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LICARA nanoSCAN
-
Example of Use in nano-TiO_2 containing façade coating

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1 Tool description and use domain(s)

The Life Cycle Assessment and Risk Assessment (LICARA) nanoSCAN model is a web-based tool that guides SMEs through their decision-making processes about new nanoproducts. The LICARA nanoSCAN is a tool for SMEs to explore the benefits and risks of nanoproducts at an early stage of innovation. The tool design to serve as a screening level self-assessment. While the tool aids in decision making it must be noted that the tool cannot replace a comprehensive in-depth risk and benefit assessment.

LICARA nanoSCAN has a modular structure and contains eight sections. It guides through the decision-making processes and produces an overview of what the social, economic and environmental benefits of a new nano-product are compared to another, e.g. conventional product. In decision support section the benefits are valued against health risks for consumers, workers and the environment (fig. 1).

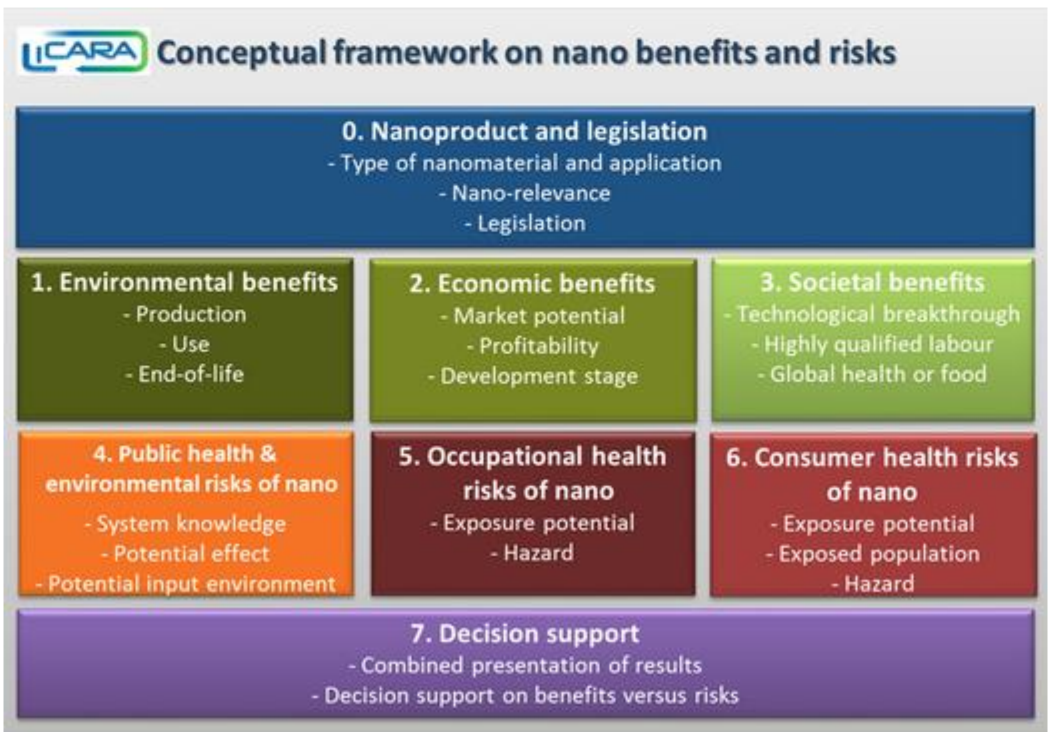

Figure 1. Overall structure of LICARAN nanoSCAN.

Depending on the specific aims of the screening, different sections might be relevant. However, the screening process should always start with the section 0. Nanoproduct and legislation. This is necessary to assess whether the use of LICARA nanoSCAN is relevant. Each section consists of several qualitative or semi-quantitative questions where nanoproduct is compared against the reference product. Based on the answers a summary of the benefits and risks are presented. Also, a graph showing total risks and total benefits are presented with the rough guidance on decision that can be made based on the analysis.

2 Description of case study

The performance of two different façade coating systems are compared. One system compromise as a first layer a traditional paint, covered then by a second layer, a coating containing nano-TiO_2 having a self-cleaning function. The reference system represents a façade that is coated only with the traditional paint (van Harmelen et al 2016). Life-cycle stages of production of nano-TiO2, production of coating and the application of the traditional outdoor paint and coating, The use phase comprises several applications of paint and/or coating along the lifetime of the building, the regular cleaning with pressurized water and eventual releases due to weathering effects. As a final step the End-of-Life treatment of the paint or the paint together with the photocatalytic coating is evaluated.

3 Input parameters

Input parameters needed in this case study is presented in table 1.

Table 1. Parametrization of the case study for LICARA nanoSCAN input parameters.

Entry	Input	Comment
0. Nanoproduct and legislation		
Type of nanomaterial and application		
Which nanomaterial will be used? Please specify additional nano subtype or indications / properties:	Titanium dioxide (TiO_2) TiO2-Coating	
In which type of application is the nanomaterial be used?	Facade coating	

Entry	Input	Comment
Is this a completely new product with a new functionality (which cannot easily be compared with a conventional product)?	No	New coating replace paint containing pigment grade TiO2 in repainting operations
If not, what conventional product is being replaced by the new nanoproduct? (this can also be 'doing nothing')	Conventional paint	
The product under evaluation is:	A product for consumer and professional markets	
What is the main function that the nanomaterial provides in your application?	Self-cleaning / photocatalytic function	
What is the appropriate unit to compare the nanoproduct with the conventional product? (It is fair to compare same functionality)	1 m^2	
In case you have selected 'Other' please specify:		
Nano-relevance		
Approach 1 (precautionary approach): Ranges of sizes of primary particles contained in the materials (free, bound or as aggregates or agglomerates)?	1-500 nm	
Approach 2 (EU-proposed definition 2011/696/EU): Material containing primary particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the primary particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm or (if the number size distribution is unknown) Material where the specific surface area by volume is greater than 60m2/cm3 or Material consists of fullerenes, graphene flakes or single wall nanotubes.	Yes	
Legislation		
Are you aware of existing legisation (e.g. EU Nr. 1907/2006 (REACH), The EU Biocides Regulation 528/2012 (EU BPR), Regulation (EC) No 1223/2009 on cosmetic products …)	Yes	
Is your nanomaterial approved or notified according to relevant EU-legislation (e.g. EU Nr. 1907/2006 (REACH), The EU Biocides Regulation 528/2012 (EU BPR), Regulation (EC) No 1223/2009 on cosmetic products …)	Yes	
Do you use the nanomaterial below its specific concentration limits recommended in the legal framework (e.g. http://ec.europa.eu/environment/chemicals/biocides/active-substances/approved-substances_en.htm)	Yes	
1. Environmental benefits		

Entry	Input	Comment
Manufacturing phase of the nanoproduct versus conventional product		Compare to manufacture of contentional paint containing pigment-grade TiO_2 Almost the same process in producing TiO_2. Less coating is used in repainting. In producing nano-TiO_2 urea has to be used in precipitation process instead of water. Utilization of urea in precipitation process causes emissions of ammonia.
Energy consumption of the manufacturing process of the product?	Equal	
Materials consumption in this manufacturing process?	Better	
Amounts of hazardous substances used in the manufacture? Efforts needed to produce the product using the nanomaterial?	Worse Worse	
Amount of solid waste from the manufacturing process?	Equal	
Amount of wastewater from the manufacturing process?	Equal	
Emissions to the air or (waste) water from the manufacturing process itself?	Worse	
Use phase (only for final products and articles)		
Product lifetime (use phase)?	Worse	Application of paint & coating; recoating after 15 years (5 time in 75 years) compared to repainting after 20 years (4 times in 75 years) Cleaning of the façade similar Product lifetime --> worse (shorter life time with the coating) Maintenance according to the description the same procedures are used --> equal Solid waste --> nanocoating is applied more times --> more solid waste --> worse Emissions → equal emission expected in description.
Need for maintenance?	Equal	
Amounts of hazardous substances used in maintenance?	Equal	
Amount of solid waste from using the product? Amount of wastewater resulting from use of the product?	Worse Equal	
Emissions of hazardous substances to air, water and/or solid?	Equal	
Efficiency of use?	Better	
End-of-life (only for final products and articles)		
Volume of waste (due to e.g. longer lifetime, less weight, less material used)?	Equal	Equal handling of the waste for both products according to the description
Amounts of other hazardous substances released from the waste water treatment?	Equal	

Entry	Input	Comment
Amounts of other hazardous substances released during incineration?	Equal	
Established recycling systems (glass, PET, paper, carton, batteries, biowaste, electronic devices, etc.) exposed to the nanomaterial in the product?	Equal	
Can the wastewater treatment facility eliminate the nanoproduct's emissions?	Yes	According description 0,03% to water and from MSWI 0,0002% to air and 0,086% to water. --> Yes
Can the waste incineration facility eliminate the nanoproduct's emissions?	Yes	
2 .Economic benefits		
Market potential		All these should be discussed with the company (building up business case)
Does the nanoproduct have increased marketability due to an improved functionality or a new functionality (for example: UV-protection, enhanced photolytical self-cleaning/ self-cleaning capacity/property, conductible, antimicrobial function), or a clear image advantage compared to the conventional product (e.g.: more resistant to environmental effects, prolonged lifetime/persistence, reduced weight or increased strength)?	higher	expected
What is the foreseen market potential of the nanoproduct or -application in Europe?	high (> 1 M€ sales)	expected
Profitability		
What is the (expected) purchase price per unit of the nanobased product or material compared to the conventional one?	higher	expected
What are the operational costs (i.e. maintenance, energy use etc) during the use phase of the nanobased product or application compared to the conventional one? (Think of advantages due to nanoproperties in the manufacturing process)	equal	Operational costs --> equal because in description the maitenance procedures are the same in both cases
Development stage		
What is the time-to-market to manufacture the nanoproduct on a commercial scale?	medium (1 - <5 year)	expected
3. Societal benefits		
Technological breakthrough		
Could the use or application of the nanoproduct be considered a technological breakthrough (in general, but particularly in energy systems and Information and	more or less equal	

Entry	Input	Comment
Communication Technologies, ICT) compared to the conventional alternative?		
Highly qualified labour force		
Does the production of the application lead to a substantial improvement in the development of a highly qualified labour force compared to the conventional alternative?	more or less equal	
Improving global health or food situation		
Does the use or application of the nano-based product lead to improvements in feeding the world's population, a marked increase in food production and the nutritional value of food? OR Does the use or application of the nano-based product lead to improvements in people's health, particularly the direct user, e.g. by improvements in water purity, sanitation or medicines and pharmaceuticals?	more or less equal	
4. Public health & environmental risks		
System knowledge		
Is the origin of the (nanoscale) starting materials known?	Yes	
Are the next users of the nanomaterials under consideration known?	Yes	
How accurately is the material system known or can disturbing factors (e.g. impurities) be estimated?	Accurately	
Potential effect		
Do the nanomaterials cause redox activity, catalytic activity, have a potential for oxygen radical formation or to induce inflammation reactions?	High, TiO2, uncoated, >10nm	
What is the stability (half-life) of the nanoparticles present in the nanomaterial under ambient environmental conditions?	Months	
Potential input into the environment		
What is the annual quantity of nanoparticles from the ***manufacturing phase*** that reaches the environment via wastewater, exhaust gases or solid waste?	5-500 kg	Expected emission rates: 2.16 E-03 kg/kg coating Expected production 100 tn/year
What is the physical surrounding or carrier material of the nanoparticles in the product during the ***use phase***?	Solid matrix, stable under conditions of use, nanoparticles not mobile	
What is the annual quantity of nanoparticles in products that reaches from production or use phase the environment via utility products, waste water, exhaust gases or solid waste?	5-500 kg	Expected emission rates: 4.46 E-03 kg/kg coating Expected production 100 tn/year

Entry	Input	Comment
What is the annual quantity of disposed nanomaterial (from the production or use phase)?	> 500 kg	Expected emission rates: 1,04E-02 kg/kg coating Expected production 100 tn/year
5. Occupational health risks		
Hazard & exposure during manufacture of the nanomaterial	D1	Synthesis of n-TiO2 Mutagenic, hazard class D, from Expert judgement table
Hazard & exposure during processing the nanomaterial	D3	Production of coating Pouring of n-TiO_2 sacks to the reactor
Hazard & exposure during application of the nanoproduct	D1	Application of coating
6. Consumer health risks		
Hazard & exposure by consumers during use phase		
At what location is the nanoelement situated in the article or the product? The product…	contains nanostructured particles that are surface bound (IIIa): may cause exposure	
What is the size of the consumer population using the nanoproduct and hence which may be exposed?	Low (fraction of households <5%)	

4 Results

Both the benefits and risks of a nanoproduct are evaluated in comparison with a reference material, ie. conventional non-nanoproduct. The results of this comparison are presented using bar graphs.

4.1 Benefits

The benefits can have a relative scale from -1 indicating negative benefit to +1 meaning that all aspects of the nanoproduct are better than the reference product. A score around zero indicates that the nanoproduct is as good as the reference alternative.

Environmental benefits

Screening of the environmental benefits shows that using these assumptions the positive benefits in the end-of-life phases is overruled by the negative benefits in the manufacturing phase (fig. 2). Efforts for finding more benefits in use or end-of-life phases and/or reduce the negative effects of manufacturing of the product are needed. Especially, the shorter lifetime of the new nanocoating needs improvements.

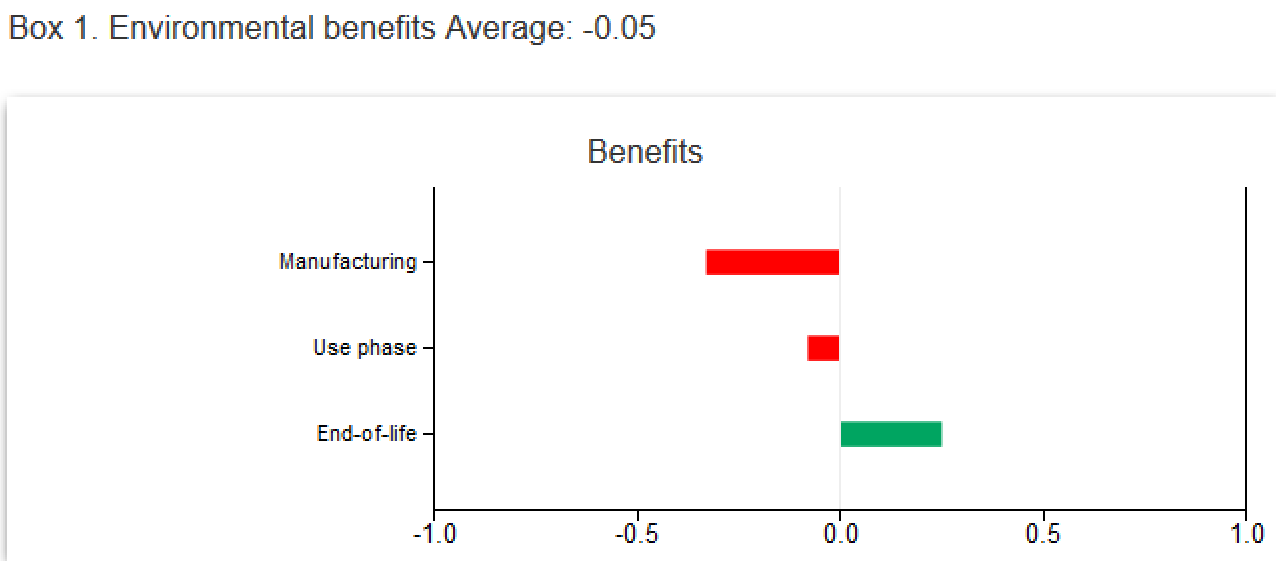

Figure 2. Presentation of the environmental benefits

Economic benefits

It is expected that the product has high market potential (fig. 3). On the contrary it is valued that in the profitability there is room for improvement mainly due to short lifetime and need for re-coating process sooner than with conventional paint.

Box 2. Economic benefits Average: 0.17

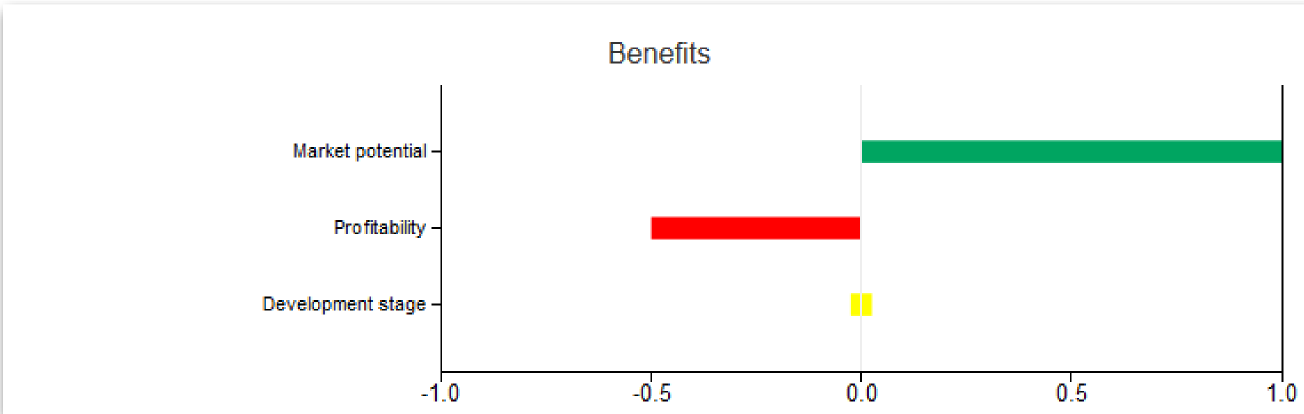

Figure 3. Presentation of the economic benefits.

Societal benefits

In the societal benefits the new nano-coating is valued to be equal with the reference product (fig. 4).

Box 3. Societal benefits Average: 0

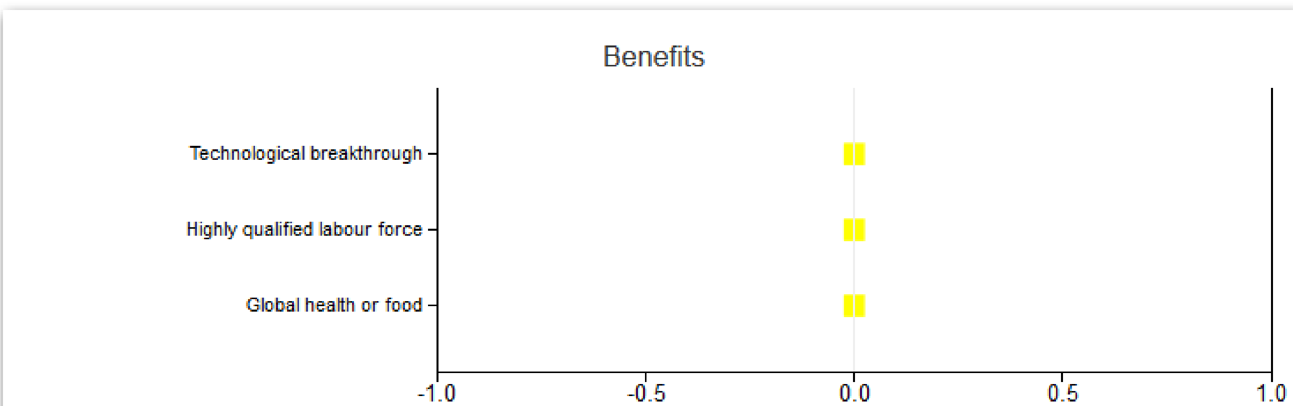

Figure 4. Presentation of societal benefits

4.2 Risks

Risks of the nanoproduct is presented on a scale from 0 to 1. Scores below 0.3 indicate low nanomaterial risks, scores from 0.3 to 0.7 indicate moderate risks, and a score higher than 0.7 indicates a high risk from nanomaterials.

Public health and environmental risks

According to the analysis, risks to public health and environment can be considered moderate. Potential effects of nano-TiO_2 is ranked as high.

Box 4. Public Health & Environmental Risks Average: 0.5

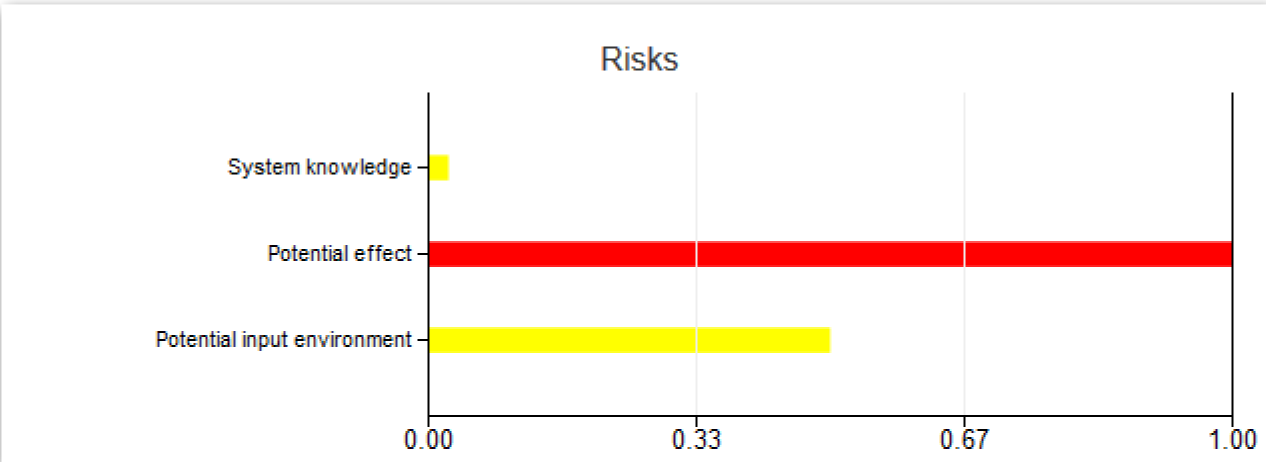

Figure 5. Presentation of risks to public health and environmental risks

Occupational health risks

Occupational health risks are expect to be high, mainly due to high risks during processing of nanomaterial, ie. in the production of the coating (fig 6). Occupational risk modelled with Stoffenmanager® nano module v 1.0 is shown in table 2 and input parameters used in table 3. According to the guidance of LICARA nanoSCAN you should use the task weighted values obtained from Stoffenmanager® nano.

Box 5. Occupational Health Risks Average: 0.71

Hazard x Exposure code Stoffenmanager: D3

Occupational Health Risks are high! (normalized result > 0.67)

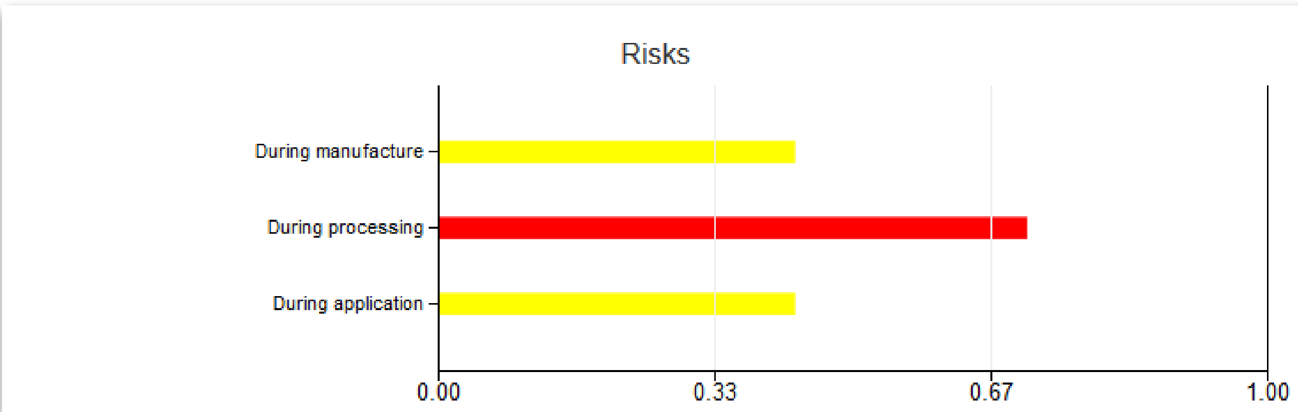

Figure 6. Presentation of occupational risks.

Table 2. Results of the Stoffenmanger® nano v 1.0 for production of nano-TiO2 coating.

Result risk assessment		
	Task weighted	**Time and frequency weighted**
Hazard class:	D	D
Exposure class :	3	2
Risk score:	I	II

Table 3. Input parameters for Stoffenmanager® nano v 1.0.

Question	Entered data
Nano particle:	titanium dioxide
Concentration nano particles in the product:	30
Name risk assessment:	Production of n-TiO_2 coating
Source domain:	Handling of bulk aggregated/agglomerated nanopowders
Product type:	-
Product appearance:	Powder
Dustiness of the product:	Very high (>500 mg/kg)
Moisture content of the product:	Dry product (< 5% moisture content)
Dilution:	-
Viscosity:	-
Fibers:	No
Fiber size :	No
Hazardous properties :	Carcinogenic (not mutagenic), reprotoxic and/or very toxic
Nano particle type:	-
Task:	Handling of products with a relatively high speed/force which leads to dispersion of dust
Duration of the task:	0.5 to 2 hours a day
Frequency of the task :	2 to 3 days a week
Activity in the breathing zone:	Yes
Multiple employees:	No
Regular cleaning of the working room:	Yes
Regular inspections and maintenance:	Yes
Local control measures:	Containment of the source with local exhaust ventilation
Segregation of the employee:	Mechanical and or natural ventilation
Protection of the employee:	Filter mask P3 (FFP3)

Consumer health risks

Analysis show that the health risks for consumer is considered moderate (fig. 7).

Box 6. Consumer Health Risks Average: 0.57

Hazard x Exposure code: D2

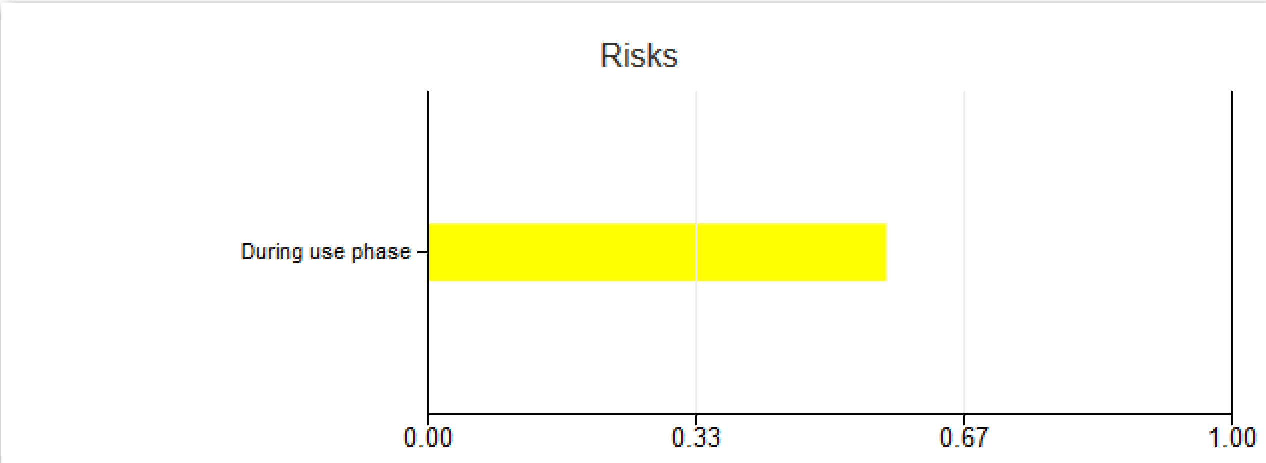

Figure 7. Presentation of consumer health risks.

4.3 Summary of benefits and risks

In decision support section of the summary of benefits and risks are presented (fig. 8) together with evaluation and the guidance for the development of the new product compared the selected reference product. In this case study the benefits of the use of the TiO_2 is considered to have only minimal benefits but the risks are moderate. This led to the conclusion to 'Undecided' area in the risks - benefits graph (fig. 9) where benefits and risks are more or less equally important and distinguishing the value of the nanoproduct from that of the conventional product is infeasible.

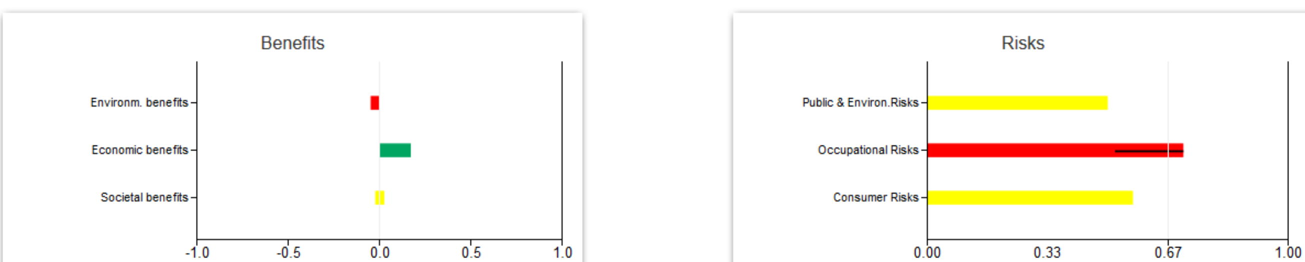

Figure 8. Summary presentation of the benefits and risks.

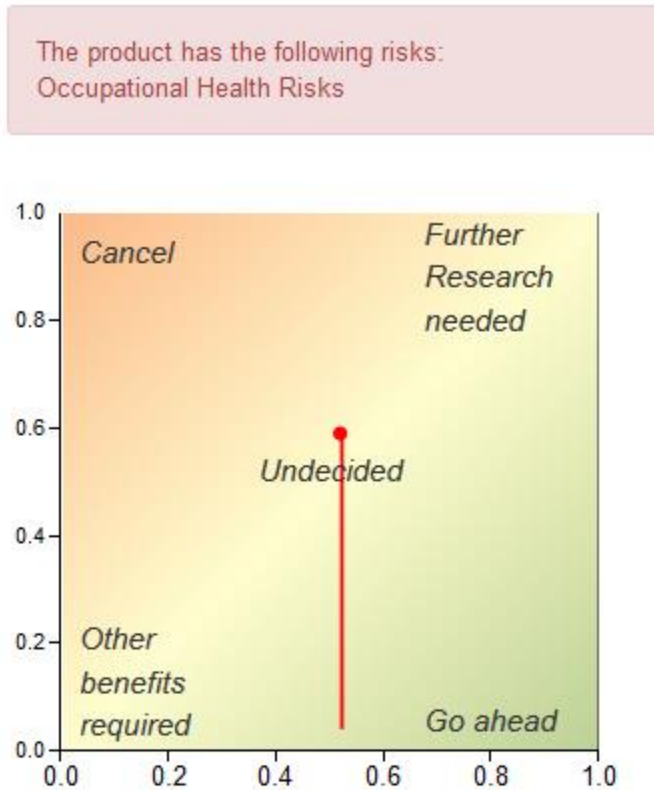

Figure 9. The overall evaluation of the comparison nano-TiO2 coating with the conventional façade paint.

5 References / Selected sources of information

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