm
Average Length	1,5	µm
C purity	90	wt%
Surface area	250-300	m ² /g
Bulk density	70-75	g/L

Highly conductive MWCNT powder

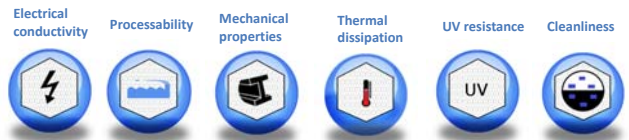


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NC7000™ carbon nanotubes outperform other carbon fillers

NC7000™ is an ideal and multifunctional additive in different matrices:



Our strategy is to focus and deliver benefits to the challenges of the Transportation, Energy, Electronics and industrial sectors.



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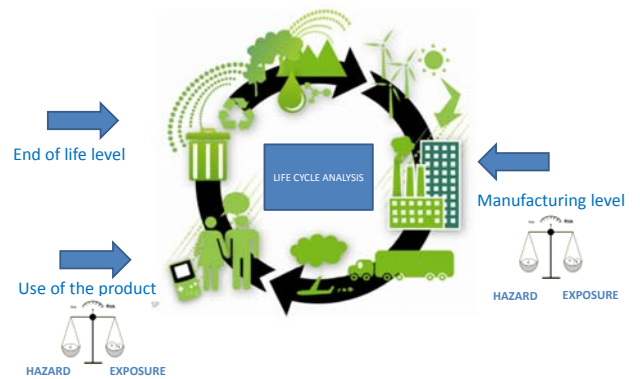
Responsible care product stewardship program

Product stewardship towards Nanocyl involves the active management of chemical products on site and beyond, and a dynamic engagement with downstream users and suppliers.

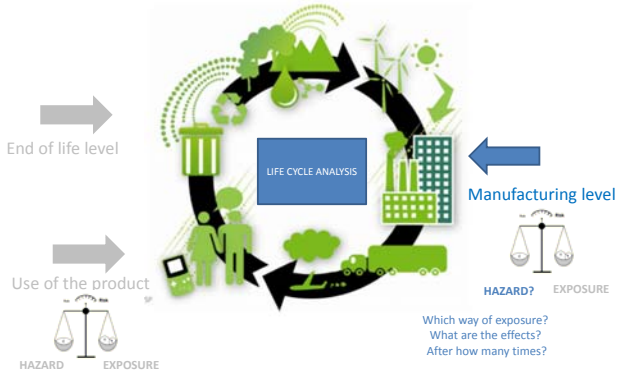
- **Risk based analysis:** Research and testing for the hazard and risk evaluation of NC7000™. Nanocyl is active in many collaborative projects, development of methods for exposure assessment and characterization
- **Reduction of actual and potential risks:** RMM (Risk Management Measures) including product handling guidelines, safety procedures,...
- **Commitment to continuous improvement**
- **Commitment to provide product information and support:** Communication with customers on safe handling, Handling Guidelines, HSE Position Paper, MSDS,...
- **Partnerships:** Participation in association work (e.g. Cefic, national taskforce, NIA), in dialogues with stakeholders (e.g. OECD)



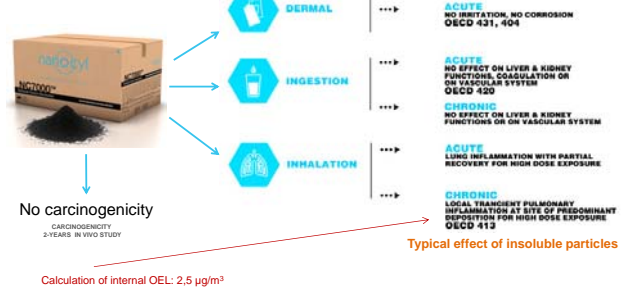
Safe use of NC7000™ along LCA



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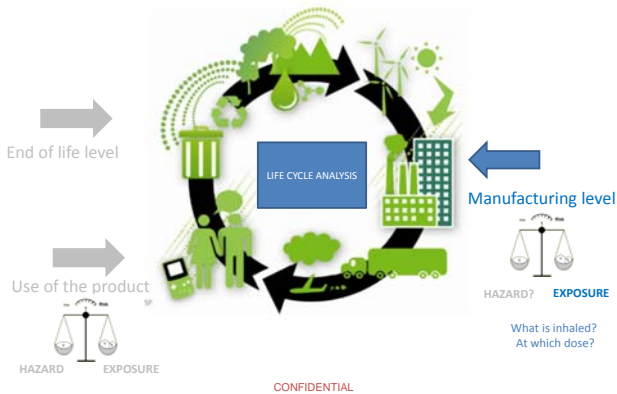
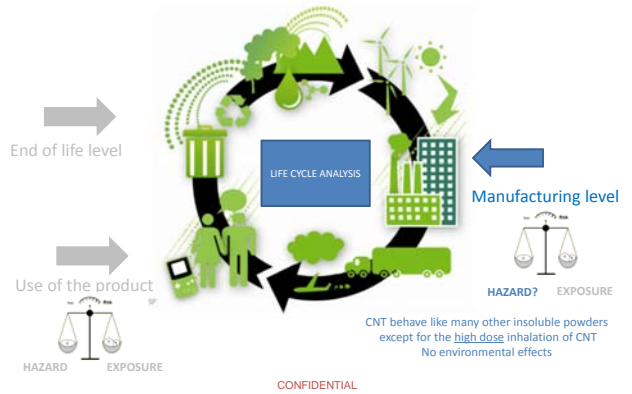
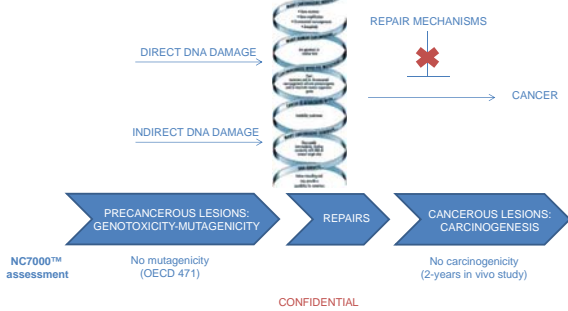


WHAT ABOUT HUMAN HEALTH OF NC7000™ (powder)?

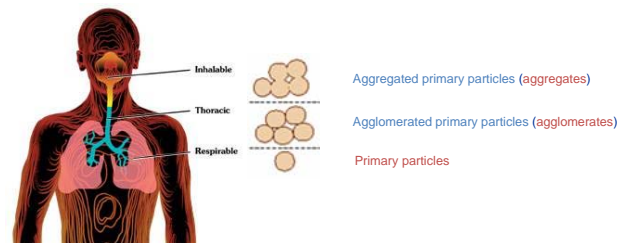


News
Carbon nanotubes: the new asbestos?

Calls for caution as nanotubes cause precancerous growths in mice.



WHAT IS INHALED BY THE WORKERS?
HOW DEEP THE CNT CAN ENTER THE RESPIRATORY TRACT?



Workers are mainly exposed to aggregates/agglomerates (mean diameter 14 µm) instead of isolated NC7000™ → Risk Management measures similar to traditional dust have to be applied

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Manufacturing level: CNT field measurements

Personal exposure to airborne MWCNT: determined by measuring the concentration of elemental carbon (EC) in the breathing zone of the worker. (IOM respirable sampler 2,2l/min with a metallic cyclon Casella)

→ particles present in the breathing zone of the workers are collected onto a quartz filters of 25mm diameter for offline analysis

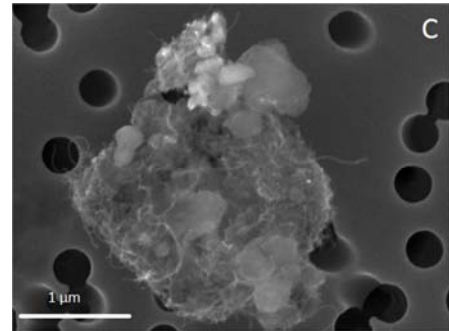
offline analysis: concentration EC is evaluated - the filters are thermally treated in helium atmosphere and oxygen is added to the atmosphere to evolve or oxidize the carbon component. EC is determined by the quantification of the carbon dioxide produced during the combustion phase. EC is further categorized into EC1, EC2 and EC3 based on oxidized temperature. MWCNT are usually observed in EC3.

→ The filters can be also semi-quantitatively analyzed by SEM/TEM or EDX in order to evaluate the presence of free-single or aggregate/agglomerate MWCNT.

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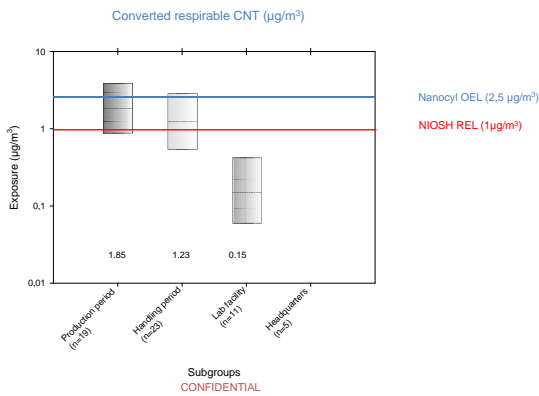
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Manufacturing level

Typical airborne structures

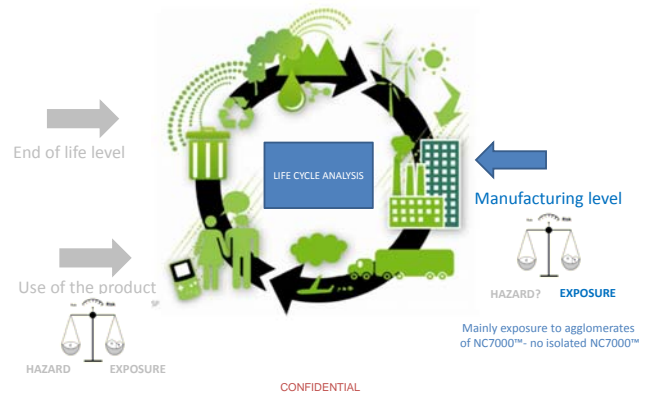


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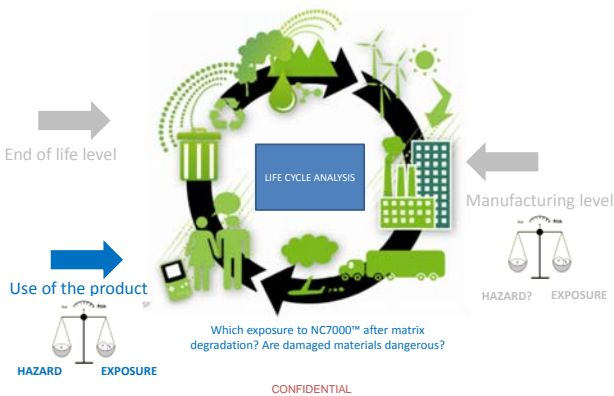
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Manufacturing level



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Safe use of NC7000™ along LCA



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Use of NC7000™ containing product

Different kind of stress cases can be considered and can be categorized into:

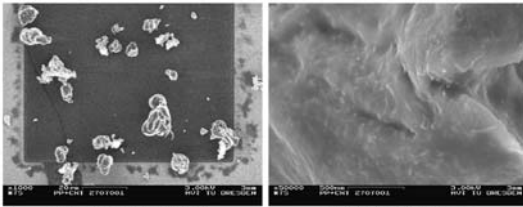
PHYSICAL PROCESS (e.g. abrasion, cutting, drilling)	CHEMICAL PROCESS (e.g. influence of solvents, thermal degradation)	ENVIRONMENTAL PROCESS (e.g. weathering)
<p>ABRASION / SANDING / DRILLING on: • Thermoplastics (PP, TPU, POM, PVDF, PA) • Hardened resin (epoxy, PU) • Rubber (NR, SBR/BR, NR/BR, FKM, EPDM and NBR) loaded or not with NC7000™</p>		<p>UV WEATHERING on: • Thermoplastics (POM, TPU, PC, HDPE) • Hardened resin (PU, epoxy) • Rubber (NR) loaded or not with NC7000™</p>

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ABRASION: ABRASION OF THERMOPLASTIC (PP) CONTAINING NC7000™

Surface morphology - PP/CNT



a) swarf particles of PP-CNT magnification 1 : 1-10³
b) swarf particles of PP-CNT magnification 1 : 5-10⁴

No protrusion and no free CNT were found in the swarf. SEM images show only particles with embedded CNTs

Is there a difference in term of lung effect (abraded material w or w/ NC7000™)?

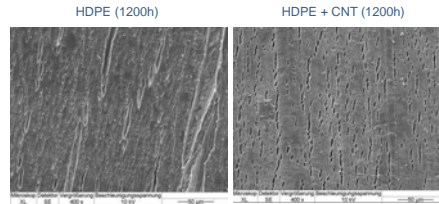
No additional lung toxicity with the material containing NC7000™

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UV-WEATHERING: WEATHERING OF THERMOPLASTIC (HDPE) CONTAINING NC7000™

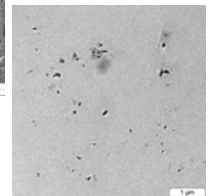
Surface morphology - HDPE/CNT



HDPE (1200h) HDPE + CNT (1200h)

No migration of CNT to the surface during ageing

Leaching medium (after sonication)



Release from composites was dominated by matrix NOT by nanofiller.

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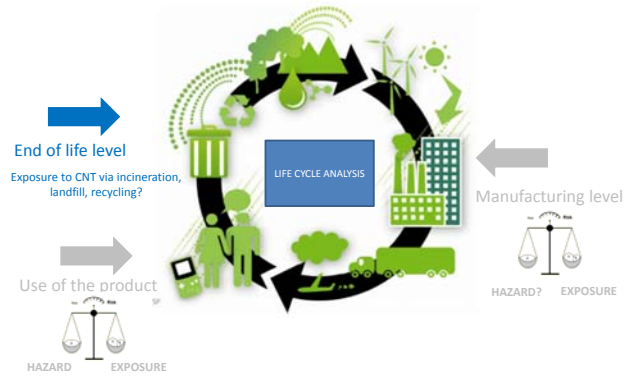
Safe use of NC7000™ along LCA



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Safe use of NC7000™ along LCA

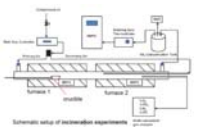


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Use of NC7000™ containing product

INCINERATION OF MATERIALS CONTAINING NC7000™



INCINERATION on:

- PC
- PA
- PE

loaded or not with NC7000™

Only soot and no CNT - no free CNT taken from airborne samples were observed.

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Handling guidelines depending on Exposure Scenarios

Handling guidelines, similar to those applied for insoluble particles, are needed to avoid high dose exposure.

STEP 1: Identify the risky tasks

	PRODUCT FORM	TASKS/OPERATIONS	EXPOSURE POTENTIAL
PHYSICAL STATE OF CNT	Dry powder	Handling: opening bags, weighing, measuring, packaging, transferring	High
		Processing: blending, mixing, casting, extruding, pulling, grinding, scraping, mixing	
	Suspension (liquid/paste)	Handling: opening packaging, transferring	Moderate
		Processing: aerosolization, mixing, spraying, coating	
	Embedded in polymeric matrix	Cleaning/Maintenance: powder spillage	Moderate
		Processing: cutting, grinding, sawing, spraying, whirling	
		Handling: packaging, transferring, weighing, opening bag	Low
		Processing: moulding, extrusion	
		Cleaning: granules spillage	

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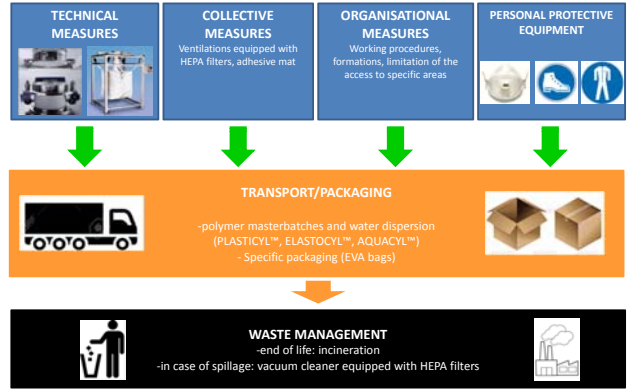
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Handling guidelines: High exposure potential

STEP 2: Support the customer in the choice of the appropriate risk management measures to apply



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Risk management measures

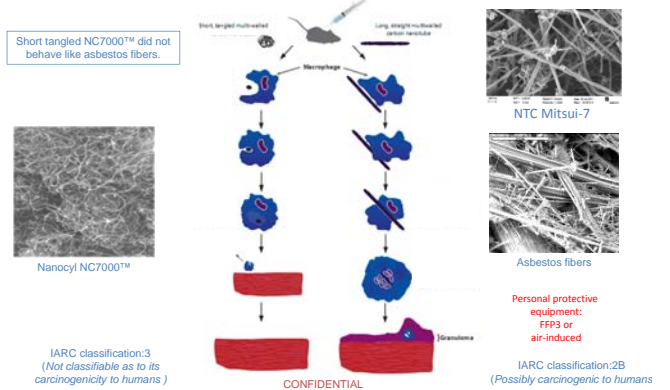


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Take home message

- Pro-active attitude within Nanocyl towards HSE questions
- Based on available recognised (eco)toxicological data, it appears that MWCNT behave similarly to many other powders except for the inhalation of high doses where CNT behaves like traditional insoluble particles
- As soon as MWCNT are embedded in a matrix no release of free particles is expected
- Handling guidelines similar to those applied to traditional insoluble particles are sufficient to ensure a high level of safety
- Compliance is a priority for Nanocyl :
 - Regulatory watch at European, international and national level
 - EU REACH registered
 - US TSCA PMN granted
 - Canada CEPA –Schedule 5 grant agreement

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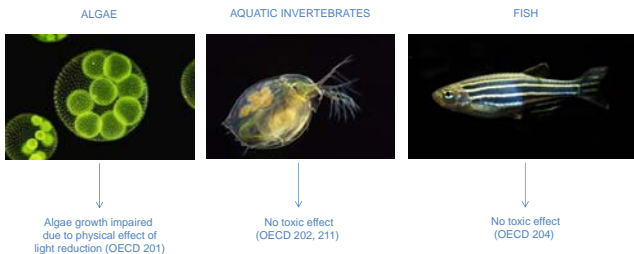
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(Eco)toxicological overview – NC7000™



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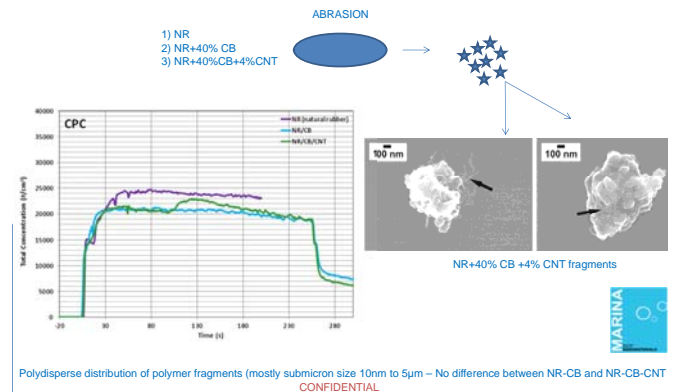
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(Eco)toxicological overview – NC7000™

WHAT ABOUT ENVIRONMENTAL EFFECTS OF NC7000™?



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ABRASION
 ABRASION OF RUBBER CONTAINING NC7000™

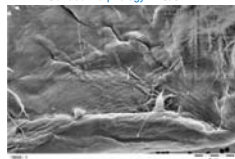
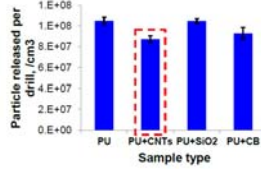
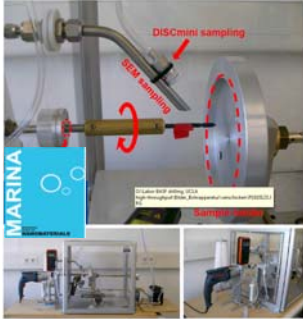


Polydisperse distribution of polymer fragments (mostly submicron size 10nm to 5µm – No difference between NR-CB and NR-CB-CNT)

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DRILLING

DRILLING OF CROSSLINKED PU CONTAINING NC7000™
AND COMPARISON WITH PU FILLED WITH CB AND SiO₂



No protrusions were found and no free CNT were found in the swarf

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