European Strategy for Nanosafety

nanoSAFE

Safe production and use of nanomaterials

How to estimate nanoaerosol explosion risk?

Dissemination report
October 2008
DR-152/423 200810-4

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An European Integrated Project Supported by through the Sixth Framework Programme if research and Technological Development

Dissemination reports from Nanosafe2 project are designed to highlight and present in a simplified way the main results obtained in the studies carried out during this project. These reports mainly deal with one question which is of general concern for whom is interested by the safe production and use of nanomaterials. The full results are summarized in the corresponding Technical reports.
All the Dissemination reports and Technical reports are publicly available from Nanosafe2 project website**: **http://www.nanosafe.org

Refer to:

DR 152: Safety Parameter Characterisation Techniques for Nanoparticles
DR 423: Preliminary Implementation of health and explosion risk methods

Author:

J.BOUILLARD INERIS
E-mail: jacques.bouillard@ineris.fr

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How to estimate an accidental risk level?

To estimate an accidental risk level, four factors have to be evaluated:

Nanopowder Safety Parameter	***Process factors***	***Probability of occurrence of accident***	***Vulnerability of the target, worker or environment***
			

The accidental risk level of the situation is function of these four factors.

How to Characterise Nanopowder Morphology, Bulk and Surface composition, Dispersability parameters?

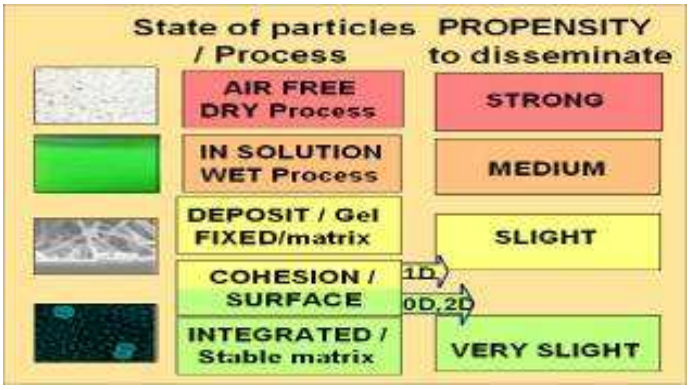
Specific methodologies and tools are necessary to characterise nanoparticle bulk and surface properties and their behaviour in the environment:

- ***Particle size, size distribution, and shape.*** *(Dynamic Light Scattering (DLS), Scanning and Transmission Electron Microscopy (SEM/TEM).*
- ***Surface area***
  BET (Brunaer, Emmet and Teller) ***c. Surface charge: Zeta potential***
- ***Particle composition***
  by Energy Dispersive Spectroscopy X-Ray Microanalysis (EDAX), X-Ray Diffraction (XRD) and X-Ray Fluorescence techniques.
- ***Surface composition***
  by X-Ray Photoelectron Spectroscopy (XPS), Raman Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR).

Nanoparticle Dispersability or Dissemination

The propensity to disseminate can vary:

- *strong for dry powders in gaseous atmospheres,*
- *medium in a liquid medium:*
- *low or very low when integrated in a given structure.*



To evaluate nanopowder safety characteristics, morphologic, surface and bulk properties as well as their potential to disperse in their environment have to be characterized.

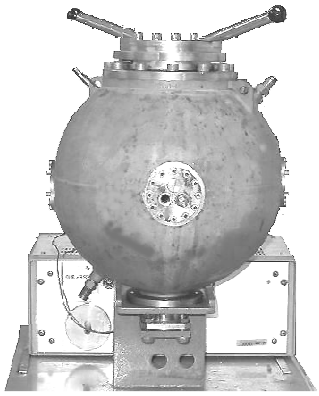
How to characterize nanopowder fire and explosion parameters?

Because of their high specific surface, nanopowders can exhibit highly reactive characteriristics that can lead to very flammable or explosive behaviours. Main characterisation technique to assess flammability and explosivity safety parameters are described in the DR 152

Combustion tests

Modified Hartman tube

Various tools and characterisation techniques allow for assessing important safety sensitivity parameters such as Electrostatic MIE, Auto Ignition Temperature (AIT)



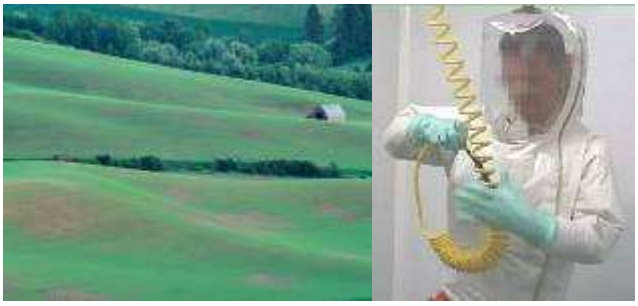
Small scale 20l explosion sphere

Large scale explosion test

Severity Parameter such as Pma, Kst, and the Explosivity Class (St1, St2, and St3) can be characterized via specific protocols.

Most nanopowders can display high reactivity characteristics that can lead to fire or explosion accidents. Specific tools and protocols are necessary to assess these parameters

What are the environmental and probability factors to consider?



Two common types of targets are considered in risk assessment: the environment or/and the worker, each of them having its own vulnerability

Target Vulnerability that includes protection measures of the worker or the environment can be lessened by the use of high performance filtration systems and/or IPEs. See D432.

Probability of occurrence of an accidental situation (ie. Leakages or generation of explosive atmospheres) can be lessened by good safety practices. See D432.

What are the process factors to consider?

Process parameters can be of various types: each of them can trigger potential dangerous conditions

Uncontrolled Process parameters such as:

- *flow velocities,*
- *pressures,*
- *temperatures,*
- *material fluxes,*
- *inventories and concentrations*

Can lead to dangerous situations such as runaway reactions.

For example, a unit operating at high pressures or high temperatures is potentially more dangerous than the one running at lower conditions.

Environmental and process factors (flow velocities, materials fluxes and inventories, Pressures, Temperatures and concentrations) are key elements to consider in the risk assessment.

How to reduce nanoaerosol explosion risks?

By reducing one of the four factors, one reduces the risk. These correspond to four specific safety barriers.

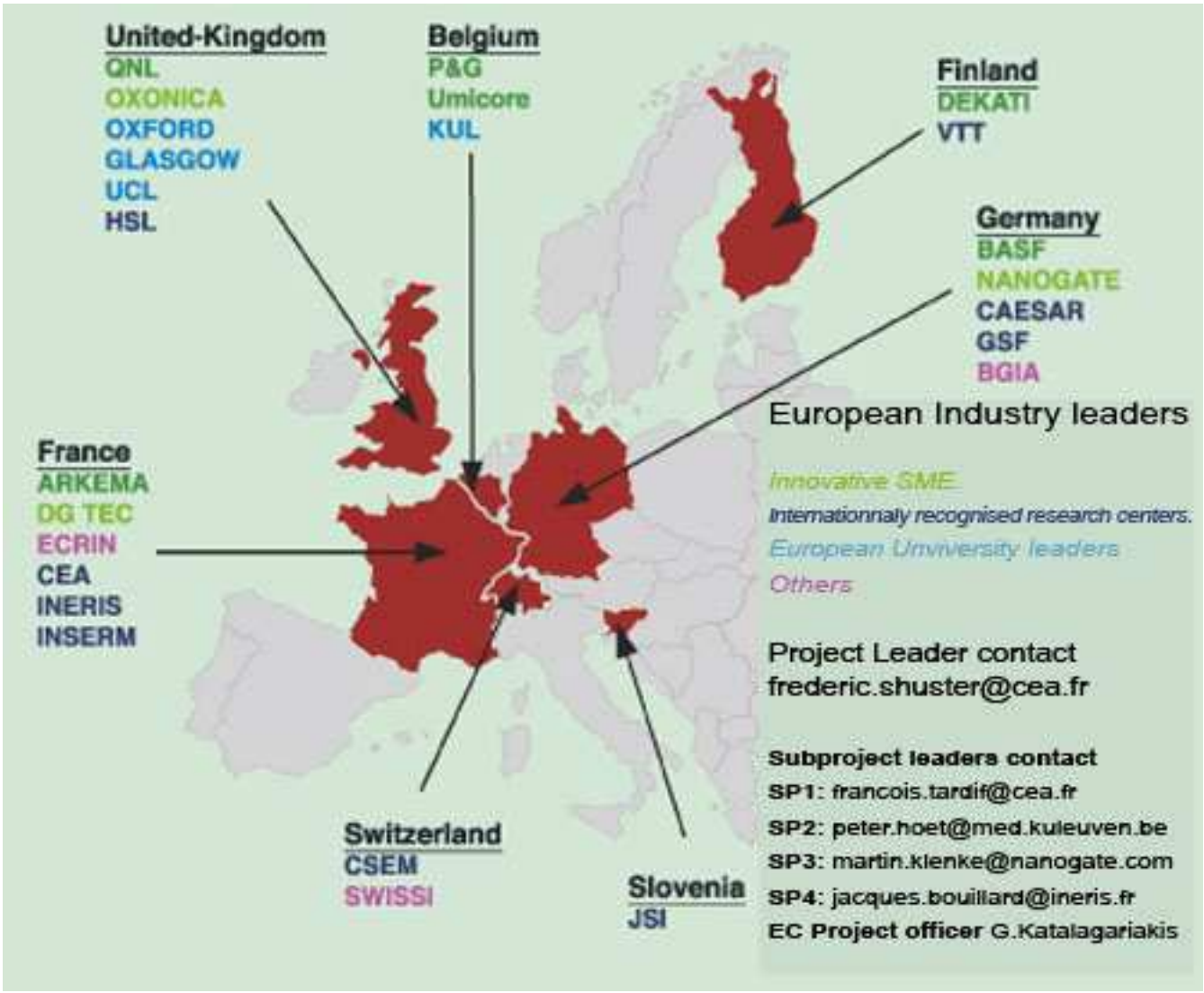
Prevention Barrier: *Reduction of the Probability of occurrence of an accidental situation by* ***reinforced maintenance procedures*** 	***Mitigation Barrier:*** *Reduction of Process factors by* ***lowering process temperature or pressures****.* 
Mitigation Barrier: *Reduce Nanopowder severity parameters by* ***substitution or dilution*** 	***Protection Barriers:*** *Vulnerability (****degree of protection****) of the target* 

Once the risk evaluated, one can propose various types of safety barriers to reduce the risk:

- ***A Prevention barrier to reduce the probability of occurrence of an accident.***
- ***A Mitigation barrier to reduce the effects of process parameters or propose product substitution or severity attenuation.***
- ***A Protection barrier, such as protection equipments, confinement technologies or venting system, to protect the worker or the environment.***

Nanosafe2 brings together twenty five partners from seven countries of the European Union, mainly small, medium and large enterprises and public research laboratories. The project is supported through the Sixth Framework Programme for Research and technological Development of the European Commission and addresses the thematic priority3.43.2-1: Hazard reduction in production plant and storage sites. The project started in April 2005 and will end in March 2009.
Nanosafe2 main objective is to develop risk assessment and management for secure industrial production of nanoparticles. It focuses on four areas: detection and characterisation techniques, Health hazard assessment, development of secure industrial production systems and safe applications, societal and environmental aspects.

Partners



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