

# Report about nanofluid's health, safety and environmental impact

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2019

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Nanouptake COST Action

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## Report about nanofluid's health, safety and environmental impact

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**Title:** Report about nanofluid's health, safety and environmental impact

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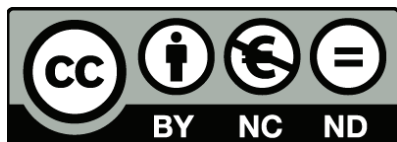
- Nanouptake COST Action
- Pexels

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## Section 1

### 1.1 EXECUTIVE SUMMARY

The **aim** of this report from Nanouptake is to review the main challenges on the use of nanofluids related to **health, safety and environmental** issues.

The **methodology** used has been double.

Primary sources:

- Workshops with a group of experts from academia and industry fields.
- Online questionnaire.

Secondary sources:

- Compendium of nanofluid's health, safety and environmental resources.

***“Health and safety knowledge on the use of nanofluids to overcome barriers in its implementation”***

The **results** obtained in the workshop emphasise the concern about the lack of a legal framework and its impact on the implementation of nanofluids in the market. Some actions were proposed to overcome the main challenges on the use of nanofluids as networking or writing and sharing protocols.

On the other hand, the results obtained on the questionnaire highlight that participants are much aware of the risks related to nanofluids, although hardly any specific regulations exist to avoid these risks.

To conclude, a wide range of resources has been gathered in order to facilitate access to protocols, lab resources, networks and projects working with nanofluids.

# Section 2

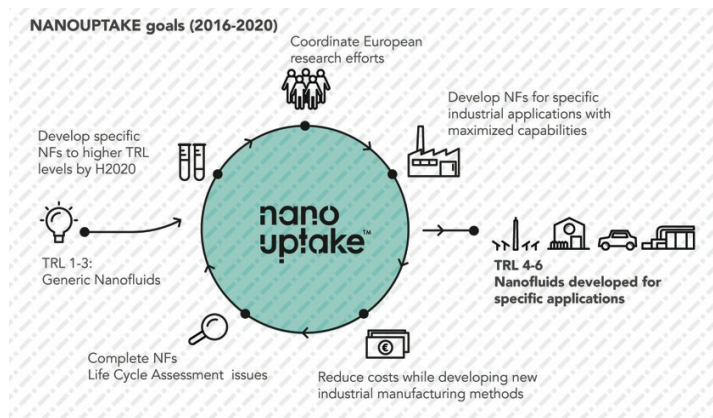
## 2.1 INTRODUCTION

### 2.1.1 BACKGROUND

[Nanouptake](#) (Overcoming Barriers to Nanofluids Market Uptake) is a COST Action that aims to strengthen the scientific coordination and collaboration of the network of leading nanofluid R+D+i centres and industries to develop and foster the use of nanofluids as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems.

By developing of nanofluids up to higher Technological Readiness Levels (TRL) and overcoming commercial application barriers, **Nanouptake** will contribute to achieve the European Horizon 2020 Energy and Climate objectives (Societal Challenges 3: Secure, efficient and clean energy; and 6: Climate action, environment, resource efficiency and raw materials).

Among its objectives is fostering the development of a joint research agenda in order to assess health and safety of nanofluids and their potential impact on the environment and on selected industrial applications.



*Illustration 1: Infographic with Nanouptake goals.*

### 2.1.2 OBJECTIVES

Aligned with the objectives of Nanouptake, this report aims to better involve the industry partners in the discussion, analysing the perspectives about nanofluids market uptake, trying to achieve this secondary objectives:

- Promote the development of a joint agenda to analyse **health, safety and environment potential impacts of nanofluids**.
- Create **new synergies and encourage cooperation** of several nanofluids research institutions and industries across Europe.
- Perform a collaborative **compendium of resources** about health and safety in the use of nanofluids.

### 2.1.3 METHODS

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The assignment of this report has been composed of the following phases:

- **Strategic meeting**

To achieve these challenges, a **strategic meeting** with the Nanouptake Core Group and industries was organised. Diagnosis workshops were carried out to obtain a complete analysis of the situation of nanofluid's health, safety and environmental aspects.

- **Online questionnaire**

A questionnaire was released to identify the main concerns and expectations related to health and safety issues.

- **Gathering resources.**

On the strategic meeting was pointed out that a compilation of good practices and information related to health, safety and environmental issues would be desirable. After the meeting, different institutions shared their resources.

- **Produce the report and cross-check with the Nanouptake Core Group.**

### 2.1.4 STRUCTURE OF THE REPORT

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After this introduction, which aims to context the report, section 3 addresses the results of the strategic meeting in Birmingham. Section 3.1 indicates the negative external factors through a pentagonal analysis workshop designed from a perspective of problems and solutions. Some of these challenges have a technical profile, others are the consequence of the lack of rules and regulations.

Section 4 gathers the results of the survey answered by experts in order to identify how the risks related to the use of nanofluids are estimated, which measures are undertaken to handle them and if special regulations exist for treating nanoparticles and nanofluids in laboratories.

Section 5 offers a compendium of resources and advances in the field of health and safety. Section 6 includes an annex with the NanoSafety questionnaire.



## Section 3

# 3.1 STRATEGIC MEETING



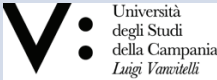





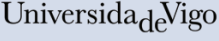





### 3.1.1 OBJECTIVES

The **aim** of the meeting was to identify the present barriers for the nanofluid implementation in the industry and encourage cooperation of several nanofluids research institutions and industries across Europe to advance in overcoming them. Workshops were carried out to analyse the progress of the project and to promote joint objectives.

### 3.1.2 PARTICIPANTS

Representatives from eleven research institutions from the European network Nanouptake ([www.nanouptake.eu](http://www.nanouptake.eu)), led by the Universitat Jaume I, and representatives of four industries, met in the University of Birmingham (United Kingdom) the 1st of February of 2019 (table 1).

Table 1: Institutions represented on the strategic meeting in Birmingham.

NANOUP TAKE CORE GROUP				
<b>Universitat Jaume I, Spain</b>  	<b>Rzeszow University of Technology, Poland</b>  	<b>Università degli Studi della Campania Luigi Vanvitelli, Italy</b>  	<b>Lund University, Sweden</b>  	<b>Gheorghe Asachi Technical University of Iasi, Romania</b>  
<b>Université Rennes 1, France</b>  	<b>University of Birmingham, United Kingdom</b>  	<b>ILK Dresden gGmbH, Germany</b>  	<b>University of Vigo, Spain</b>  	<b>Universidade de Lisboa, Portugal</b>  
<b>Wroclaw University of Science and Technology, Poland</b>  	INDUSTRIES			
	<b>Synano-cooling</b>  	<b>JJ Bioenergy</b>  	<b>End user company</b>	<b>Plin-Nanotechnology</b>  

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*Illustration 2: Participants of the Strategic Meeting of Nanouptake COST Action in Birmingham.*

### 3.1.3 METHODS

Primary research was conducted to obtain accurate data and qualitative assessments about the perception of the external situation in the use of nanofluids. Data was obtained through the following workshop:

- **Pentagonal analysis – PESTEL:** nanofluid's health, safety and environmental issues.

The audio of the meeting was recorded and photos were taken to document and analyse the key findings.

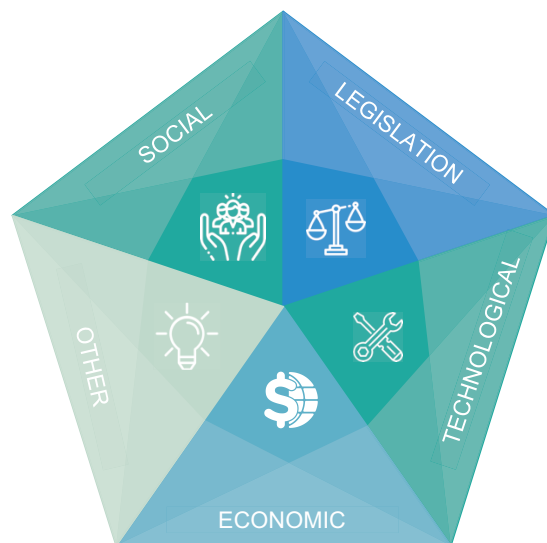
## 3.2 PENTAGONAL ANALYSIS - PESTEL

### 3.2.1 PROCESS

The workshop aimed to point out the negative aspects associated to external factors, as environmental, health or safety issues among others, in order to reflect about possible solutions to each one.

With the idea of visualizing easily those external factors and to obtain with a simple glimpse a picture of the negative aspects related to a **PESTEL analysis** (analysis of external factors: Political, Economic, Social, Technology, Ecology and Legal issues) a pentagon was used.

Each side of the pentagon highlighted one external factor that was considered of meaningful interest: economic, social, legislative and technological fields (academic, knowledge). The last side of the pentagon was assigned to other issues (illustration 3).



*Illustration 3: Pentagon for the analysis. Icons made by Freepik from [www.flaticon.com](http://www.flaticon.com).*

The workshop was developed in two parts, the first one was assigned to analyse the problems and the other to analyse possible solutions related to the mentioned problems.

- **First part: Analyse of problems**

The workshop was explained and participants received pink post-its and instructions to write one idea in each post-it related to a problem with the objective of including it in the pentagon chart. Participants wrote down their ideas and completed the chart (illustration 4).

Once the chart was completed with problems related to external factors, a debate was followed to analyse the results.

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- **Second part: Analyse of solutions**

Participants received yellow post-its to write down possible solutions to the problems mentioned in the pentagon analysis. Once the chart was completed, the solutions were analysed in an open debate among participants.

To conclude, the last minutes were driven to analyse how can Nanouptake contribute to improve the nanofluid's health, safety and environmental issues that were highlighted.



After the meeting, the notes from the post-its were written down (see section 3.2.2) and the audios were listened to obtain the key ideas from the workshops (see section 3.2.3).

*Illustration 4: Pentagon analysis workshop in Birmingham.*

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### 3.2.2 RESULTS

The pentagon was completed with the post-its of the participants (illustration 5). Pink post-its represent negative aspects, the yellow ones include solutions to those negative aspects and green ones highlight possible contributions from Nanouptake.

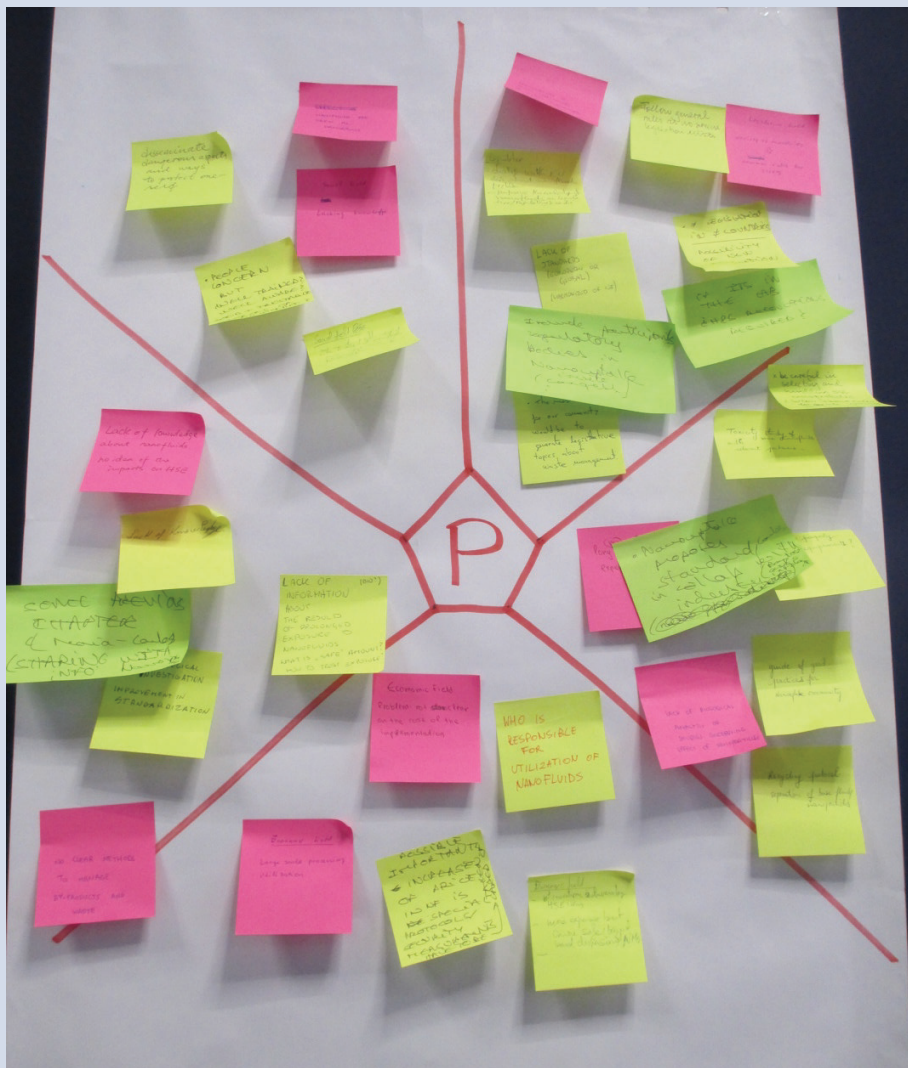


Illustration 5: Pentagon built with the contributions of participants.

To maintain the visual effect from the chart of the workshop, the negative issues are written in red, possible solutions in black, and possible contributions from Nanouptake in green.



### SOCIAL FIELD

- Nanofluids are seen as dangerous.
- Lacking knowledge.
- Disseminate dangerous aspects and ways to protect one self.
- People concern, well trained? / well aware? / good + trustable sources of knowledge?
- Improve drug efficiency with biological nanofluids.
- Analyse applications of nanosystem in bone treatment.



### LEGISLATIVE FIELD

- Variety of nanofluids: common rules for safety.
- Legislation is still changing. No clear framework.
- Follow general rules as no precise legislation exists.
- Dialogue with EU dg's about nanofluids problems
- Improve knowledge of nanofluids in legislative/regulatory boards
- Different legislation in different countries.
- Possibility of new legislation.
- Lack of standards (european or global, harmonized or not).
- The most important for our community would be to generate legislative topics about waste management.
- Are H&S regulations implemented in Nanouptake labs?
- Try to include participants from H&S regulatory bodies in Nanouptake. Invite them to congress?



### TECHNOLOGICAL FIELD Academic / Knowledge

- No long term experiment data.
- How to properly clean equipments?
- Lack of biological analysis or studies concerning effect of nanoparticles.
- Be careful in selecting and handling the nanoparticles.
- Toxicity study of some nanofluids with relevant partners.
- Guide of good practices for Nanouptake community.
- Recycling protocol - separation of base fluid / nanoparticles.
- Follow labour rules for safe working environment.
- Nanouptake proposes standards / codes in collaboration with industry.



### ECONOMIC FIELD

- Problem not clear on the cost of the implementation.
- Large scale processing utilization.
- Who is responsible for utilization of nanofluids?
- Possible important increase of price in nanofluids is special protocols / security measurements have to be taken / cared of.
- Innovation driven by HSE issues.
- More expensive but more safe liquid based dispersion of NMs.



### OTHER FIELDS

- No clear methods to manage by products and waste.
- Lack of knowledge.
- Lack of knowledge about nanofluids. No idea of the impacts on HSE.
- (Bio) Lack of information about the results of prolonged exposure to nanofluids. What is "safe" amount? How to treat exposure?
- More epidemiological investigation.
- Improvement in standardization.
- Share more H&S information among Nanouptake network.

### 3.2.3 CONCLUSIONS

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There was a strong agreement in all the areas and key issues were identified.



To start with, the main factor related to the **social field** was the perception of danger connected with the use of nanofluids. To overcome that concern, writing and sharing protocols to handle nanofluids arise as a solution.



To continue with, in regard to the **legislative field**, the lack of a legal framework was the key factor. To advance in that area it was proposed to include participants from regulatory bodies in the Nanouptake network, for instance assistance to the session dedicated to that field in the ICNf2019 ([International Congress on Nanofluids](#)) It was also suggested to write H&S (health and safety) protocols for the use of nanofluids in laboratories.

Moreover, it is important to take into account that this field is connected to other fields, for instance the lack of regulation regarding waste management is related to the environmental field and the lack of regulation concerning health and safety is related to the social field.



In reference to the **technologic / academic field**, participants shared their enthusiasm about the idea of having a guide of good practices regarding environmental and health issues. The main concern related to this field was the lack of long term experiment data as well as issues related to safety, maintenance and waste management in the lab. Then, the suggestion for Nanouptake was to propose standard codes in collaboration with industry.



Concerning the **economic field**, there were named different issues, some related to the cost of implementation, others to large scale processing utilization. Another issue expressed on the debate was the need of regulation and of defining responsibilities on the use of nanofluids (manufacturer, user and distributors).



To conclude, the main topics expressed when analysing **other fields** were related to lack of information and knowledge, health and safety and waste management. The proposed solution for the network was to exchange and share information with the network. There were suggested some documents and after the meeting were gathered (see section 05).

Solutions related to epidemiological investigation were also suggested.



## Section 4

# 4.1 QUESTIONNAIRE ANALYSIS

### 4.1.1 INTRODUCTION

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Nanofluids are related to certain risks that have not been specified yet and demand special regulation. Within the framework of the COST Action CA15119 NanoUptake, a survey was carried out in October 2018, including institutions from 19 countries, majority being from Europe. The Nanosafety questionnaire can be found in **section 6**.

The answers received from 68 participants have been analysed in a paper submitted to the 1st International Congress on Nanofluids (ICNf2019) and gathered on this report:

#### **NanoSafety – A survey on the safety of nanofluid use**

**J. Kaur<sup>1,3</sup>, L. Hernandez<sup>2</sup> and M.H. Buschmann<sup>3\*</sup>**

<sup>1</sup>Hochschule für Technik und Wirtschaft Dresden, Friedrich-List-Platz 1, 01069 Dresden, Germany

<sup>2</sup>Departamento de Ingeniería Mecánica y Construcción, Universitat Jaume I, Castelló de la Plana 12071, Spain

<sup>3</sup>Institut für Luft- und Kältetechnik gGmbH Dresden, 01309 Dresden, Germany

### 4.1.2 OBJECTIVES

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The **objectives** of the questionnaire are:

- to investigate how the risks related to nanofluids are estimated,
- which measures are undertaken to handle them and
- to know if special regulations exist for treating nanoparticles/nanofluids in laboratories.

### 4.1.3 METHODS AND PARTICIPANTS

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The survey consists of 45 questions divided into 6 sections, which were sent to about 220 individuals. Answers were received from 68 participants.

It must be emphasised, that these results do not necessarily give a complete picture of the institutions/countries involved. However, it is expected that the survey is a sufficient sample out of the population and gives reliable information.

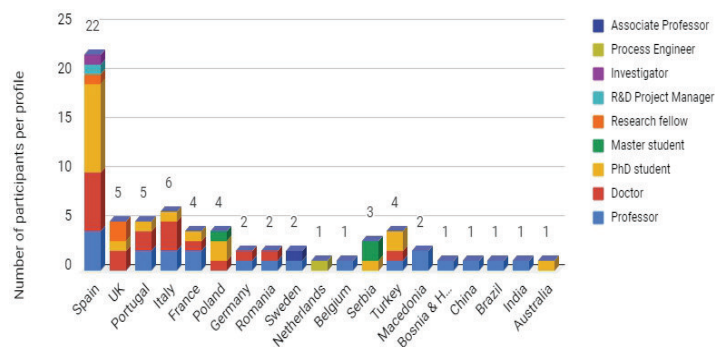
### 4.1.4 ABSTRACT

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One of the major findings is, that despite the participants being very much aware of the risks related to nanofluids, hardly any specific regulations exist to avoid these risks.

### 4.1.5 RESULTS

**Figure 1** gives the **country wise distribution** of participants. Out of these 60 (88.2%) participants deal with nanoparticles/nanofluids. The overall trend in the survey shows that more than half of the participants (61.7%)<sup>1</sup> are of the opinion, that nanoparticles/nanofluids both pose a **risk to human's health**. About 18.3% of the participants are of the opinion that only nanoparticles are harmful. Just one participant believes, that only nanofluids are injurious to health. Another 18.3% of the participants are unsure of the health risks. No participant is of the view, that neither nanoparticles nor nanofluids are harmful.



**Figure 1: Country wise distribution of participants.**

For a similar analysis for environmental risk, 65% hold the opinion that both nanoparticles and nanofluids pose an **environmental risk**. However, the level of unsurety is really high. Around 28.3% of the participants believe, that nanoparticles/nanofluids may or may not cause risk to environment. Merely three people hold the view that only nanoparticles are harmful. None of the participants credit nanofluids for posing risk to environment. One participant believes, that neither nanoparticles nor nanofluids are harmful to the environment.

**Figure 2** indicates the share of participants with (53.3%) and without (46.7%) **health and safety regulations** in their institution and the results are almost comparable. Some institutions do not have health and safety regulations so far. It becomes clear from the survey, that most of the organisations do not provide special health and safety training to their employees. In Spain alone, only 43% of all participating organisations have health and safety training. Portugal, Poland, Romania, Sweden, Belgium, Turkey, Macedonia, India and Australia provide no provision for training at all. Similarly the question with respect to criteria for risk assessment indicates, that majority of the institutions do not have any criteria. Only 38.3% of the participants have risk assessment criteria of which majority are from Spain and the UK. About 47% of all countries involved do not to have any criteria.

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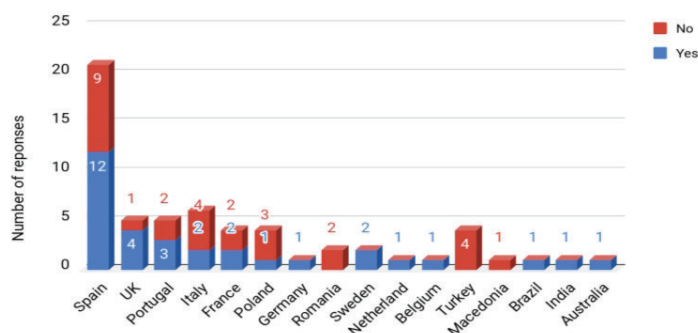


Figure 2: Existence of health and safety regulations.

<sup>1</sup> Note: All percentages are related to the number of 68 responses obtained. There are cases with no response at all, whereas some had multiple answers. Therefore, completion to 100% based on the data given might not be possible in all cases.

The survey indicates, that the **amount of nanoparticles/nanofluid handled** by the different institutions spans a wide range from nothing (theoretical/numerical research only) to 1 kg/month (nanoparticles) and 26 l/per month (nanofluids) respectively.

- **Main route of exposure**

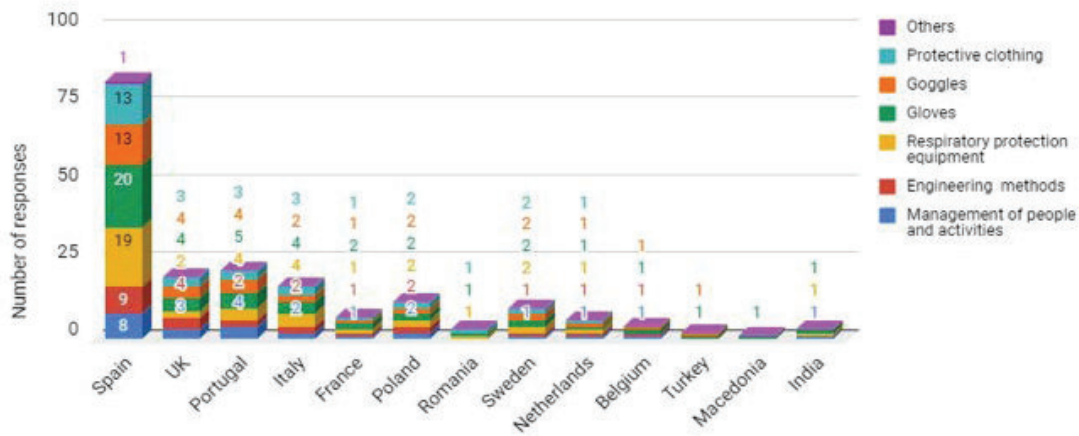
The majority of the participants (65%) think that **inhalation** is a main route of exposure to nanoparticles, followed by the dermal route (44%) and ingestion (13%). About 66% of the participants responded that the **dermal** is the major route of exposure to nanofluids. Some proportion (28%) of participants from each of the country find **injection** of nanofluids to be of main concern. Just 20% consider **ingestion** as a problem.

- **Waste management**

Most of the participants dispose of the waste nanoparticles either as ordinary chemical waste (35%) or hand it over to special waste disposal companies (29%). A few organisations in the UK and Portugal follow their own procedures. Interestingly 10% of the organisations claim to have no waste nanoparticles at all. The majority of the countries dispose of the nanofluids as ordinary chemical waste (44%) or handover it over to special waste disposal organisations (24%). One participant in Turkey follows its own waste disposal method along with standard methods. Consequently, most of the groups (51 to 53%) have **specific storage places** for nanoparticles/nanofluids in their laboratories and employ appropriate **measures to reduce the risk of exposure** (figure 3).

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## Nanoparticles



## Nanofluids

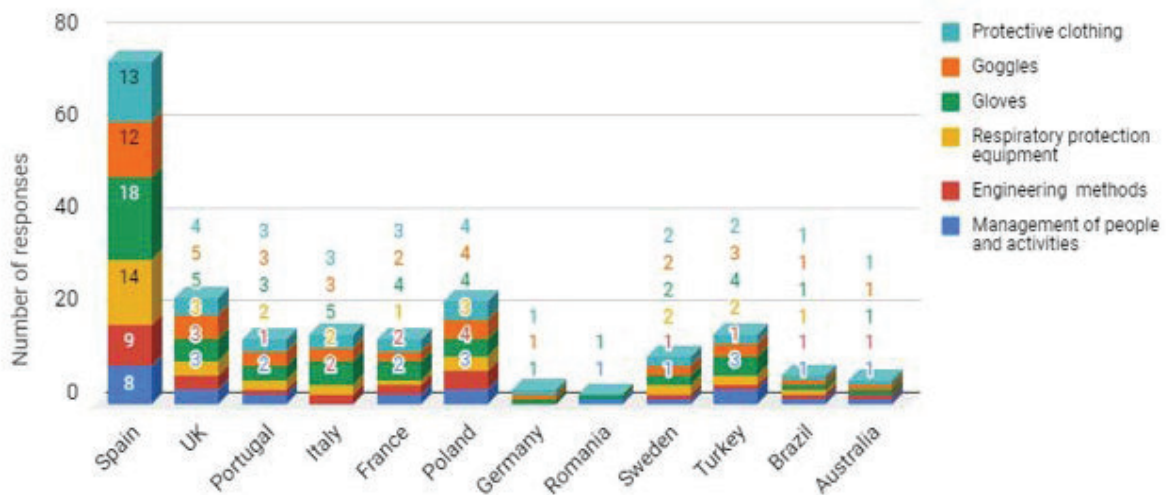


Figure 3: Measures to reduce risk of exposure.

### 4.1.6 CONCLUSIONS

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A survey on the safety requirements while using nanoparticles/nanofluids has been carried out under 19 countries. From the 68 responses, first conclusions are drawn. The majority of the answers indicate a very **careful handling** of these special materials based on **standard safety rules** usually employed to similar chemical substances. However, it seems that there are no specific rules for handling nanofluids/nanoparticles. Especially the nanofluids seem to be treated as any other comparable chemical risky liquids. This goes along with the finding that there is no special literature on the subject of nanofluid safety. The found and analysed references deal with safety aspects of solid nanomaterials and their processing but not with nanofluids (see e.g. [3]). Moreover, no references on the subject could be provided.

All participants are obviously aware of the specific risks which are related to nanoparticles/nanofluids. However, **special training** of employees or monitoring of workplaces is very limited. Merely 6 to 7% monitor workplace for nanoparticles/nanofluids and only 28% provide special training to employees. This is really surprising because the survey reveals that more than 750 people are working either with nanoparticles or with nanofluids or with both. It is hypothesised, that the reason for this finding is, that majority of the nanoparticles/nanofluids handling has research character and is still carried out in laboratories. Anyway, the expected future industrial applications demand the development of clear European standards for handling these specific nanomaterials.

### 4.1.7 REFERENCES

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2. [http://www.cost.eu/COST\\_Actions/ca/CA15119](http://www.cost.eu/COST_Actions/ca/CA15119), <http://www.nanouptake.eu/>
3. B. Fadeel et al., Safety assessment of graphene-based materials: Focus on human health and the environment, ACS Nano. 12(11) (2018) 10582–10620.

## Section 5

# 5.1 COMPENDIUM OF RESOURCES

### 5.1.1 INTRODUCTION

---

Attending to the demand of a compilation of information related to health, safety and environmental issues (as requested on the strategic meeting), Nanouptake has gathered resources of these areas grouped by: documents of interest, networks, projects and lab resources.

### 5.1.2 DOCUMENTS OF INTEREST

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- **NNI Environmental, Health and Safety related documents**

**National Nanotechnology Initiative (NNI).**

**Link:** <https://www.nano.gov/node/1164>

- **Nanomaterial Occupational Risk Management Matrix**

**Good Nano Guide**

**Link:** <https://nanohub.org/groups/gng/matrix>

- **Links to general and material specific protocols**

**Good Nano Guide**

**Link:** <https://nanohub.org/groups/gng/protocols>

- **Investigating the Different Types of Risk Assessments of Manufactured Nanomaterials**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2018

**Link:**

[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono\(2018\)24&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2018)24&doclanguage=en)

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- **WHO guidelines on protecting workers from potential risks of manufactured nanomaterials**

**WHO (World Health Organization)**

**Date:** 2017

**Link:** [https://www.who.int/occupational\\_health/publications/manufactured-nanomaterials/en/](https://www.who.int/occupational_health/publications/manufactured-nanomaterials/en/)

- **Alternative testing strategies in risk assessment of manufactured nanomaterials: current state of knowledge and research needs to advance their use**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2017

**Link:**

[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO\(2016\)63&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2016)63&doclanguage=en)

- **Building a Safety Program to Protect the Nanotechnology Workforce: A Guide for Small to Medium-Sized Enterprises**

**National Institute for Occupational Safety and Health (NIOSH) Nanotechnology Research Center (NTRC)**

**Date:** 2016

**Link:** <https://www.cdc.gov/niosh/docs/2016-102/pdfs/2016-102.pdf>

- **Guidance Manual towards the Integration of Risk Assessment into Life Cycle Assessment of Nano-Enabled Applications**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2015

**Link:**

[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono\(2015\)30&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2015)30&doclanguage=en)

## Report about nanofluid's health, safety and environmental impact

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- **Summary of work undertaken to assess workplace exposure and control measures during the manufacture and handling of engineered nanomaterials**

Health and Safety Laboratory

Date: 2015

Link: <http://www.hse.gov.uk/research/rrpdf/rr1068.pdf>

- **Working Safely with Manufactured Nanomaterials – Guidance for Workers**

European Commission, Employment, Social Affairs & Inclusion

Date: 2014

Link: <https://www.safenano.org/knowledgebase/guidance/safehandling/ec-2014-working-safely-with-nanomaterials/>

- **Nanofluids preparation methodology**

M. J. Lourenço and S. I. Vieira

Centro de Ciências Moleculares e Materiais - Faculdade de Ciências, Universidade de Lisboa

Date: 2014

Link:

[https://www.researchgate.net/publication/290364072\\_Nanofluids\\_preparation\\_methodology](https://www.researchgate.net/publication/290364072_Nanofluids_preparation_methodology)

- **Guidance on the protection of the health and safety of workers from the potential risks related to nanomaterials at work** - Guidance for employers and health and safety practitioners

European Commission, Employment, Social Affairs & Inclusion.

Date: 2013

Link: <https://ec.europa.eu/social/BlobServlet?docId=13087&langId=en>



## Report about nanofluid's health, safety and environmental impact

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- **Nanosafety in Europe 2015-2025: Towards Safe and Sustainable Nanomaterials and Nanotechnology Innovations**

Kai Savolainen (coordinator), Ulrika Backman, Derk Brouwer, Bengt Fadeel, Teresa Fernandes, Thomas Kuhlbusch, Robert Landsiedel, Iseult Lynch, and Lea Pylkkänen together with the members of the NanoSafety Cluster

Date: 2013

Link: <https://www.nanosafetycluster.eu/uploads/files/pdf/report159.pdf>

- **Co-operation on Risk Assessment: Prioritisation of Important Issues on Risk Assessment of Manufactured Nanomaterials - Final Report**

Organisation for Economic Co-operation and Development (OECD)

Date: 2013

Link:

<http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono%282013%2918&doclanguage=en>

- **Tools for the management of nanomaterials in the workplace and prevention measures**

European Agency for Safety and Health at Work

Date: 2013

Link: <https://osha.europa.eu/en/publications/e-facts/e-fact-72-tools-for-the-management-of-nanomaterials-in-the-workplace-and-prevention-measures/view>

- **Safe Handling and Use of Carbon Nanotubes**

Safe Work Australia

Date: 2012

Link:

[https://www.safeworkaustralia.gov.au/system/files/documents/1702/safe\\_handling\\_of\\_nanotubes\\_info\\_sheet.pdf](https://www.safeworkaustralia.gov.au/system/files/documents/1702/safe_handling_of_nanotubes_info_sheet.pdf)

## Report about nanofluid's health, safety and environmental impact

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- **Important Issues on Risk Assessment of Manufactured Nanomaterials**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2012

**Link:**

<http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono%282012%298&doclanguage=en>

- **Risk perception and risk communication with regard to nanomaterials in the workplace**

**European Agency for Safety and Health at Work**

**Date:** 2012

**Link:**

[https://osha.europa.eu/en/publications/literature\\_reviews/risk-perception-and-risk-communication-with-regard-to-nanomaterials-in-the-workplace](https://osha.europa.eu/en/publications/literature_reviews/risk-perception-and-risk-communication-with-regard-to-nanomaterials-in-the-workplace)

- **Environmentally Sustainable Use of Manufactured Nanomaterials.** Workshop held on 14 September 2011 in Rome, Italy

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2011

**Link:**

<http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono%282013%2917&doclanguage=en>

- **Guidance working safely with nanomaterials and nanoproducts** - The guide for employers and employees

**Dutch Social Partners FNV, VNO-NCV and CNV.**

**Date:** 2011

**Link:**

<http://www.industox.nl/Guidance%20on%20safe%20handling%20nanomats&products.pdf>

## Report about nanofluid's health, safety and environmental impact

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- **Guidance manual for the testing of manufactured nanomaterials: OECD's sponsorship programme; first revision**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2010

**Link:**

<http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono%282009%2920/rev&doclanguage=en>

- **Emission Assessment for Identification of Sources and Release of Airborne Manufactured Nanomaterials in the Workplace: Compilation of Existing Guidance**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2009

**Link:** <http://www.oecd.org/science/nanosafety/43289645.pdf>

- **Comparison of Guidance on Selection of Skin Protective Equipment and Respirators for Use in the Workplace: Manufactured Nanomaterials**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2009

**Link:** <https://www.oecd.org/science/nanosafety/43289781.pdf>

- **Preliminary Analysis of Exposure Measurement and Exposure Mitigation in Occupational Settings: Manufactured Nanomaterials**

**Organisation for Economic Co-operation and Development (OECD)**

**Date:** 2009

**Link:**

[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/jm/mono\(2009\)6](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/jm/mono(2009)6)

## Report about nanofluid's health, safety and environmental impact

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- **Best Practices Guide to Synthetic Nanoparticle Risk Management**

Institut de recherche Robert-Sauvéen santé et en sécurité du travail (IRSST)

Date: 2009

Link: <https://www.irsst.qc.ca/en/publications-tools/publication/i/100423/n/best-practices-guide-to-synthetic-nanoparticle-risk-management-r-599/redirected/1>

- **Workplace exposure to nanoparticles**

European Agency for Safety and Health at Work

Date: 2009

Link: [https://osha.europa.eu/en/publications/literature\\_reviews/workplace\\_exposure\\_to\\_nanoparticles](https://osha.europa.eu/en/publications/literature_reviews/workplace_exposure_to_nanoparticles)

- **Nanotechnologies – Part 2: Guide to safe handling and disposal of manufactured nanomaterials**

BSi

Date: 2007

Link: <http://www3.imperial.ac.uk/pls/portallive/docs/1/34683696.PDF>

### 5.1.3 NETWORKS

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- **NanoHub.org**

A community of researchers and educators for computational nanotechnology research, education, and collaboration. The site hosts a collection of Simulation Programs for nanoscale phenomena that run in the cloud and are accessible through a web browser.

Link: <https://nanohub.org/>

- **NanoSafety Cluster**

The EU NanoSafety Cluster maximises the synergies between European-level projects addressing the safety of materials and technologies enabled by the use of nanoparticles. The studied aspects include toxicology, ecotoxicology, exposure assessment, mechanisms of interaction, risk assessment and standardisation.

Link: <https://www.nanosafetycluster.eu>

- **SAFENANO**

SAFENANO is dedicated to providing the highest quality expertise to help nanotechnology emerge and develop on a safe and sustainable basis, maximising its commercial potential, through a continuous development and improvement of our knowledge, equipment and practice.

Link: <https://www.safenano.org/>

- **Joint Research Centre (JRC)**

The Joint Research Centre is the European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. JRC scientists are contributing to the reduction of uncertainties about the potential impact of nanomaterials on health and the environment

Link: <https://ec.europa.eu/jrc/en/research-topic/nanotechnology>

- **European Commission, Research and Innovation: Policy Issues**

Link: [http://ec.europa.eu/research/industrial\\_technologies/policy\\_en.html](http://ec.europa.eu/research/industrial_technologies/policy_en.html)

## Report about nanofluid's health, safety and environmental impact

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- **Nanocentre**

Nanocentre offers information about safety of nanomaterials, guidance to get familiar with the huge amount of information on nanomaterials. The site offers an opportunity to exchange information between companies, research organisations and the government.

**Link:** <http://www.nanocentre.nl/index.aspx?id=262>

- **Australian Nanotechnology Network - Ausnano**

The Australian Nanotechnology Network promotes effective collaborations, exposing researchers to complementary approaches from other fields, encouraging forums for postgraduate students and early career researchers, increasing nanotechnology infrastructure, enhancing awareness of existing infrastructure, and promoting international links.

**Link:** <http://www.nanocentre.nl/index.aspx?id=262>

- **Organisation for Economic Co-operation and Development (OECD)**

The OECD promotes policies to improve the economic and social well-being of people around the world. OECD identified the need to analyse the potential safety concerns caused by manufactured nanomaterials. EHS launched a programme of work to ensure that the approaches for hazard, exposure and risk assessment are of a high quality, science-based and internationally harmonised.

**Link:** <http://www.oecd.org/env/ehs/nanosafety/>

- **NanoRisk App, Safe handling of nanomaterials in research**

This application developed by the University of Los Andes is a guide to help the researcher in the risk assessment of nanomaterials.

**Link:** [https://nanoseguridad.uniandes.edu.co/nano\\_en/indexeng.html](https://nanoseguridad.uniandes.edu.co/nano_en/indexeng.html)

- **EHS-ADVANCE**

EHS-ADVANCE is an initiative of the Government of the Basque Autonomous Community (Spain) that sets out to provide industry with a service and support in the areas relating to the Environment, Health and Safety whenever nanotechnologies are incorporated into its products and processes.

**Link:** <http://www.ehsadvance.com/en/web/guest/quienes-somos>

### 5.1.4 PROJECTS

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- **Scaffold**

Innovative strategies, methods, and tools for occupational risks management of manufactured nanomaterials (MNMs) in the construction industry

**Link:** <http://scaffold.eu-vri.eu/>

- **NANoReg**, a common European approach to the regulatory testing of Manufactured Nanomaterials

NANoREG provide answers to Society, Industry and the National Regulation and Legislation Authorities.

**Link:** <http://www.nanoreg.eu/>

- **Nano-Portal: Safe Handling of Nanomaterials**

The Nano-Portal is the result of a project supported by the DGUV and extends the knowledge about occupational safety and health in the fields of nanomaterials / nanotechnologies, serving as a basis for qualification and information.

**Link:** <http://nano.dguv.de/home/>

- **SIINN ERA-NET**, Safe Implementation of Innovative Nanoscience and Nanotechnology

The SIINN ERA-NET promotes the safe and rapid transfer of European research results in nanoscience and nanotechnology (N&N) into industrial applications.

**Link:** <http://www.siinn.eu/index.html>

- **caLIBRAte**

An interdisciplinary group of researchers, risk assessors, test facilities, and industry developing tools that manufacturers, authorities and companies can use to manage workplace risks during innovation, production and use of manufactured nanomaterials.

**Link:** <http://www.nanocalibrate.eu/home>

## Report about nanofluid's health, safety and environmental impact

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- **Gov4Nano**

The Gov4Nano project develops the implementation of a future-proof operational Nano Risk Governance Model (NRGM) that addresses the needs of the transdisciplinary field and innovative (and key enabling) character of nanotechnology.

Link: <https://www.gov4nano.eu/>

- **GRACIUS**

In order to streamline the risk assessment process, the main goal of GRACIOUS is to generate a highly innovative science-based Framework to enable practical application of grouping, leading to read-across and classification of nanomaterials/nanofoms.

Link: <https://www.h2020gracious.eu/>

- **CERASAFE**

CERASAFE is a pioneering European project supported by the [SIINN ERA-NET](#). In the particular framework seven main partners, from different European research institutions, are participating and cooperating ([CSIC - IDAEA](#), [UL](#), [Nova ID](#), [UJI](#), [BBU](#), [INSA](#), [ULCO](#))

Link: <http://www.cerasafe.eu/>

- **HISENTS, High level Integrated Sensor for Nanotoxicity Screening**

HISENTS aims to deliver an advanced nanosafety platform capable of providing high-throughput toxicity screening for the risk assessment of novel nanomaterials.

Link: <https://hisents.eu/>

- **NanoFASE, Nanomaterial Fate and Speciation in the Environment**

NanoFASE delivers an integrated Exposure Assessment Framework, including methods, parameter values, model and guidance that will allow Industry to assess the full diversity of industrial nano-enabled products to a standard acceptable in regulatory registrations.

Link: <http://www.nanofase.eu/>



## Report about nanofluid's health, safety and environmental impact

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- **NanoStreeM**

The NanoStreeM consortium has taken up the challenge in defining a road map of Safety of nanomaterials in nanoelectronics to identify the existing gaps in knowledge and a number of recommendations for their mitigation.

**Link:** [www.nanostreem.eu](http://www.nanostreem.eu)

- **PATROLS - Physiologically Anchored Tools for Realistic nanOmateriAL hazard aSsessment**

PATROLS is an international project combining a team of academics, industrial scientists, government officials and risk assessors to deliver advanced and realistic tools and methods for nanomaterial safety assessment.

**Link:** <https://www.patrols-h2020.eu/>

- **SmartNano Tox**

Smart tools for gauging nano hazards.

**Link:** <http://www.smartnanotox.eu/>

### 5.1.5 LAB RESOURCES

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- **National Nanotechnology Initiative (NNI)**

A U.S. Government research and development (R&D) initiative involving the nanotechnology-related activities of 20 departments and independent agencies.

**Link:** <https://www.nano.gov/LabSafety>

- **Imperial College London**

Offers links to government and academic sites and give up-to-date information and advice on the current status of health and safety in these areas. It is worth noting that the commercial manufacture of nanoparticles is considered to be well-controlled, but that their use and manufacture in academic areas may not be so stringent.

**Link:** <http://www.imperial.ac.uk/safety/safety-by-topic/laboratory-safety/nanotechnology/>

## Section 6

### 6.1 ANNEX

#### 6.1.1 – NanoSafety Questionnaire

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##### NanoSafety questionnaire

Thank you for agreeing to take part in this questionnaire regarding the safety and health regulations for handling nanofluids. Our aim is to gather your thoughts and opinions on this subject, in order to formulate regulations that meet the Nanouptake objective of "Promoting the development of a joint research agenda in order to evaluate health and safety of nanofluids and their potential impact on the environment and on selected industrial applications". This questionnaire will only take about 5-10 min to complete. Please be assured that all your responses are anonymous and will be kept in strictest confidentiality.

\*Obligatorio

1. Name of the person filling the form:

\_\_\_\_\_

2. Are you a member of an academic institution or a company? \*

*Marca solo un óvalo.*

Yes

No

3. Country where the academic institution/company is situated: \*

\_\_\_\_\_

4. Which is your profile? \*

*Marca solo un óvalo.*

Professor

Doctor

PhD student

Master student

Otro: \_\_\_\_\_

## Report about nanofluid's health, safety and environmental impact

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5. Does your organisation deal with nanoparticles/nanofluids? \*

*Marca solo un óvalo.*

Yes

No *Deja de rellenar este formulario.*

## Regulations and Training

6. In your opinion do you think nanoparticles/nanofluids present health risk? \*

*Marca solo un óvalo.*

Yes, both of them

Only nanoparticles

Only nanofluids

Neither of them

Maybe

7. Please explain why you hold the above opinion: \*

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8. In your opinion do you think nanoparticles/nanofluids present environmental risk? \*

*Marca solo un óvalo.*

Yes, both of them

Only nanoparticles

Only nanofluids

Neither of them

Maybe

9. Please explain why you hold the above opinion: \*

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## Report about nanofluid's health, safety and environmental impact

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10. Does your organisation follow any health and safety regulations for handling nanomaterials? \*

*Marca solo un óvalo.*

- Yes  
 No

11. If yes, could you name the regulation or link it (if possible)?

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12. Does your organisation offer health and safety training for your employees on handling nanomaterials? \*

*Marca solo un óvalo.*

- Yes  
 No

13. If yes, could you include some information about it (duration, topics covered, trainers, compulsory/voluntary training etc.)?

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14. Do you have a specific criteria for assessing the nanomaterials according to the level of their risk to the employees and environment? \*

*Marca solo un óvalo.*

- No  
 Yes

15. If yes, describe the criteria used to identify risk:

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## Report about nanofluid's health, safety and environmental impact

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16. How many people are involved in handling of nanomaterials in your organisation? \*

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### Type of Nanomaterials handled

17. Nanomaterials handled or manufactured? \*

*Marca solo un óvalo.*

- Nanoparticles *Pasa a la pregunta 18.*
- Nanofluids *Pasa a la pregunta 31.*
- Both

### Nanoparticles

18. Nanoparticles handled: \*

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19. Rough estimate of the amount of nanoparticles handled per month: (in mg) \*

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20. Way(s) of handling the nanoparticles: (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Synthesis
- Processing
- Transportation/Storage
- Disposal

21. In your opinion what is the main route(s) of exposure for the nanoparticles used on site? (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Dermal (by diffusion through skin)
- Inhalation (by respiratory tract)
- Ingestion (by swallowing through mouth)
- Injection (by cuts in the skin)

## Report about nanofluid's health, safety and environmental impact

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22. Do you have a specific storage place for nanoparticles in the lab, with proper labeling?

*Marca solo un óvalo.*

- Yes  
 No

23. What measure(s) are taken to reduce the risk of exposure? (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Management of people and activities (e.g. having restricted zones)  
 Engineering methods (fume cupboard + HEPA filter, Open fronted spray booth)  
 Respiratory protection equipment  
 Gloves  
 Goggles  
 Protective clothing  
 Otro: \_\_\_\_\_

24. How are the nanoparticles transported to, from and inside the organisation? \*

\_\_\_\_\_

25. Are their health and safety measures involved in transportation? If yes explain. \*

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

26. How do you dispose of the waste nanoparticles or things contaminated with nanoparticles? (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- No waste (all nanoparticles are used up)  
 Disposed of as ordinary chemical waste  
 Handover to special waste disposal organizations  
 Otro: \_\_\_\_\_

27. Does your organisation monitor the workplace for nanoparticles? \*

*Marca solo un óvalo.*

- No  
 Yes

## Report about nanofluid's health, safety and environmental impact

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28. If yes, what monitoring system is employed?

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29. What emergency and first aid procedures are followed in case of accident involving nanoparticles? \*

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### Dealing with nanofluids

30. Does your organisation deal with nanofluids? \*

*Marca solo un óvalo.*

Yes

No *Deja de rellenar este formulario.*

### Nanofluids

31. Nanofluids handled: \*

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32. Rough estimate of the amount of nanofluids handled per month: (in ml) \*

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33. Way(s) of handling the nanofluids: (multiple responses possible) \*

*Selecciona todos los que correspondan.*

Synthesis

Processing

Transportation/Storage

Disposal



## Report about nanofluid's health, safety and environmental impact

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34. In your opinion what is the main route(s) of exposure for the nanofluids used on site? (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Injection (by cuts in the skin)
- Dermal (by diffusion through skin)
- Ingestion (by swallowing through mouth)

35. Do you have a specific storage place for nanofluids in the lab, with proper labeling?

*Marca solo un óvalo.*

- Yes
- No

36. Do you chemically stabilize the nanofluids before using them? \*

*Marca solo un óvalo.*

- Yes
- No

37. If yes, what stabilizers do you use?

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38. What measure(s) are taken to reduce the risk of exposure? (multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Management of people and activities (e.g. having restricted zones)
- Engineering methods (fume cupboard + HEPA filter, Open fronted spray booth)
- Respiratory protection equipment
- Gloves
- Goggles
- Protective clothing
- Otro: \_\_\_\_\_

39. How are the nanofluids transported to, from and inside the organisation? \*

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40. Are their health and safety measures involved in transportation? If yes explain. \*

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## Report about nanofluid's health, safety and environmental impact

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41. How do you dispose of the waste nanofluids or things contaminated with nanofluids?  
(multiple responses possible) \*

*Selecciona todos los que correspondan.*

- Disposed of as normal chemical waste
- Handover to special waste disposal organizations
- Otro: \_\_\_\_\_

42. Does your organisation monitor the workplace for nanofluids? \*

*Marca solo un óvalo.*

- No
- Yes

43. If yes, what monitoring system is employed?

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44. What emergency and first aid procedures are followed in case of accident involving nanofluids? \*

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