Role of Green Nanotechnology in Sustainable Nanotechnology

Panel Discussion

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Prince of Wales Award
For Innovation & Production

SUN - SNO – GUIDENANO Sustainable Nanotechnology, March 2015, Venice

Dr Virginie Heidweiller
GuideNano

Your Panel

- Dr Mark Wiesner, Duke U, US*
- Dr Barb Karn, SNO, US*
- Dr Anna Costa, Istec CNR, IT
- Dr Socorro Vázquez-Campos, LEITAT, ES
- Dr John Warner, Warner-Babcock Institute for Green Chemistry, LLC, US
- Prof Terry Wilkins, Leeds U, UK*

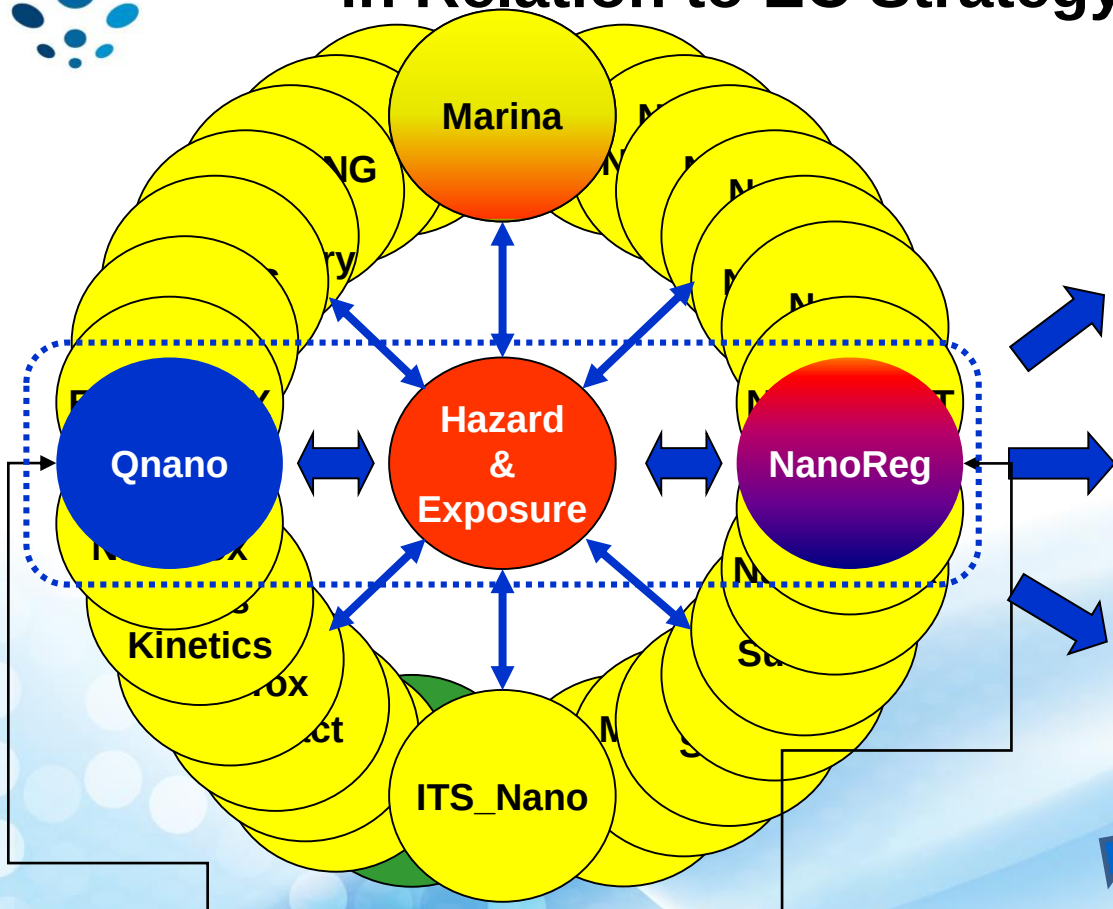
** Short presentations*

Designing Green(er) Nanotechnology

Exploitation of the validated knowledge and tools from global nanosafety research to design both products and processes that quantitatively minimise negative impacts &/or maximise benefits for the environment

NB: Nanomaterials have one or more dimensions between1-100 nm

Analysis of 50 FP7 Nano EHS Projects in Relation to EC Strategy for REACH



REACH & CLP
Regulation, Classification, Labelling, & Packaging of Nanomaterials

New ENPs Submitted For regulatory testing

REACH & CLP Approval

European Industry
Development & Scale up of novel nanomaterials

Research Infrastructure

Regulatory Testing Infrastructure

SUN — "Safe-by-design" Products & processes

Modena — "Safe-by-design" Modelling

NanoReg-2 — "Safe-by-design" Modelling

Key

- Nanomaterials hazard and risk research and Innovation projects
- Nanomaterials hazard and risk infrastructure development projects
- Quantitative Structure Activity Analysis (QSAR)
- NanoFutures European Technology Platform (11 Industry Sectors Input into nanosafety research needs)

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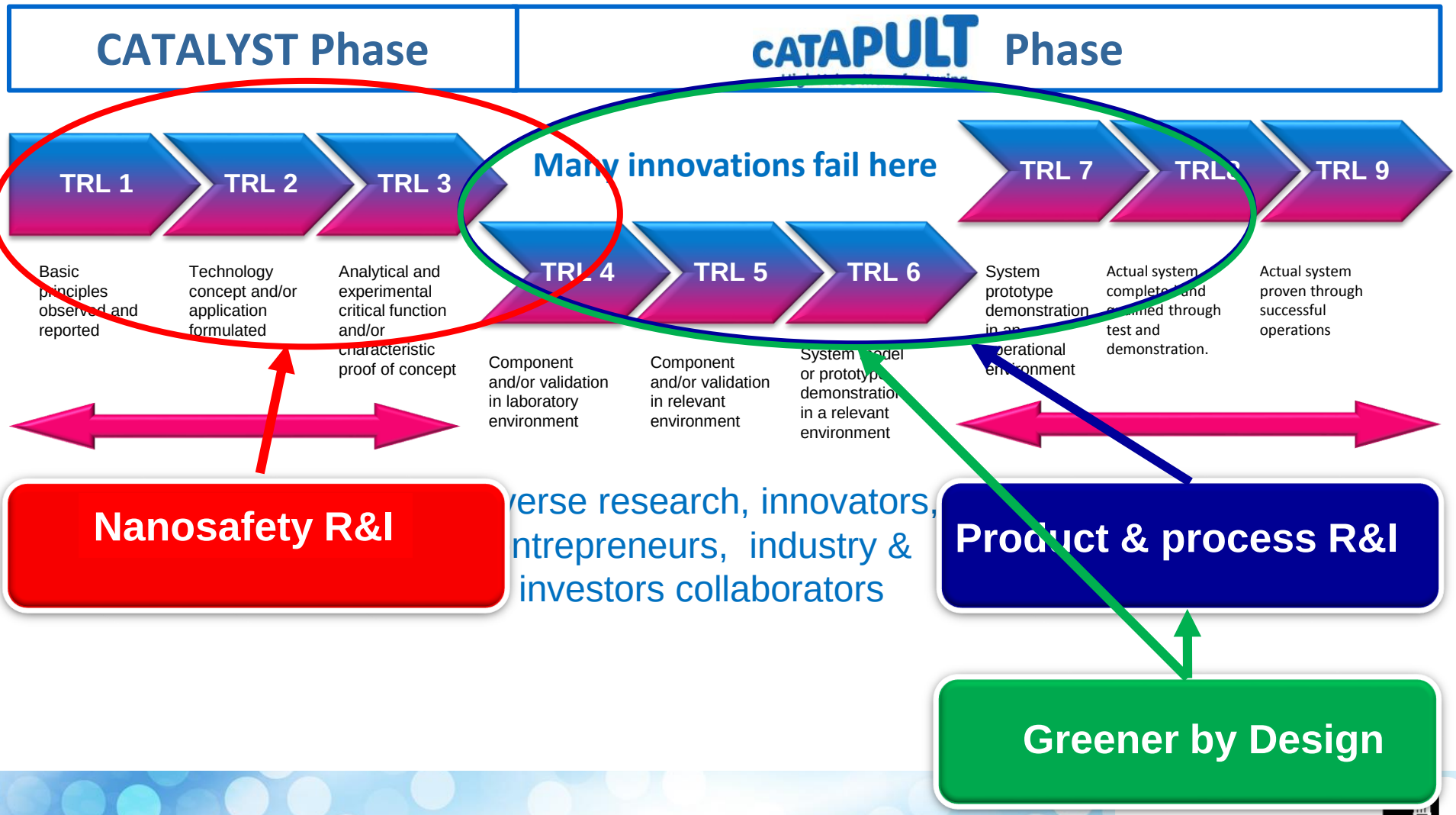
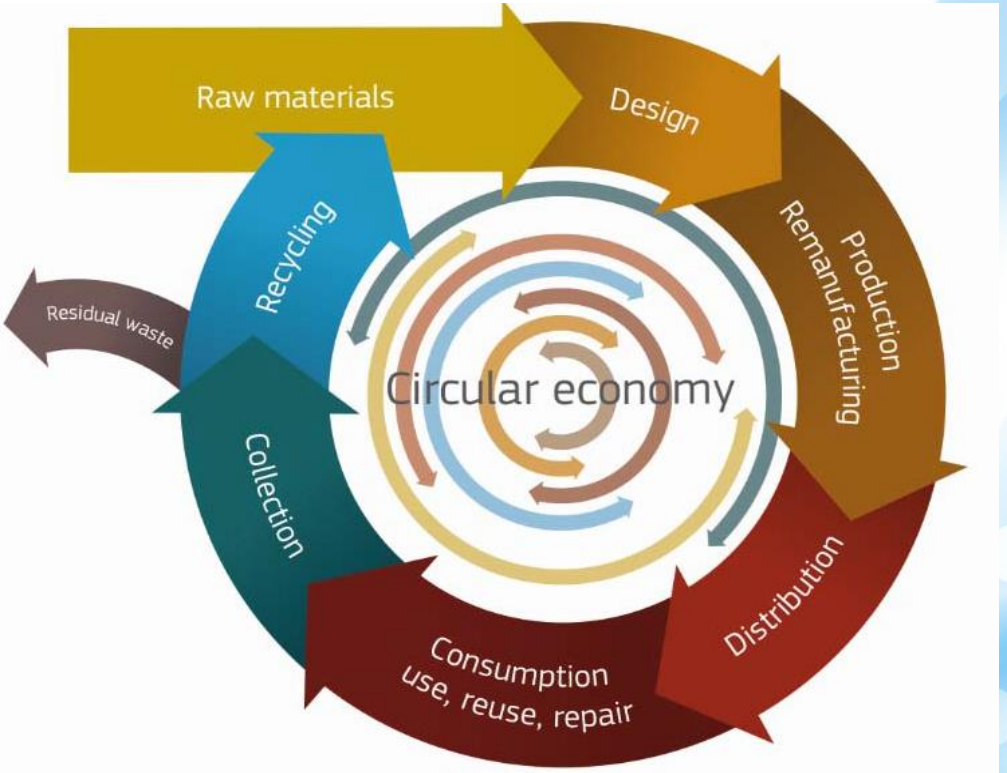
What TRLs are: a) nanotechnology and b) nanosafety translational research currently at?



CIRCULAR ECONOMY

H2020 NMBP Industrial Technologies R&I Programme Objective

- no longer linear
- extended life time
- collaborative approach
- cross-sectors
- multi-stakeholders
- innovation in all forms
- design strategies
- new business models
- demand-side measures
- etc…



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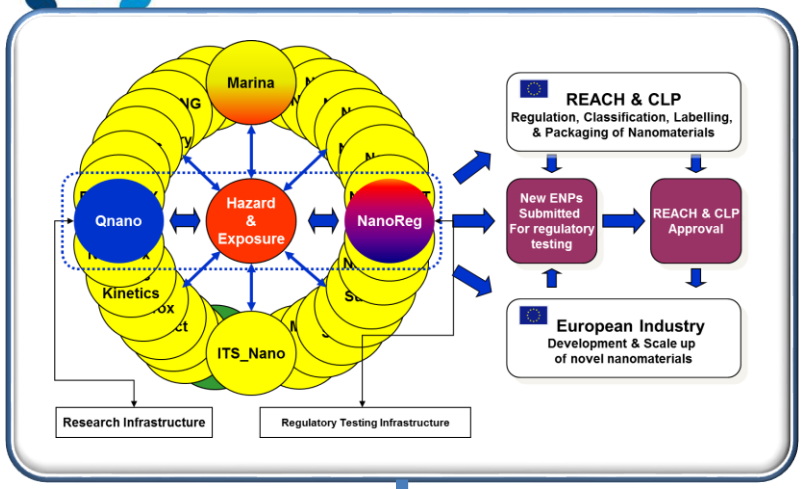
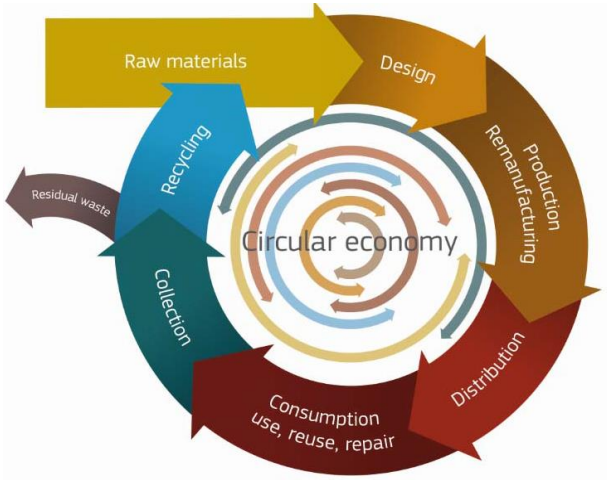
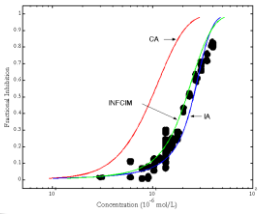
Designing Green(er) Nanotechnology





Physicochemical data
Hazard data

QSAR



Multiscale Modelling

Products

Processes

Multiscale Modelling

Treatment

Remediation

NanoRem

Multi-vartiate statistical process control

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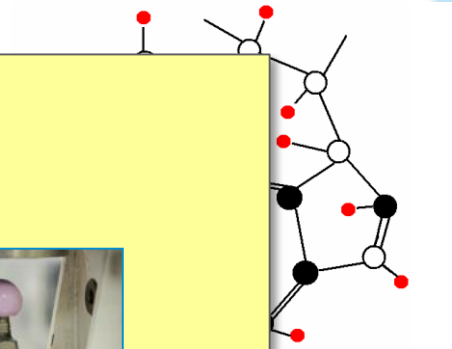
Nano-Dynamic Lubricant Systems
FP7 2020 Interface Project (TRANSPORT)

8 Car Engine components

Plasma Enhanced Chemical Vapor Deposition

Diamond-like Carbon Coating

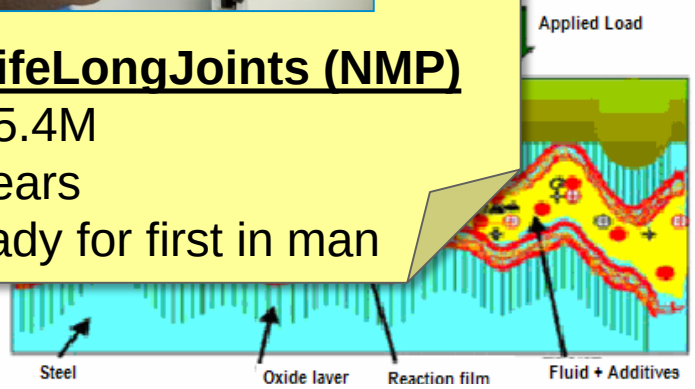


Note:

Migrating Innovation from one sector to another!

FP7 2020 Interface
- €2.8M
- 3 years
- Market in 2 years

FP7 LifeLongJoints (NMP)
- € 15.4M
- 5 years
- Ready for first in man

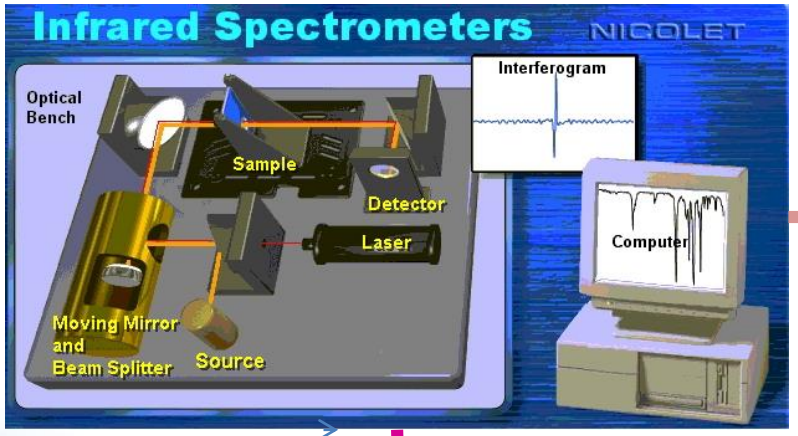


20% increase in fuel efficiency

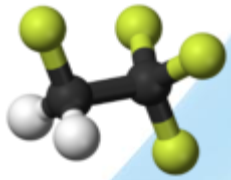
Triggers nano-layering of lubricant

HFC Refrigerant Gas Manufacturing

In 1995



KLEA 134a



Hydrofluoroethane

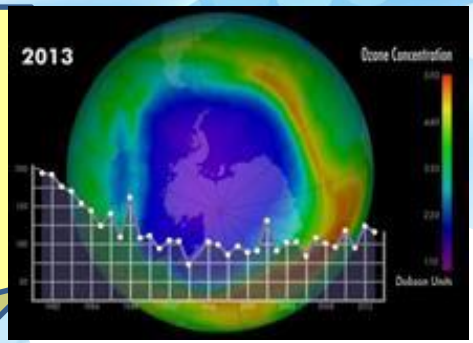
Closed loop control system

Chemical engineering
Design models

NB: Measures all reactants & products at T=200°C & P= 200 psi in an atmosphere of HF (75%) and HCl (25%)

Ozone layer hole repairing (due to HFCs replacement of CFCs) UN Environment Panel Sept 2014

NB: HFC Sales €15Bn/year



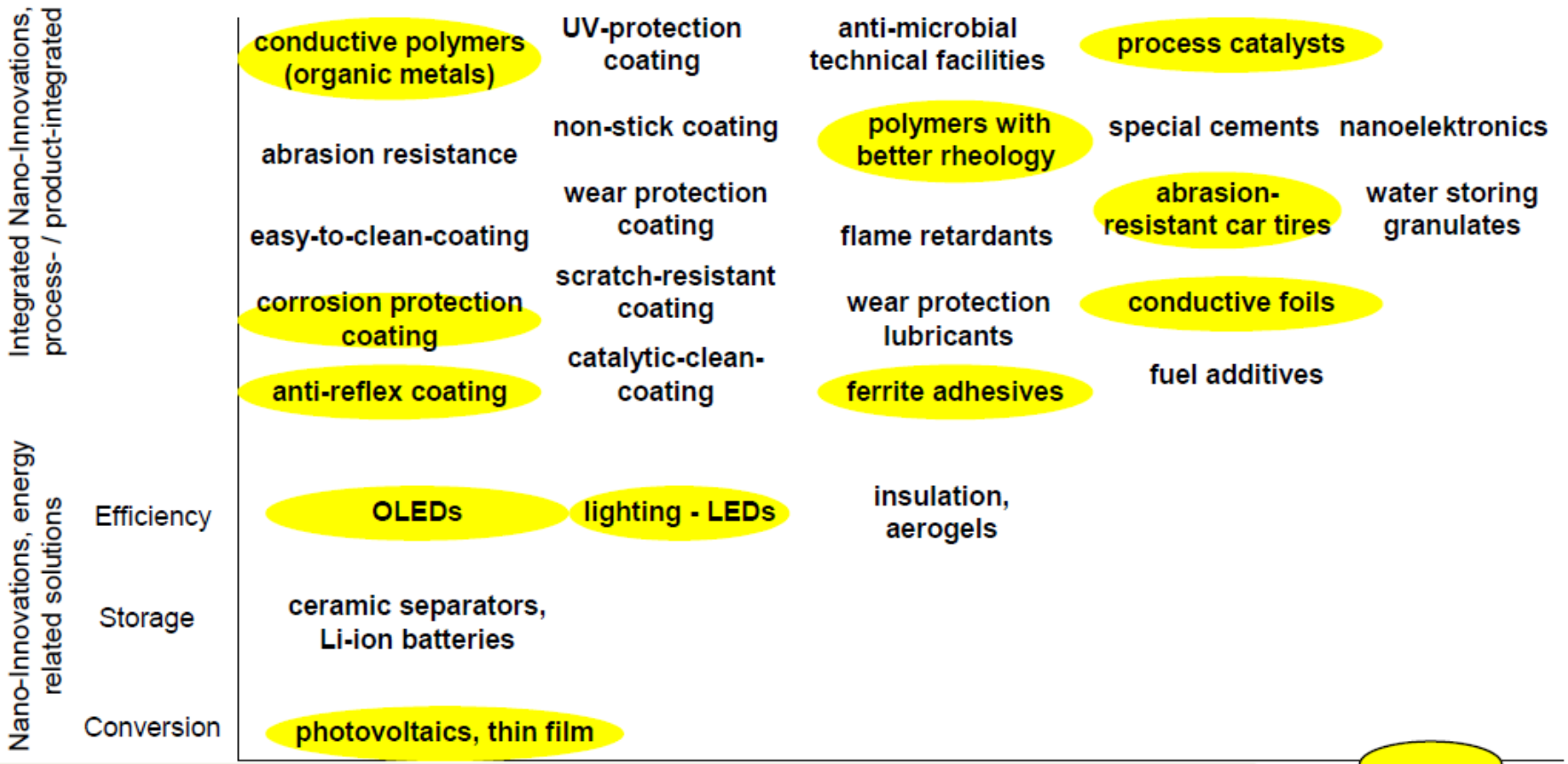
Life Cycle Assessment of Nanomaterials and Nanoproducts

1st Sustainable Nanotechnology School

Dipl. Ing. Michael Steinfeldt

Venice, 12th January 2015

Nanotechnology-based products / applications on the market (II)



Overview of studies of published LCAs of the manufacture of nanoparticles and nanocomponents

- only 35 publications: "LCA" of Nano-Applications
- only 15 publications: "LCA" of the manufacture of nanoparticles and nanocomponents

Nanoparticle and/or nanocomponent	Assessed impact(s)	References
Metal nanoparticle production (TiO_2, ZrO_2)	Cradle to gate energy assessment, global warming potential	(Osterwalder, N., Capello, C., Hungerbühler, K. and Stark, W.J. 2006)
Nanoclay production	Cradle to gate assessment, energy use, global warming potential, ozone layer depletion, abiotic depletion, photochemical oxidant formation, acidification, eutrophication, cost	(Roes, A., Marsili, E., Nieuwlaar, E. and Patel, M. K. 2007)
Several nanomaterial syntheses	E-factor Analysis	(Eckelman, M.J., Zimmerman, J.B. and Paul T. Anastas, P.T. 2008)
Carbon nanoparticle production	Cradle to gate energy assessment	(Kushnir, D. and Sandén, B. A. 2008)
Carbon nanotube production	Cradle to gate assessment with SimaPro software, energy use, global warming potential, ...	(Singh, A., Lou, H.H., Pike, R.W., Agboola, A., Li, X., Hopper, J.R. and Yaws, C.L. 2008)
Single-walled carbon nanotube (SWCNT) production	Cradle to gate assessment with SimaPro software, energy use, global warming potential, ...	(Healy, M. L., Dahlben, L. J.and Isaacs, J. A. 2008)
Carbon nanofiber production	energy use, global warming potential, ozone layer depletion, radiation, ecotoxicity, acidification, eutrophication, land use	(Khanna, V., Bakshi, B. R. and Lee, J. 2008)
Nanoscale semiconductor	Cradle to gate assessment, energy use, global warming potential	(Krishnan, N., Boyd, S., Somani, A., Raoux, S., Clark, D. and Dornfeld, D. A. 2008)
Nanoscaled polyanilin production	Cradle to gate assessment with Umberto software, energy use, global warming potential, ...	(Steinfeldt, M., von Gleich, A., Petschow, U., Pade, C. and Sprenger, R.U. 2010)
Multi-walled carbon nanotube (MWCNT) production	Cradle to gate assessment with Umberto software, energy use, global warming potential, ...	(Steinfeldt, M., von Gleich, A., Petschow, U., Pade, C. and Sprenger, R.U. 2010)
Nanoscaled Titanium di-	Cradle to gate assessment, Ecoindicator	(Grubb, G.F. and Bakshi, B. R.

Universität Bremen

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Nanotechnology for contaminated land **Rem**ediation

University of Stuttgart, USTUTT – VEGAS

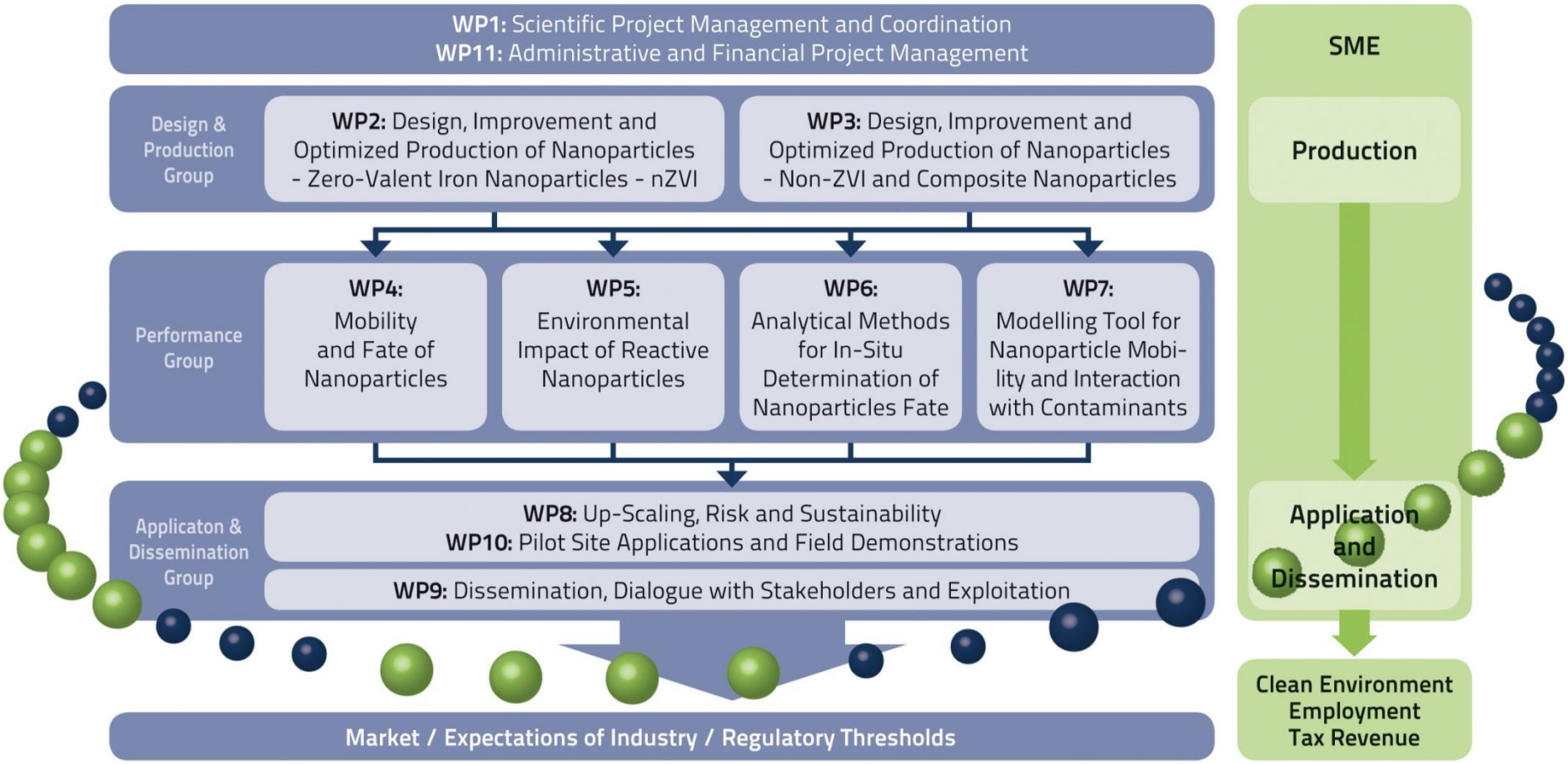
Hans-Peter Koschitzky

Nano particles for *in situ* remediation

- Small size
  ➔ higher surface area
  ➔ more reactive
- NPs (in a carrier fluid) injected into saturated zone via wells
- Focus on source treatment
- Applicable below buildings
- “independent” of application depth
- „semi-passive“ technology
- particles e.g. nZVI
- innovative technology

NanoRem Structure

Taking **Nano**technological **Rem**ediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment



NanoRem Pilot Sites

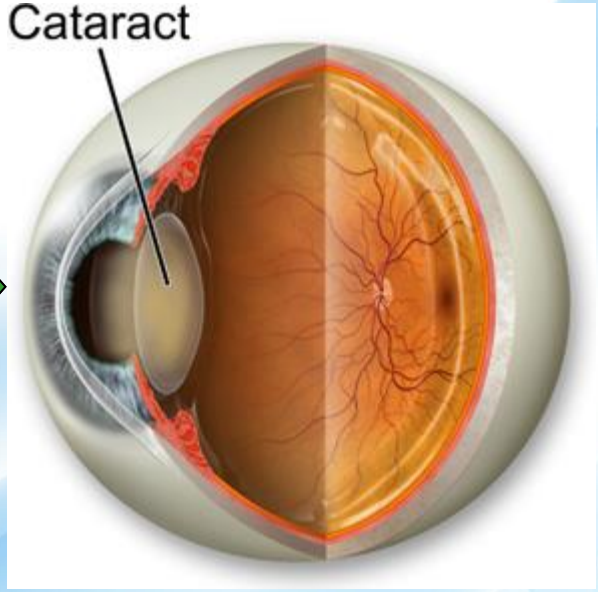
Site	Country	Site Primary Investigator	Target Cont.	NP-Type	Reaction Principle	Aquifer
Zurzach	CH	Solvay	CHC	milled nZVI	Reduction/ Sorption	porous / unconfined
Spolchemie 1	CZ	Aquatest	CHC	NANOFER 25s	Reduction	porous / unconfined
Spolchemie 2	CZ	Aquatest	BTEX	Iron-Oxide	Oxidation/ microbial Enhancement	porous / unconfined
Barreiro	PO	GeoPlano	HM	Iron-Oxide	Immobilisation	porous / unconfined
Besor-Secher Neot Hovar	IS	Negev, BGU	CHC	air-stable nZVI NANOFER STAR*	Reduction	fractured
Balassagyarmat	H	Golder	CHC	Carbo-Iron	Reduction / Soption	porous / unconfined
Bizkaia	ES	Tecnalia	HM	Iron-Oxide	Reduction/ Immobilisation	porous / unconfined

Panel discussion topics:

- Definition of “Green nanotechnology in Sustainable nanotechnology”?
  - Greener by design principle for products and processes
  - Nanotechnology to address big environmental issues (Ozone layer, energy global warming etc.)
  - Nanotechnology for environmental remediation
- Where are the gaps in science and translational research?
- What new challenges are there for regulators and industry?
- Addressing ethical and public dialogue issues?
- What should our priorities be for future collaborative projects?

Cataract Eye Surgery…
……a Personal View of “Green by Design”

Jan 2009



Aug 2009

Diffraction Lens Cross-section (~100 nm steps)

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