Institut universitaire romand de Santé au Travail
Institut für Arbeit und Gesundheit
Institute for Work and Health
Pour que santé et travail soient compatibles

Aerosol exposure and response

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Workplace Aerosols, Karlsruhe, 1 July 2010

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Particle and health paradigms of the 20th century

Particles overload the lungs	Particles carry toxic substances	Particles are biopersistent fibres
		
Gipsum is inert. OEL is 3 mg/m³ &10 mg/m³ respirable/inhalable PM	Welding fumes contain toxic metals, e.g. Chrome VI: OEL is 50 µg/m³ (e)	Individual asbestos fibres are hazardous. OEL is 0.05 fibres*/ml
Local ventilation is often sufficient	**Source capture & might need a mask**	**Enclose workspace, wear full protection**

OEL = Occupational Exposure Limits after SUVA, 2009, PM = Particulate Matter.

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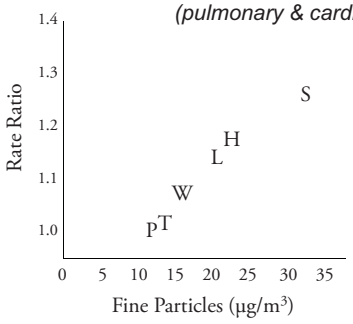
Public health in the 90ies: A few µg/m³ can kill (?)

Six-city study: Linear association of exposure and mortality (pulmonary & cardiovascular).

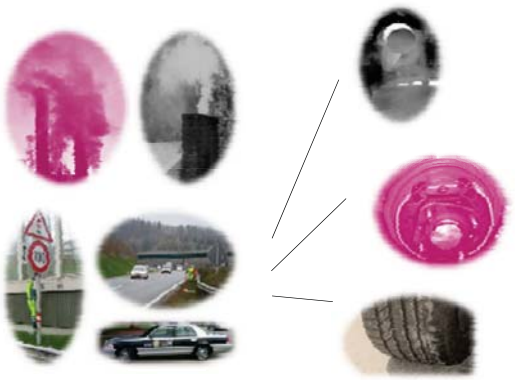


- Six U.S. cities
- Mortality rate relative to Portage (P), Stratified by age and gender
- Controlled for smoking, education and body-mass-index

What is so toxic?
What mechanisms?
Which sources?

Modified from Dockery et al., NEJM, 1993;329(24):1753-9.

Which particle sources?



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Nanoparticles – accidental and intentional origin

Heat related processes

Picture showing flame removed for copyright reasons.

Chemical synthesis

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Over 1000 nano-products on the market

Energy systems

Picture showing battery and solar panes removed for copyright reasons.

+ High-capacity batteries
+ semi-transparent and cheap photovoltaic panels

Nano-clean

Lotus effect:

Nano-structure + hydrophobic material
= Dirt and water cannot adhere

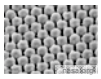
Sun blockers

+ Intransparent for UV
+ Transparent for visible light

Functionalized textiles

+ Self-cleaning clothes
+ Nano-silver against bacteria and odors

Nano-Computing



Powerful and energy-saving computers

… and more!

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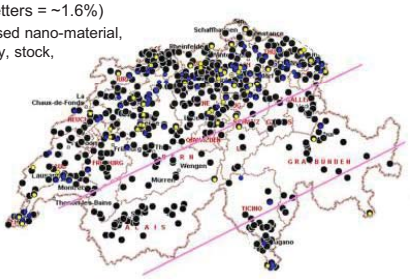
Where are nanoparticles in the (Swiss) industry?

Representative survey of SUVA clients ~100'000 Swiss companies

- Layered sampling strategy (20 layers)
- Letter survey (1626 letters = ~1.6%)
  - Questions about: Used nano-material, quantities, frequency, stock, protections etc.



Modified from Schmid, Danuser and Riediker. JOEH 2010, 7: 224–232

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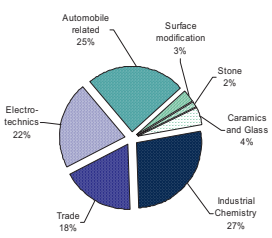
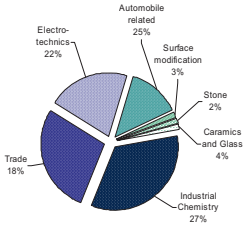
Swiss NanoInventory: Where are they?

A) Companies



600 companies
= 0.6%

B) Workers



1300 workers
=0.08%

Modified from Schmid, Danuser and Riediker. JOEH 2010, 7: 224–232

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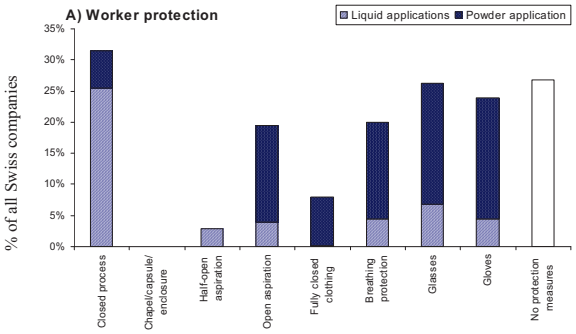
Swiss Nanoinventory: Protection strategies



Personal protection predominant -> important scenario

Modified from Schmid, Danuser and Riediker. JOEH 2010, 7: 224–232

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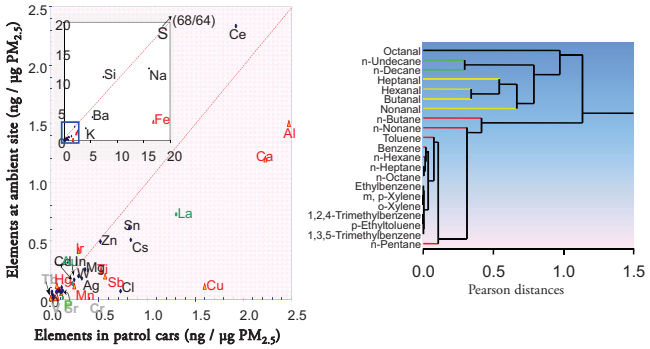
What can we learn from traffic particles?

Study about traffic particles and cardiovascular health

- NC highway patrol troopers
- Troopers work up to 9 hrs inside their cars

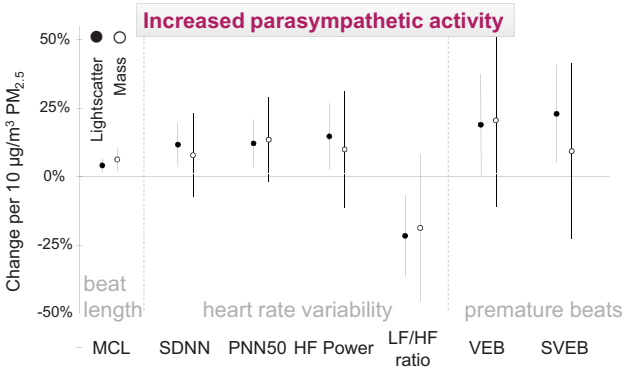
The following results were published in:
Riediker, et al. 2003. Environ Sci Technol. 37:2084-2093.
Riediker, et al. 2004. Am J Respir Crit Care Med. 169:934-940.
Riediker et al. 2004. Part Fib Toxicol. 1:2.

Pollutants inside cars: High metals, gasoline



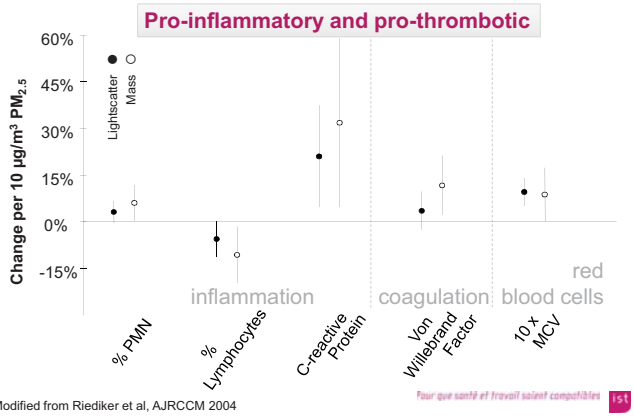
Modified from Riediker et al, ES&T 2003

$PM_{2.5}$ associated with cardiac parameters



Modified from Riediker et al, AJRCCM 2004

$PM_{2.5}$ associated with blood parameters



Modified from Riediker et al, AJRCCM 2004

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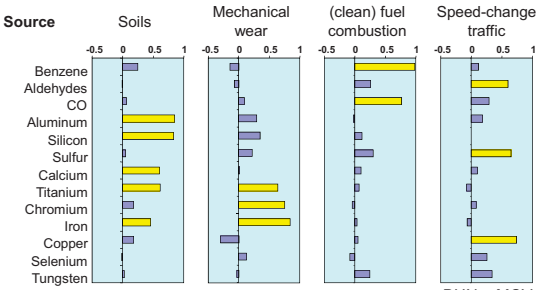
Effects differ between sources



Activity parameters = no confounders

Riediker et al, PFT 2004, Published under Creative commons attribution license

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GAeF Conference on
WORKPLACE AEROSOLS 2010
28 June - 2 July, Karlsruhe, Germany
www.gaef.de/workplace2010

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Do break wear particles play a role?

Real world cars

Cell exposure chamber around brake

Study at IST in collaboration with UBERN

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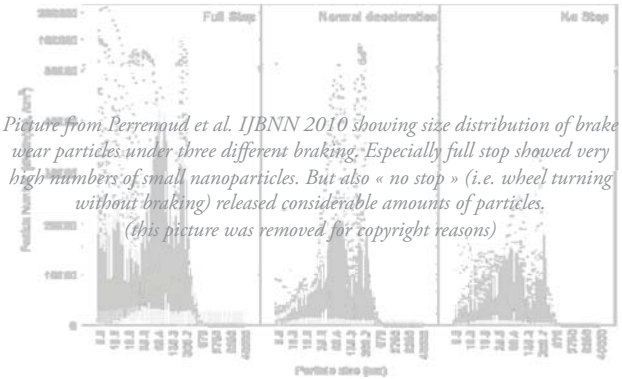
Brakes release large numbers of nanoparticles



Picture from Perrenoud et al. IJBNN 2010 showing size distribution of brake wear particles under three different braking. Especially full stop showed very high numbers of small nanoparticles. But also « no stop » (i.e. wheel turning without braking) released considerable amounts of particles.
(this picture was removed for copyright reasons)

Perrenoud, Gasser, Rothen-Rutishauser, Gehr, Riediker IJBNN 2010 *(accepted)*

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Approaches to study oxidative stress

Intrinsic ROS production potential of particles

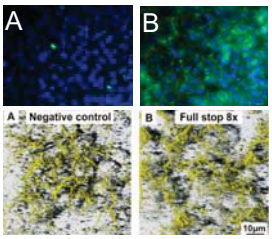
Picture from Sauvain et al. Nanotox 2008 showing ROS reactivity test results (removed for copyright reasons)

Test to measure consumption of DTT in presence of particles:

Particles differ in ROS production

Sauvain, Deslarzes, Riediker, Nanotox 2008

Consequences of exposure in cells



A549 cells and brake wear:

- ***ROS generated***
- ***Occluding reduced (tight junctions?)***

Gasser, Riediker et al PFT 2009

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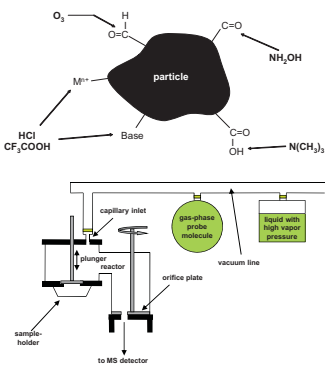
Role of functional surface groups?



After Setyan et al. Aerosol Science 40 (2009) 534 -- 548

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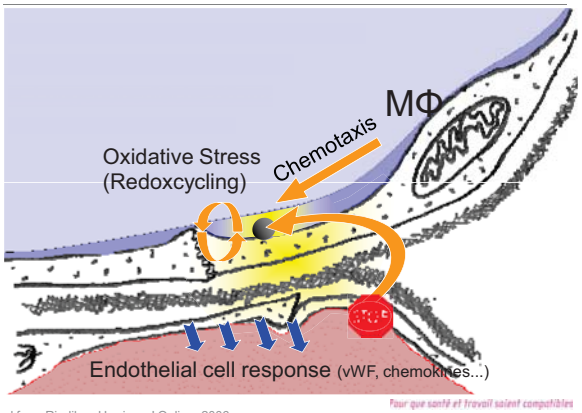
Local effects around deposited particles



Modified from Riediker, Harrisons' Online, 2006

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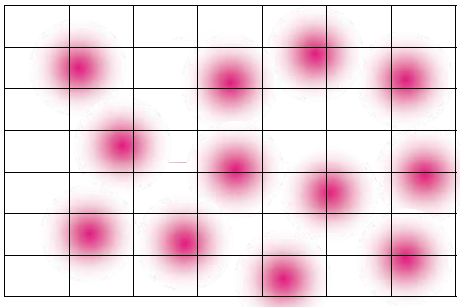
many small particles = finely distributed effect



Normal respiration of 1 µg/m^3 of 10 nm:
5000 particles/mm^2 deposited on lung surface in one hour
(lung = 80 m^2)

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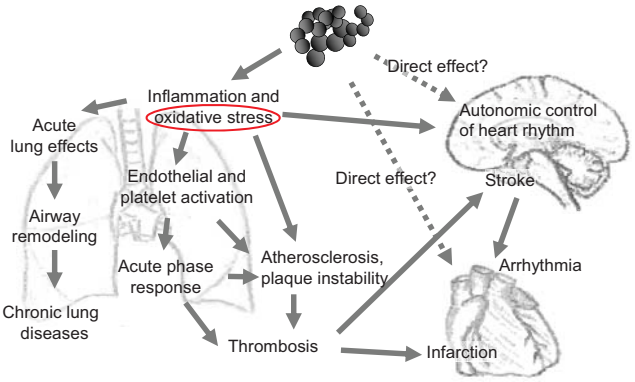
Proposed causal chain of particle effects



Modified from Riediker, Harrisons' Online, 2006

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Atherosclerosis in animals

normal feed fatty feed

Picture from Sun et al. JAMA 2005, showing how a combination of fatty food and PM dramatically increases atherosclerotic plaques in rodents (removed for copyright reasons)

filtered air particles filtered air particles

Atherosclerosis in rodents after six months of exposure:
Ambient New York particles (same level as city) and feed rich in fat.

Sun et al, JAMA Dec 2005

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Update of occupational hygiene paradigms

Particles overload lungs	Particles carry toxic substances	Particles produce toxic substances	Particles are fibres
Really?			Other structure effects?
Gipsum is inert. OEL is 3 mg/m³ &10 mg/m³ respirable/inhalable PM	Welding fumes contain toxic metals, e.g. Chrome VI: OEL is 50 µg/m³ (e)	ROS-production in A549-cells exposed to nano-TiO_2 - consequence for OEL? (Muller, Riediker et al. JRSoc Interface 2009)	Individual asbestos fibres are hazardous. OEL is 0.05 fibres*/ml
Local ventilation is often sufficient	**Source ventilation & might need a mask**	**Need to study assessment & protection!**	**Enclose workspace, wear full protection**

OEL = Occupational Exposure Limits after SUVA, 2009, PM = Particulate Matter.

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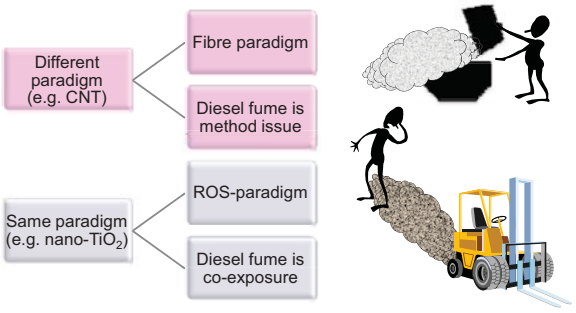
Paradigms and treatment of background-levels



GoodNanoGuide: Collaborate for good practice

- Protected Internet site on occupational practices for the safe handling of nanomaterials
- Multiple stakeholders contribute, share and discuss information
- Modern, interactive, up-to-date

http://GoodNanoGuide.org

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Upcoming events

NanoImpactNet

19 to 23 July 2010:
Training schools in Bratislava on
a) Environmental Fate and
b) Risk Assessment Strategies

6 to 9 September 2010:
Workshops in Dublin on
a) Exposure Mesurement, b) Effects on Organisms, and c) Impact Assessment

14 to 17 February 2011:
3rd Integrating Conference
in Lausanne

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Thank you!

Collaborating partners

University of North Carolina at Chapel Hill, USA
U.S. Environmental Protection Agency, USA
Brody School of Medicine, Greenville, USA
University of Bern, CH
Ecole Polytechnique Fédérale de Lausanne, CH
Eidgenössische Technische Hochschule Zürich, CH
EMPA, CH

My group

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Presentation does not necessarily reflect EPA policy.

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