Risk prediction and management tools

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OUTLINE

1. SAFER BY DESIGN APPROACH
2. FP7-SANOWORK PROJECT
3. IMPACT TO MARKET
4. INTEGRATION OF SAFER BY DESIGN STRATEGY
5. INSURANCE SECTOR
6. PROSPECTIVE
7. CONCLUSION

SAFER BY DESIGN APPROACH

RISK MANAGEMENT CONTROL

TRADITIONAL HIERARCHY OF CONTROLS (HAZARDOUS CHEMICALS)

4 **Personal Protective Equipment** — *Respiratory/Dermal protection*

3 **Administrative Controls** — *Best practice (vacuum cleaners)*

2 **Engineering Controls** — *Fume hoods/Local exhaust ventilation/Filtration*

1 **Elimination/Substitution** — *?*

STATE OF THE ART

PREVENTIVE RRS

BENEFIT

HEALTH / SAFETY

COST

PERFORMANCE MATERIALS / PROCESS EXTRA STEPS, INSURABILITY

CHALLENGE

SAFER BY MOLECULAR DESIGN (SbymD)

SAFER BY MOLECULAR DESIGN SOLUTIONS

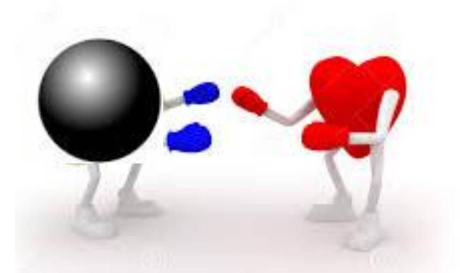
Wet dispersion state……..
Matrix encapsulation

RELEASE

FATE, KINETICS

Homo- and heteroaggregation processes, depending on ENM properties and media components

BIOLOGICAL REACTIVITY



Surface coatings are the primary dictators of many important nanomaterial properties, such as solubility, redox surface reactivity and macromolecule or cell surface interactions

KNOWLEDGE NEEDS TOWARDS SAFER DESIGN

1°

DATA GENERATION / GATHERING

NMs intrinsic properties   Biological characterization outputs

BED: Biologically Effective Dose

2°

ADVERSE-EFFECTS PREDICTING MODELS

Nanoinformatics / bioinformatics/ computational nanotoxicology

3°

VALIDATION IN REAL ENVIRONMENT

Integration within real industrial processing lines

Evaluation as primary prevention control tools

Guidelines based on Cost/Benefit ranking

Transfer to Nanotech - Insurance

FP7-SANOWORK PROJECT

SANOWORK PROJECT

IDENTIFICATION

Title: ***SAFE NANO WORKER EXPOSURE SCENARIOS***

Acronym: ***SANOWORK***

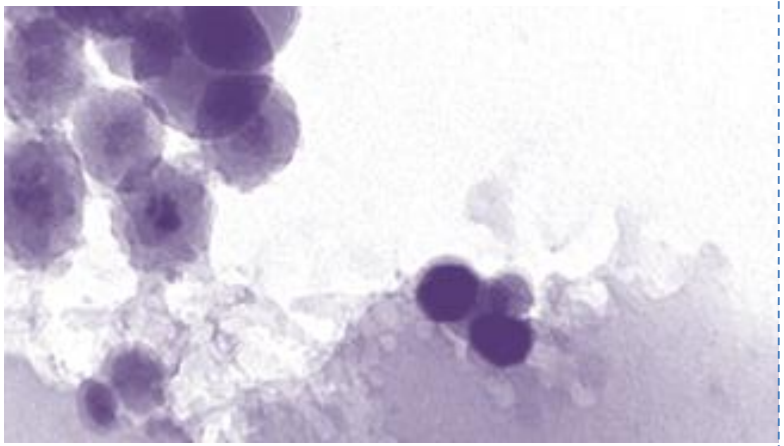
Grant Agreement N.: ***NMP4-SL-2012-280716***

Call Identifier: ***FP7-NMP-2011-SMALL-5***

Duration: ***36 months, start 1° March 2012***

Coordinator: ***Dr. Anna Luisa Costa***

Website: ***www.sanowork.eu***



MAIN GOALS

1) **TO DEVELOP "SAFER BY DESIGN" RISK REMEDIATION STRATEGIES**

2) **TO INTEGRATE THEM IN MANUFACTURING PROCESSING LINES**

3) **TO EVALUATE THEM**

•by implementing **EXPOSURE** assessment methodologies in the **WORKPLACES**

•by performing a **RISK** analysis **BEFORE** and **AFTER** the application of the proposed strategies

•by analyzing **COST / BENEFIT** on the basis of the risk analysis results, NMs performances and extra steps cost evaluation

Sanowork

istec

SANOWORK COMPANIES

COLOROBBIA

PlasmaChem

NANOMATERIALS

Elmarco NANO FOR LIFE

TECHNOLOGY

GEA-NIRO

USERS

Bayer Technology Services

LEITAT managing your technologies Technological Center member of TECNIO

SEVENTH FRAMEWORK PROGRAMME

NanoSafety Cluster

SANOWORK NANOMANUFACTURING

ZrO_2 nanoparticle applications:

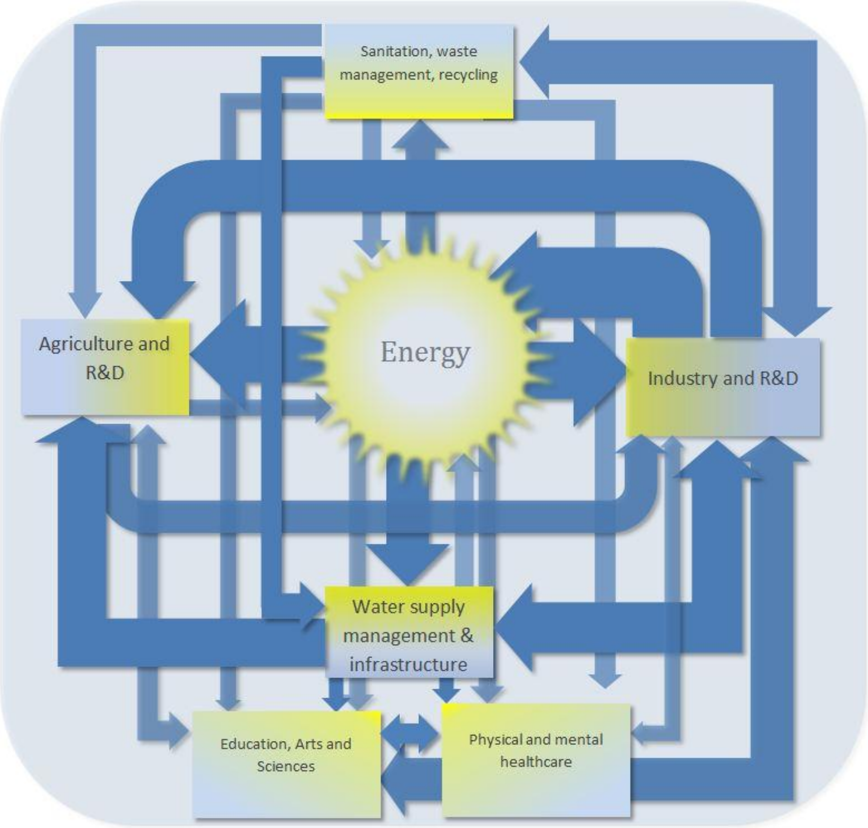
- Electronic displays
- Thermal barriers
- Wear resistant coatings
- Medical and dental implants
- Solid oxide fuel cells
- Ceramics

These are all high growth/impact market sectors.

TiO_2 nanomaterials applications:

- Paint additives
- Toothpaste, sun creams, cosmetics ,food
- Photo catalysis, photovoltaics, photochromics
- Self cleaning glass

In 2005, the global production of nanoscale TiO_2 was estimated to be worth $70 million



CNT nanomaterials applications:

- Bone tissue engineering
- Composites
- Alloys
- Coatings and films
- Microelectronics/Transistor technology

Carbon Nanotubes Market worth $2,398.4 Million by 2018

Polyamide nanofibres applications:

- Protective clothing
- Antimicrobial filters
- Tissue engineering
- Water purification/environmental remediation

The filtration technology market alone is projected to be worth ≈$700 billion by 2020

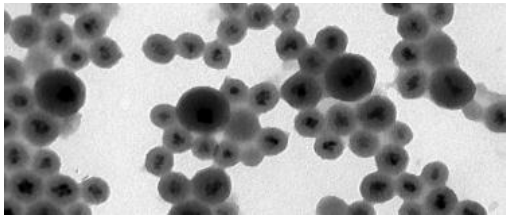
Ag nanomaterials applications:

- Antibacterial coatings/medical devices
- Water purification
- Catalytic applications
- Optics applications
- Sensor applications
- Transparent conductors

Ag NPs estimated amount of about 320 tons/year produced and used worldwide

SANOWORK MATERIALS

NANOPARTICLES



ZrO_2 nanopowders

•additive in chemical industry

•raw ceramic material

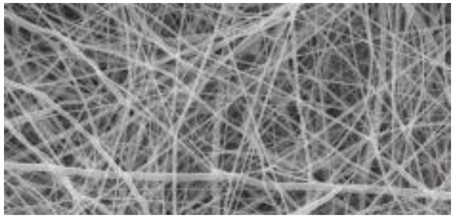
TiO_2 nanosol

photocatalytic additive for ceramic (or textile) surfaces

Ag nanosol

antibacterial additive for ceramic surfaces

NANOFIBERS



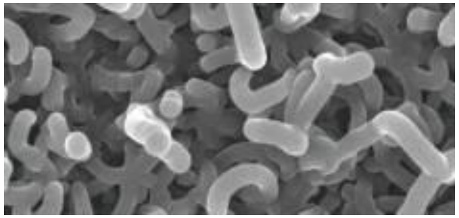
Polyamide nanofibers

nanostructured membranes for water depuration systems

TiO_2 nanofibers

photocatalytic component in solar cells

NANOTUBES



CNTs

additive in plastic industry

NMs with different

MORPHOLOGY (NPs, NFs, NTs)

CHEMISTRY (ZrO_2, TiO_2, Ag, Polyamide, C)

PHYSICAL STATE (Powder, Sol)

SANOWORK PROCESSING LINES

1

ZrO_2 NP Production Step


ZrO_2 NP Synthesis


ZrO_2 Crystallization


ZrO_2 Final Quality Control


Final ZrO_2 Product as powder or sol

2

ZrO_2 Ceramic Process Step

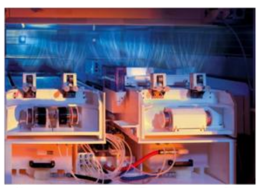

Spray Drying


Green body


Cooking 1200°C

3

PA Processing Step


PA electrospun

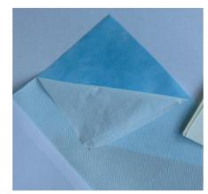

PA Manifacturing


Final filter product

4

TiO_2 Production Step


TiO_2 electrospun

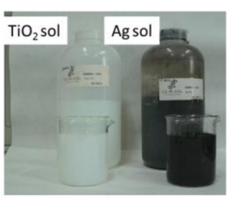

NF peel-off


Calcination


Manufacturing

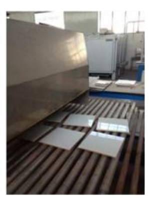
5

Ag and TiO_2 Production Step



Ag and TiO_2 nanosol


Spray-coating


Curing


Quality check

6

CNTs Processing Step

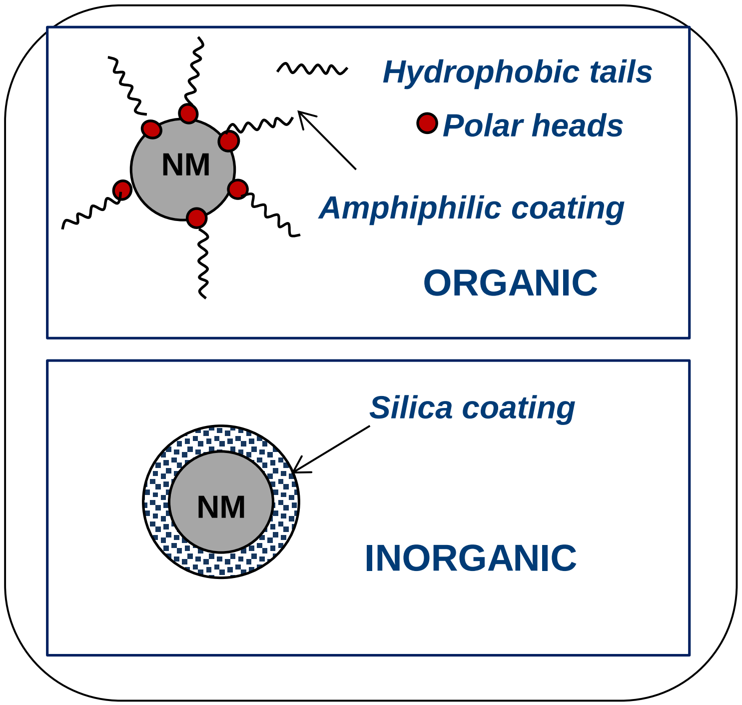

Feed Preparation


Degassing molted polymers

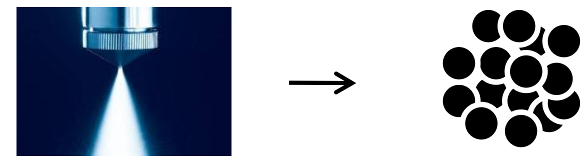

Cleaning Process

SANOWORK SbyD STRATEGIES

SURFACE COATING

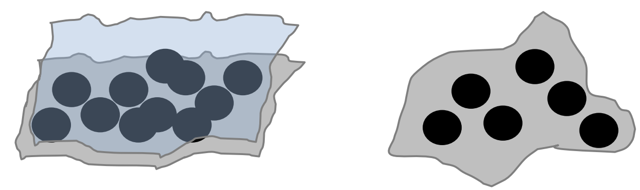


NANO IN MICRO



SPRAY-GRANULATION, GELIFICATION

IMMOBILIZATION



GEL COATING, IMPREGNATION ON

POROUS INORGANIC STRUCTURE

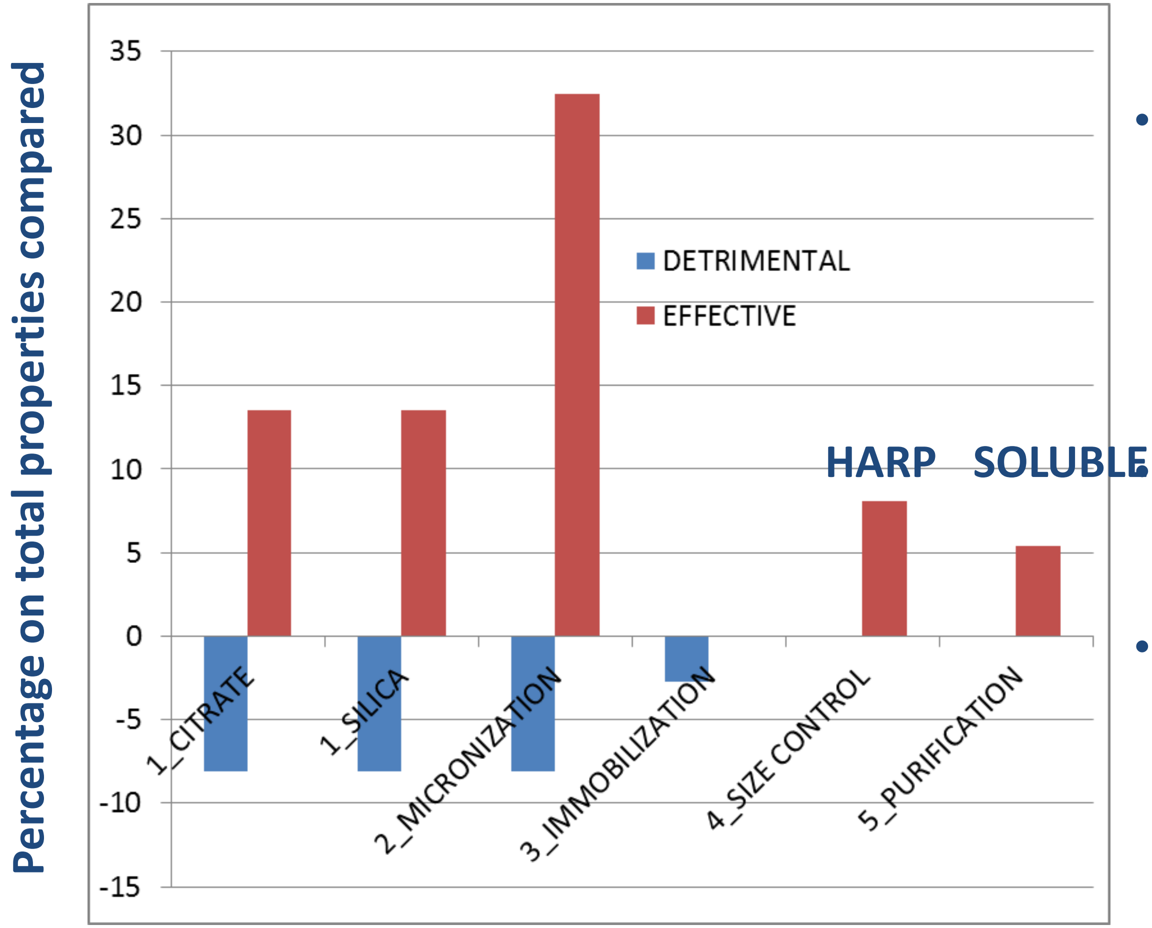
TO CREATE *PROTECTIVE LAYERS*
that control main toxicant factors:
PRODUCTION OF ROS
BIOAVAILABILITY OF METAL IONS

TO CREATE *STABILIZED STRUCTURE*
that decrease EMMISSION POTENTIAL and
improve nano-product RECOVERY and
RECYCLING

PRESERVE NANOSCALE REACTIVITY

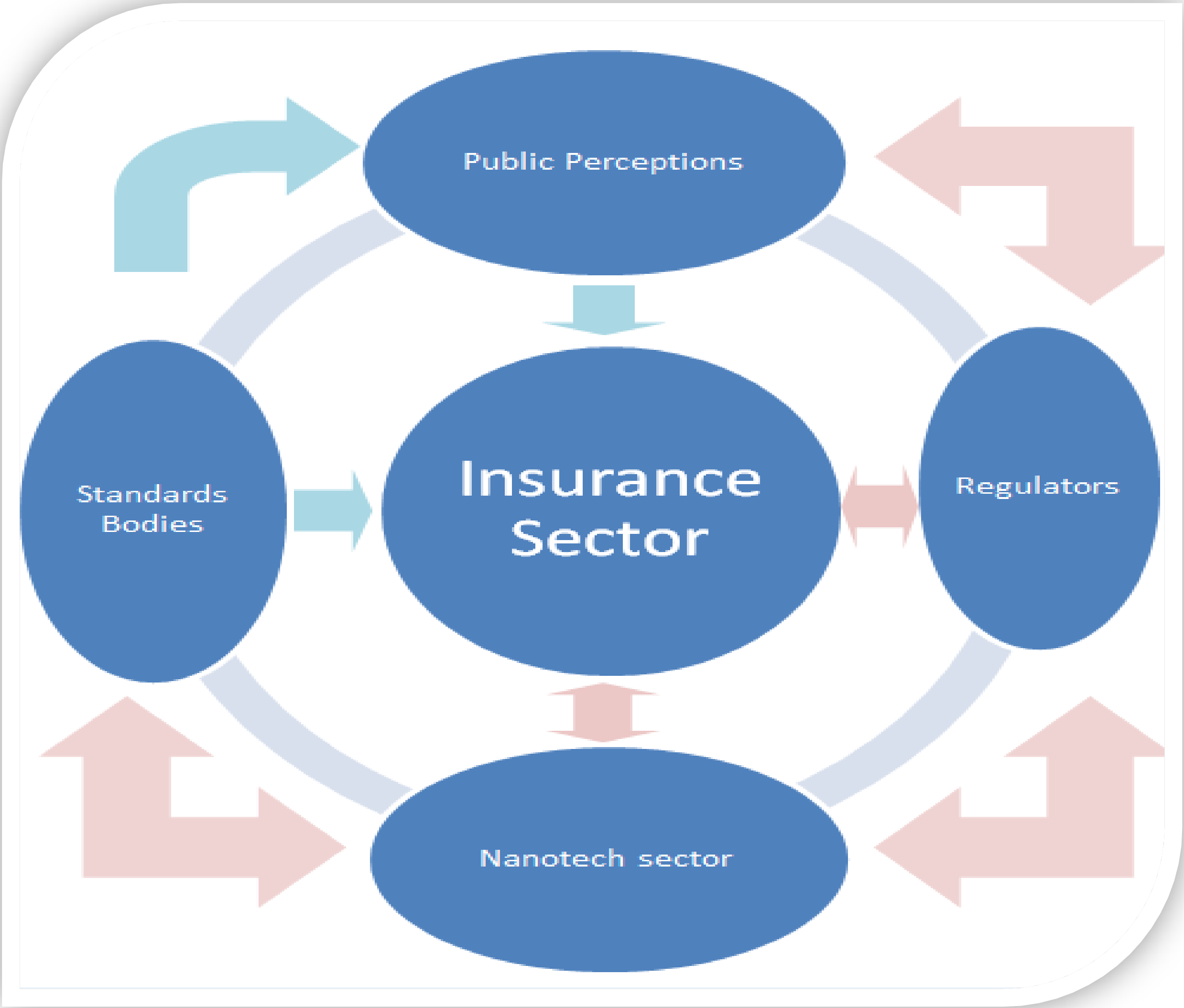
SbyD STRATEGIES EVALUATION

PROPERTIES COMPARISON **BEFORE** AND **AFTER**



- 'Nano in Micro' technologies (spray drying, spray-freeze granulation, gelification) seem to be the most promising strategies
- Inorganic and organic coatings show contrasting results
- Still ongoing discussion on Ag^+ purification strategy

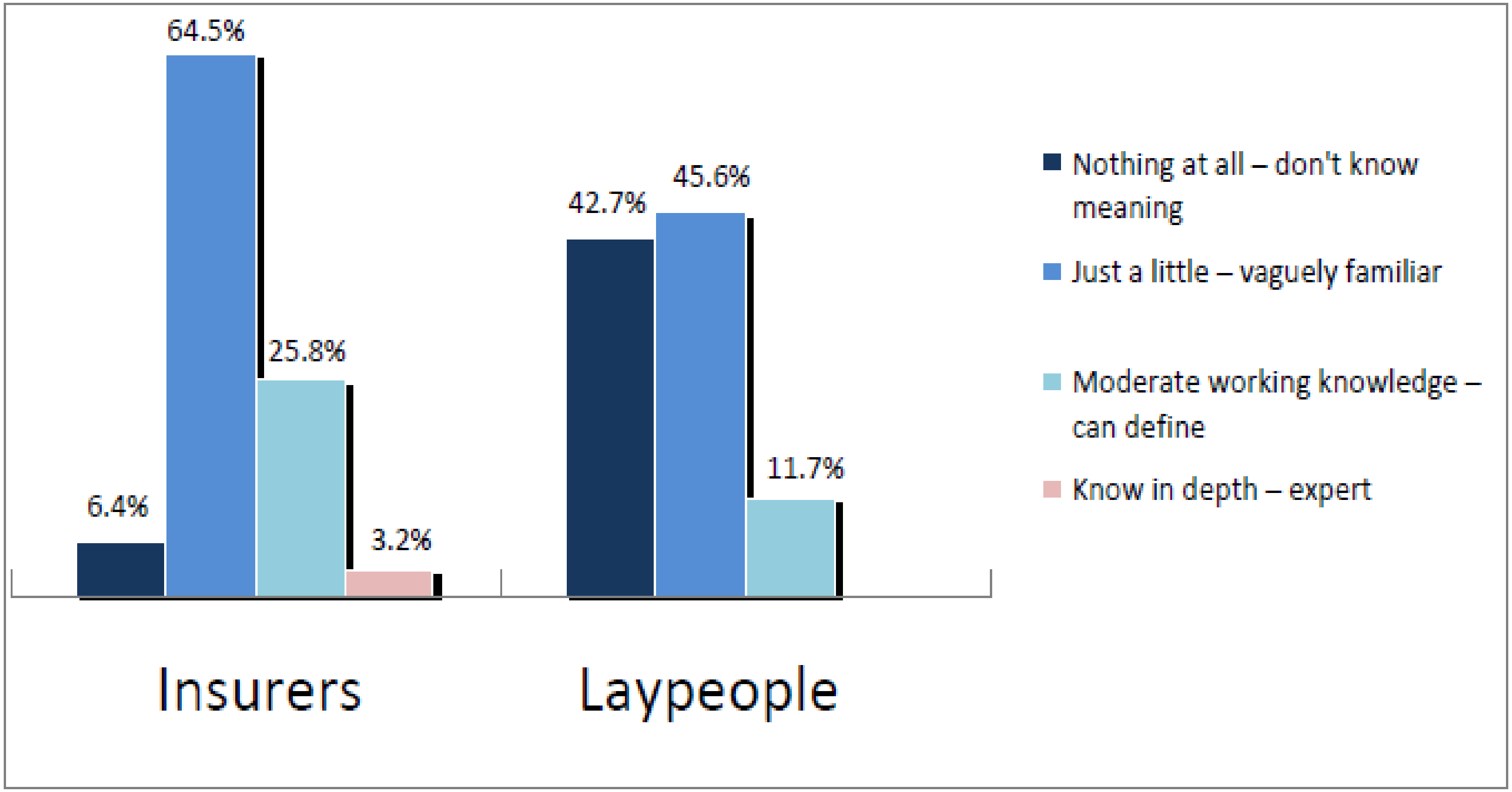
SANOWORK AND INSURANCE



Insurers play a crucial role in defining and shaping relationships between perceptions of nanotechnology risk

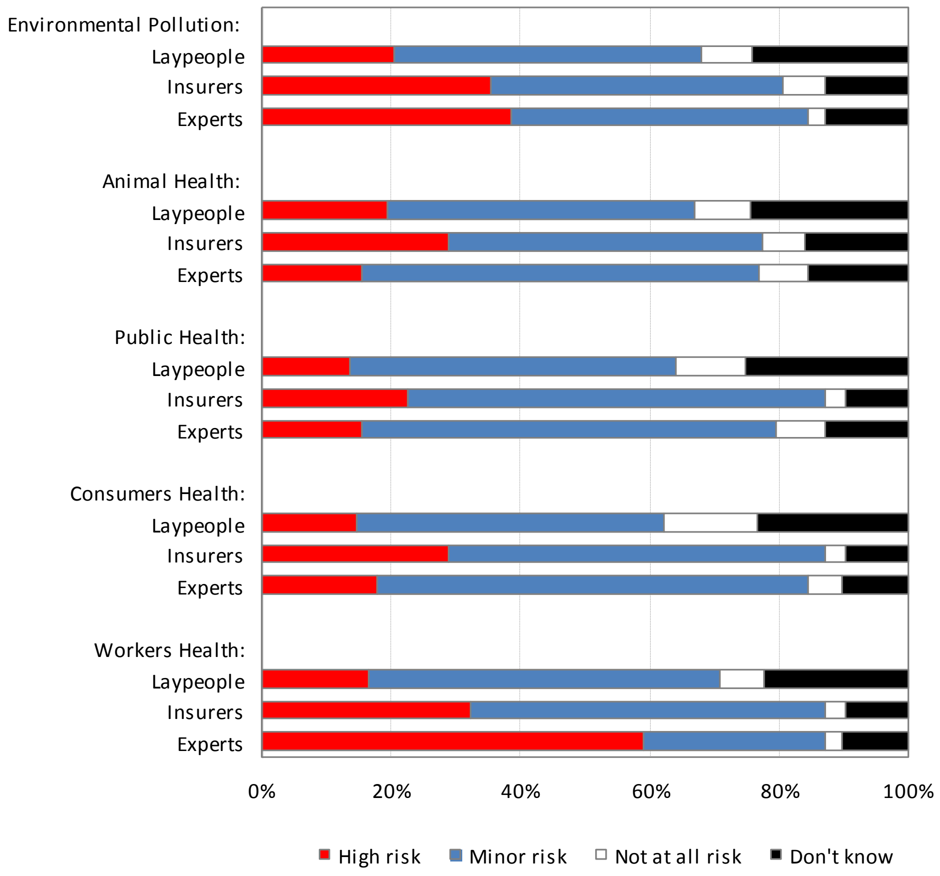
Kemmy Business school, University of Limerick

RISK PERCEPTION SURVEY



Baublyte, L., Mullins, M. and S. A. M. Tofail (2014). " Insurance Market's Perception of Nanotechnology and Nano materials Risks "

RISK PERCEPTION SURVEY

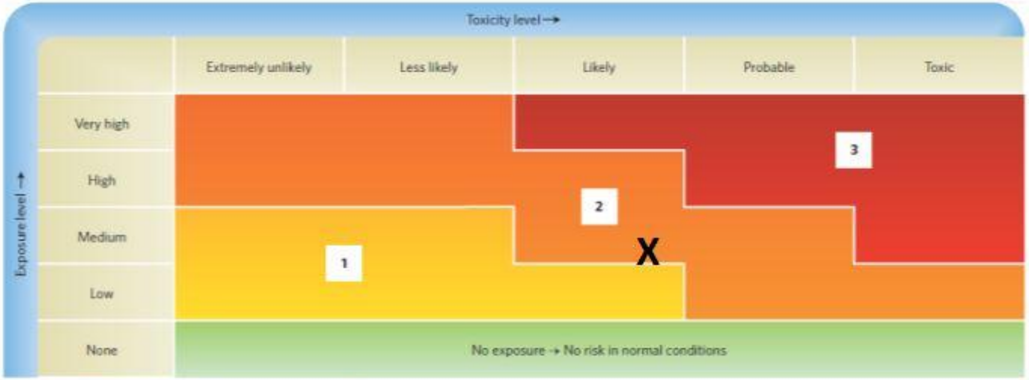


Insurers, experts and laypeople's perceptions of the risks nanomaterials will pose to society over the next 15 years in the following areas: workers health, consumers health, public health, animal health and environmental pollution.

Baublyte, L., Mullins, M. and S. A. M. Tofail (2014). " Insurance Market's Perception of Nanotechnology and Nano materials Risks "

PROTOTYPE INSURANCE TOOL

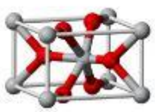
Company Name	NanoMaker
Line Of Business	Employers Liability
ENM	TiO2
Mean size < 100nM	☐
Highly Charged Surface	☑
Zeta Potential	0
Highly Acidic/Basic	☑
pH Level	7
High Aspect Respirable Particle	☑
Aspect Ratio	3
Soluble	☑



Risk level	Situation	Underwriting decision
1 (low)	Acceptable	Insurable
2 (moderate)	To be improved	Insurable subject to extra precautionary measures taken to manage worker's exposure to nanomaterials. This may include adherence to standard operating procedures to reduce exposure or chemical coating to reduce the toxicity (if applicable). Another alternative would be to adjust the contract wording to limit exposure to a claims made basis only (the occurence has to take place during the insured period thus eliminating long-tailed risk).
3 (high)	Unacceptable	Uninsurable

REACH PRECAUTIONARY STATEMENTS

332	Harmful if inhaled
351	Suspected of causing cancer
319	Causes serious eye irritation
335	May cause respiratory irritation



IARC and OTHER STATEMENTS

Group 2B carcinogen (IARC)

Corona Composition	4
Core Composition	7
Zeta Potential	9
Surface Area Volume	234
Effective Aerodynamic Radius	27
Max Length	200
Min Length	20
Mean Length	120
Bioavailability	3
Translocation Potential	8
BioPersistencet	36
Toxicity Mechanism Of Action	5
Aggragation Rate	28
Aglomeration	57
Biosolubility Fraction	66
Avergae Background Level	5
Spike Rate	7
Max Spike Intensity	8
Absorption Constant	5

Mullins, M., F. Murphy, L. Baublyte, E. M. McAlea and S. A. M. Tofail (2013). "The insurability of nanomaterial production risk." Nature Nanotechnology 8(4): 222-224

CONCLUSIONS

- Different “SAFER BY DESIGN” risk remediation strategies have been developed and integrated within real industrial processing lines
- A cost/benefit evaluation of proposed strategies represented an important step towards the promotion of preventive risk management solution.
- Based on results generated within Sanowork project and literature review, a prototype insurance tool based on control banding has been developed. This first attempt closed the risk knowledge gap for regulators and insurers and promotes the sustainability of what is still a relatively young industry.
- Future prospectives, needs to enforce “safer by design” solutions has been identified

SANOWORK LESSON: FUTURE PROSPECTIVES

Sanowork

SUN

WP 7 safe production, handling and disposal

...Future calls ?

GUIDELINES FOR NEW AND SUSTAINABLE RMS

Enforce "Safer by design" approach

NEEDS

Wet state characterization in environmental or biological relevant media

Modelling in support to design

Categorization, identification of key risk relevant factors that can be easily assessed in order to "validate" design solutions

A. L. Costa, "A Rational Approach for the Safe Design of Nanomaterial", Nanotoxicology: Progress toward Nanomedicine, Second Edition, March 3, 2014 by CRC Press Content, Editor(s): Nancy A. Monteiro-Riviere; C. Lang Tran (2014)

AKNOWLEDGEMENTS

istec

Sanowork

CONSORTIUM

SUN

NanoSafety Cluster

Paris, 13-14 March 2014,
24-Months-Meeting