# INCINERATION OF A COMMERCIAL COATING WITH NANO CEO2

Olivier Le Bihan[1], Laurent Meunier[1], Ghania Ounoughene[2], Olivier Aguerre-Chariol[1]
(1) INERIS, France –
(2) KU Leuven, ProcESS, Leuven, Belgium

olivier.le-bihan@ineris.fr

maîtriser le risque
pour un développement durable

# Outline

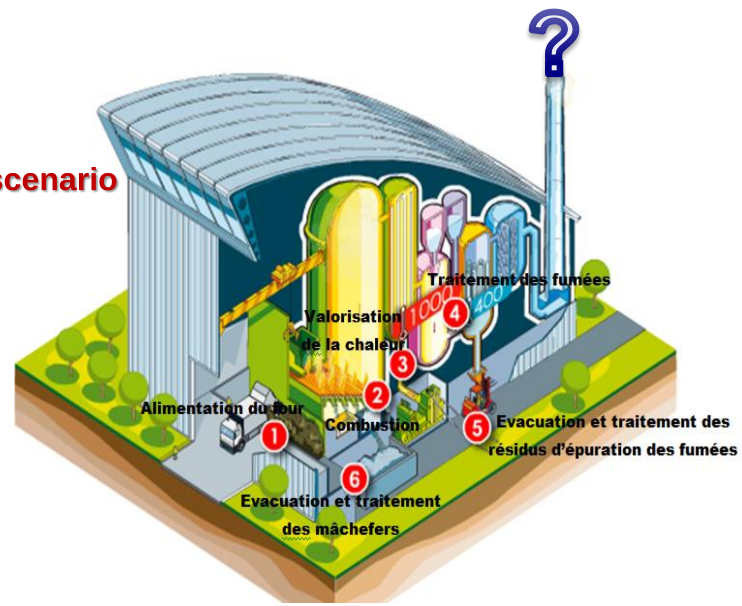
- Context and Objectives
- Material and Methods
- Results
- Conclusion

# Context 1/5 – key questions

- Risks related to the end of life nanomaterials.

- End of life scenario: disposal via incineration

Incineration scenario

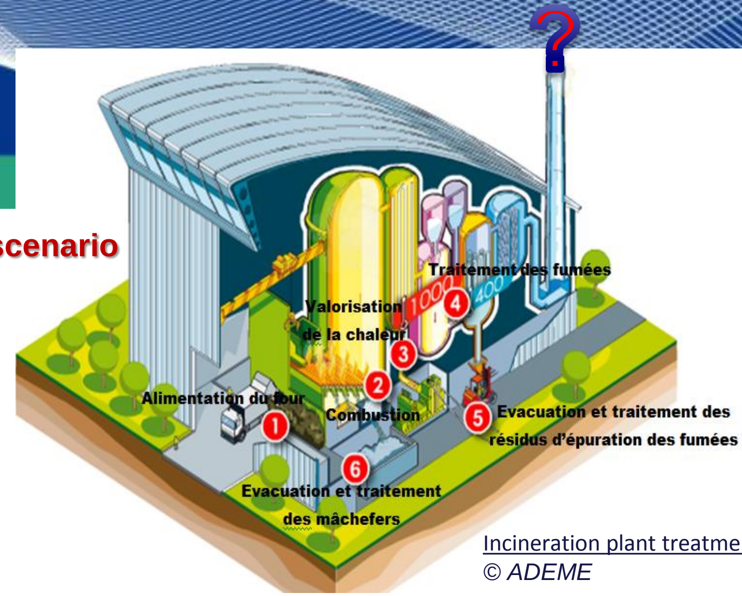



Incineration plant treatment
*© ADEME*

- **Can nanoparticles in waste (from industry/production or commercial products at the end of life) enter the environment ?**
- **Is it possible to support waste management ?**

# Context 2/5 - flue gas treatment

**Incineration scenario**




Incineration plant treatment
© *ADEME*

First studies: encouraging results

Walser et al., Nature Nanotechnology 7, 2012

- municipal solid-waste incineration plant
- effectiveness of the complete flue gas treatment systems in the most modern incinerators,
- and in particular the lack of detectable ceriated nanoparticles at the stack orifice after a massive injection of nano-CeO2, both in the primary chamber and in the post-combustion zone.

NanoFlueGas report, 2014

- Lab scale: single filtering sleeve (100% PTFE) [BAT] + injection of sorbents in mixture
- under optimal conditions: more than 99% abatement by number of carbon nanoparticles injected in a gas stream.
- However other waste types must be tested, + sensitivity to variations in operating conditions must be studied to confirm this.

Nanosafe16 – Paur et al. / KIT

# Context 3/5 - incineration chamber / scale

Scale1 campaings: complex (e.g. ~difficult to feed with only nano-wastes) + time consuming (expensive)

→ need for lab-scale

However:

- Rules from Regulation to be strictly considered
  - temperature around 850°C,
  - highly ventilated combustion
  - at least 2 s residence time for the combustion gas in a post-combustion chamber at 850°C
  - high oxygen/fuel contact
- Keep in mind Lab-scale limitations
- Upscaling has to be considered for validation

INERIS
maîtriser le risque
pour un développement durable

# Context 5/5 - Management

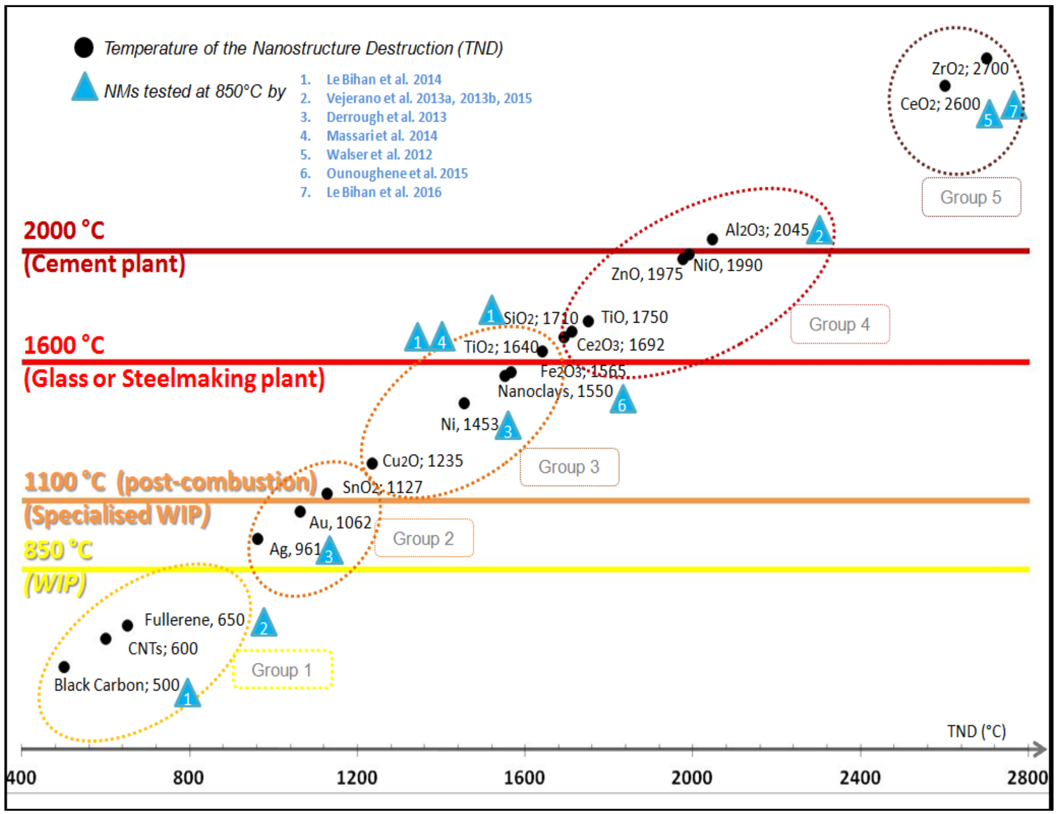
International Conference on Health & Safety issues related to Nanomaterials, Nanosafe 2016
November 7-10, 2016 – Grenoble, France

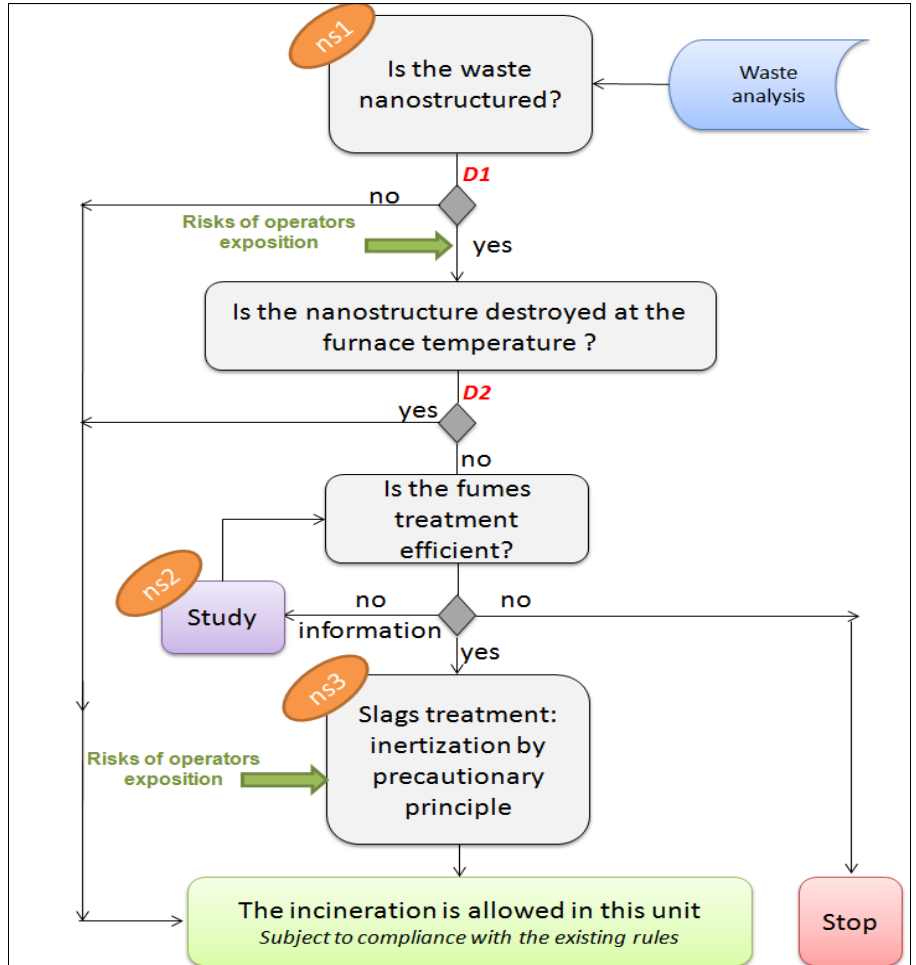
N° 3.4 - XX

**THERMAL DISPOSAL OF WASTE CONTAINING NANO-OBJECTS:
FIRST INVESTIGATIONS ON A METHODOLOGY FOR RISK MANAGEMENT**

G. Ounoughene[1,2,3], O. Le Bihan[4], C. Chivas-Joly[5], C. Longuet[2], B. Debray[4], A. Joubert[1], J-M. Lopez-Cuesta[2], L. Le Coq[1] – (1) LUNAM, Ecole des Mines de Nantes, GEPEA, CNRS, UMR 6144, 4 rue Alfred Kastler, 44307 Nantes Cedex 03, France – (2) C2MA, Ecole des Mines d'Alès, 6 Avenue de Clavières, 30319 Alès Cedex, France – (3) ADEME, 20 avenue du Grésillé, 49004 Angers Cedex 01, France – (4) INERIS, Parc Technologique Alata, 60550 Verneuil-en-Halatte, France – Roger Hennequin, 78197 Trappes Cedex, France

## Poster S3.4 – P3




*Need for study:*
*ns1 : Need to develop analysis methods and tools to characterize the waste nanostructure*
*ns2 : Need to study the efficiency of fumes treatment systems*
*ns3 : Need to study the suitability of slags treatments*
*Definitions:*
*D1 : Definition of « nanostructured waste »*
*D2 : Definition of « temperature of nanostructure destruction »*

# Objectives of the study

- To Produce data on NMs fate (chamber)
- Case study: commercial product with nano$CeO_2$
- Waste Municipal Incineration Plant

→ Fate of the nano$CeO_2$ ? Fumes ? Residues ?

maîtriser le risque
pour un développement durable

## Analysis of combustion residues and combustion aerosol

### Time tracking

(combustion aerosol)

- Gas concentration
  - Multi-gas analyzer (Portable Gas Analyzer PG-250 Horiba)

*Horiba Gas Analyzer*

- Particle Number concentration
  - ELPI (Electrical Low Pressure Impactor, Dekati) used downstream a FPS dilutor (Fine particle sampler, Dekati)

*ELPI* *Electrical Low Pressure Impactor*

### Offline analysis

(residues and particles from aerosol)

Particles from combustion aerosol

- Sampling on TEM grid with MPS (Mini particle sampler) for TEM imagery

Combustion residues

- TEM, ICP-MS



INERIS maîtriser le risque pour un développement durable

<u>Commercial coating</u>:

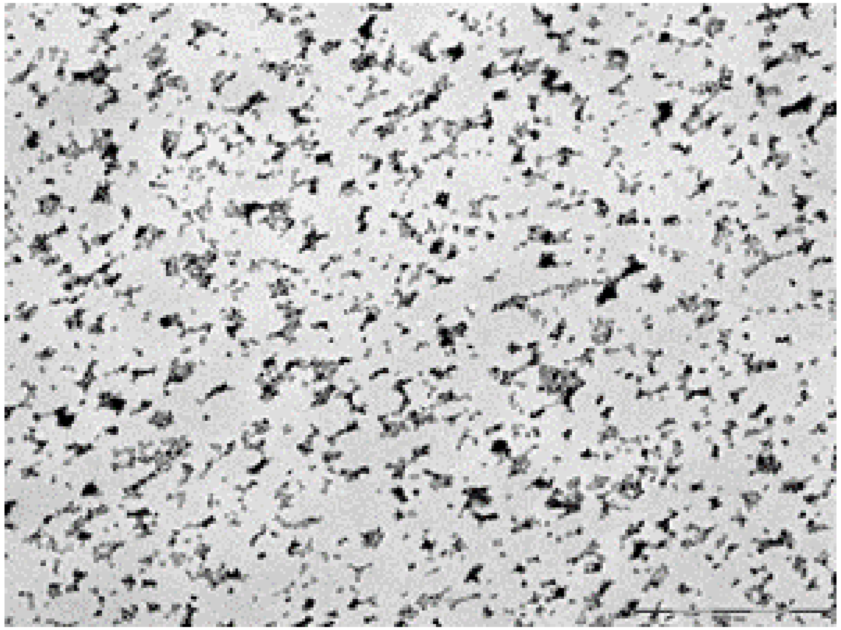
COLOURS LASURE 4ANS 1L INCOLOR

Code 101805

Groupe V33

Castorama – wood coating

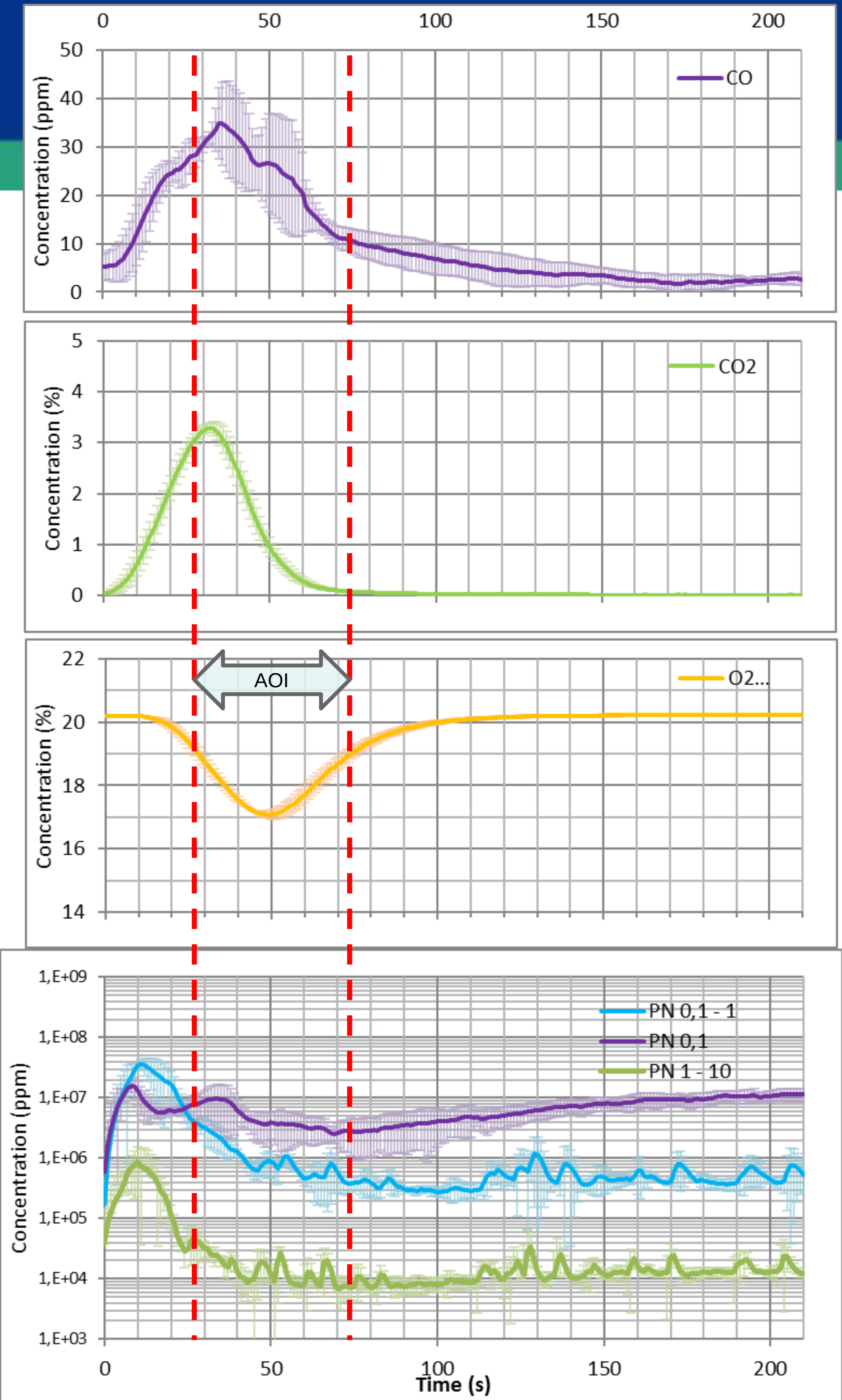
<u>In addition</u>: 7% Nanobyk 3810



TEM analysis after dilution (20X) with pure water

→ aggregates of 10 to 40 nm, with elemental particles of 2-3 nm

→ Elemental analysis: carbon, oxygen, cerium, sodium et sulfur




# Results

## Time Tracking of gaz and aerosol

Average of 3 tests.

~250 mg of product

Area of interest (AOI): 5% of O2 consumption

Flamme at the very beginning. ~19s duration.

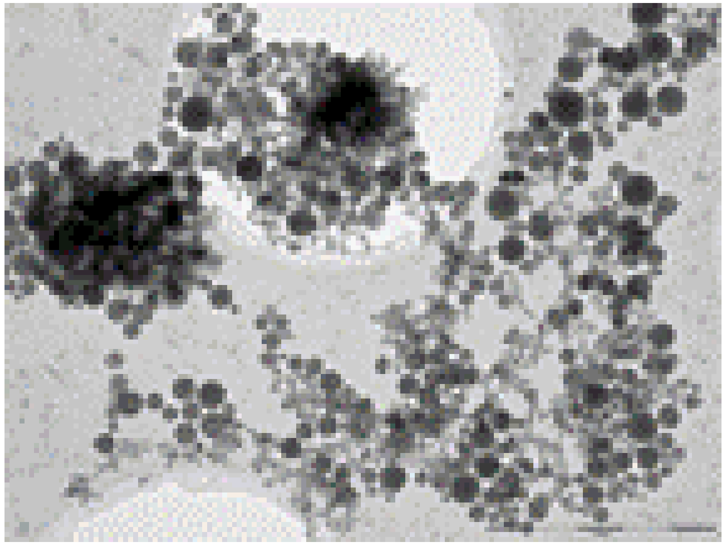
After an initial peak dominated by 0,1 – 1 µm, particles emission are dominated by < 0,1 µm range.

Phenomenology to be studied further.

INERIS

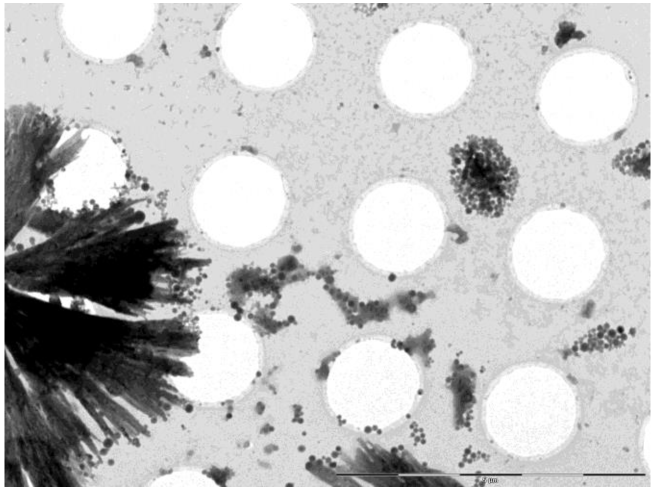
maîtriser le risque
pour un développement durable

## Analysis of the aerosol



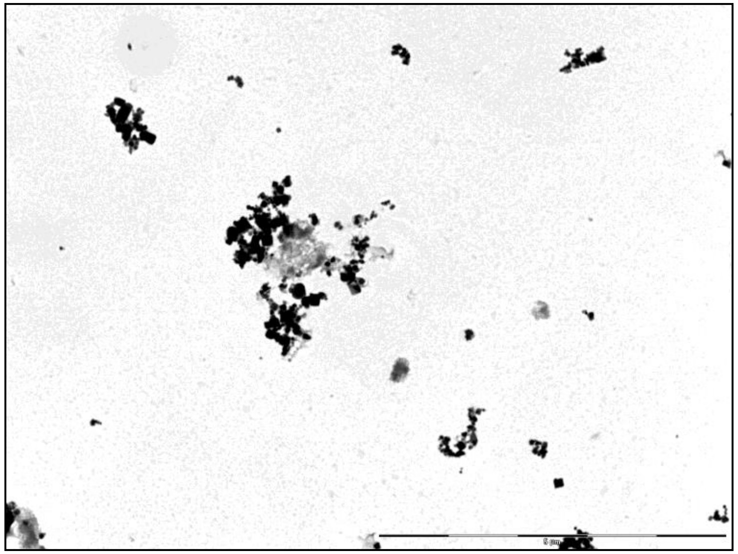
AOI - Cerium is observed by TEM/EDX analysis but

- as a minority
- in heterogeneous particles



## Analysis of the residues

- Mass of the residues: about 6% of the initial mass
- ICP-MS analysis: the residual material consists mainly of $CeO_2$ (60% of the mass).
- TEM observations of the residues:
  - 40-200 nm aggregates
  - Elemental particles: nano
  - sintering ?

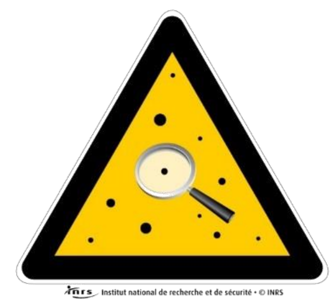


Scale: 5 µm

## Conclusion

- Small scale incineration – commercial coating with nanoCeO2
- Qualitative analysis (semi-quantitative analysis)
- The test led mainly to the release of nano-CeO2 in the residual material, as the major component.
- This is consistent with scale1 experiment conducted by spraying nano-CeO2 onto waste in the furnace entrance (Walser 2012).

→ Confirms the Need to take precautionary measures toward the residues and fumes treatments during the incineration of NMs



- Aggregates are larger compared to the initial waste. Sintering ? If so, transformation/decrease of the specific surface.

INERIS
maîtriser le risque
pour un développement durable

# Perspectives

- That case: Phenomenology

More largely:

- Nanostructure / specific surface: leading indicator ?
- From qualitative analysis to semi-quantitative analysis
- Upscaling
- Feed global view to develop support to waste management

INERIS
maîtriser le risque
pour un développement durable

# Remerciements

Ministère de l'Environnement – correspondants DRC 54

ADEME, Ecole des Mines de Nantes, Ecole des Mines d'Alès, LNE, INERIS, Séché Environnement – TREDI, Serenade-CEA-Université de Montpellier, etc.

Thanks for your attention

INERIS
maîtriser le risque
pour un développement durable