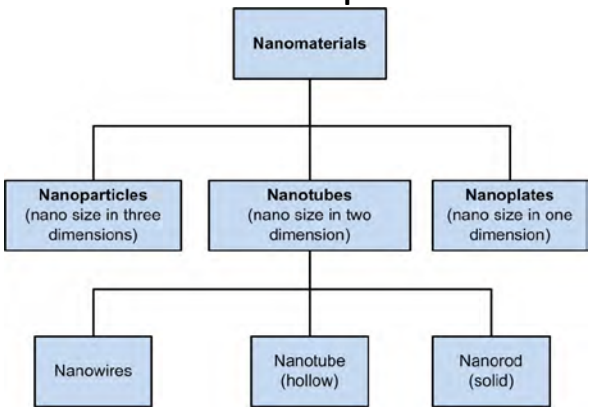
Information for employees and students working at the Faculty of Science (W&N)
This AMD information sheet explains what nanomaterials are, what the specific risks are, what rules apply at the Faculty of Science (W&N) for working with them, and which extra precautions must be taken.

1 What are nanomaterials, and what are the risks?

1.1 Definition and shapes



Nanomaterials come in many forms and shapes. The diesel exhaust of a truck consists of nanoparticles, just as volcanic ashes do. Sun cream contains nanoparticles, and so do antibacterial socks.
The nanomaterials that this information sheet refers to, are not natural but synthetic. For that definition it does not matter if you make them yourself, buy them from a chemicals supplier, or, for example, get them from another research group. At the Faculty of Science work is done with nanoforms of gold, platinum, titanium dioxide, silica, graphene, and several rare earth metal oxides.

According to the definition used by the authorities, synthetic nanomaterials have a size of <100 nm in one or more dimensions. However, nano properties may present themselves up to sizes of about 500 nm. Therefore, we prefer to use the 500 nm limit at the Faculty of Science.

In the above diagram you can see that the form in which nanomaterials occur, may differ: there are nanoplates (one dimension, often referred to as thin layers within the Faculty of Science, nanoparticles (three dimensions), and nanotubes (two dimensions). Nanotubes may be subdivided into wires, hollow tubes, or solid rods. The risks of nanomaterials vary depending on the form in which they occur.

1.2 Effects of nanomaterials

Due to their small sizes and shape, it is likely that nanomaterials can migrate through many tissue types and end up anywhere in the body. However, for most of the nanomaterials the effects on the human body are yet unknown. On the other hand, it is known that exposure to nanomaterials occurs predominantly through the respiratory tract. This is why during any activity one must keep nanomaterials from becoming airborne upon which they may be inhaled. However, one should also take exposure through the mouth or absorption through the skin into account.

Carbon, for example, is harmless in the human body, but it has been established that carbon nanotubes (CNT) are toxic and may behave similarly to asbestos fibres in the human body due to their shape. Because of these unknown risks, it has been said that nanomaterials should not be allowed to become "the new asbestos". We do not want to conclude in 30 years time that people experience health problems that may be attributed to the use of nanomaterials.

Nanopowders are often pyrophoric (they ignite upon exposure to air), even if the material in macroform does not possess that property. When you use more than one milligram per session, then please determine the pyrophoricity of the material with the smallest quantity possible. If pyrophoricity is established, precautions must be taken, such as use in a low-oxygen environment.

The potential harmfulness of nanomaterials is currently classified in the following way, in order from high to less high risk:
- Fibrous and rigid, stiff shapes that are insoluble;
- Insoluble particles for which the parent material is classified as CMR-material (for working with CMR substances, see information sheet VOM012);
- Insoluble particles (non-fibrous and parent material without CMR properties); and
- Soluble particles.

ALL activities with synthetic nanomaterials require a risk assessment!
Therefore, the following must be reported to the AMD:
- *Who works with nanomaterials and at what location(s).*
- *With which nanomaterials work is performed.*
- *What activities are performed with them.*

Due to their form and their small sizes with accompanying large surface/volume ratio, nanomaterials may have other properties and thus effects than the same material in macroform. Work with nanomaterials requires carefulness. Therefore, you have to make a prior risk assessment of the activities with nanomaterials, and you must inform the AMD who will work with nanomaterials (See Chapter 2).

2 Rules for working with nanomaterials at the Faculty of Science (W&N)

2.1 Risk assessment: the RI&E nano

All projects with nanomaterials, no matter how little you may use, must be reported to the AMD, so they may be registered and a risk assessment (RI&E) can be made according to the Control Banding method by Zalk *et al.* This is a specialistic risk assessment method for safety experts. Based on the properties of the macromaterial as well as the nanoform the severity score is determined. In addition, the probability score (chance of exposure) for each activity is determined. This way, the risk level for each activity (pipetting, filtering, etc.) may be determined using the provided matrix. Next, the

			Score Propability			
			Score 0-25	Score 26-50	Score 51-75	Score 75-100
			Extremely Unlikely	Less Likely	Likely	Probable
Score Severity	Score 75-100	Very High	RL3	RL3	RL4	RL4
	Score 51-75	High	RL2	RL2	RL3	RL4
	Score 26-50	Medium	RL1	RL1	RL2	RL3
	Score 0-25	Low	RL1	RL1	RL1	RL2

measures to be taken are linked to the risk level (See 2.2). A balanced risk assessment requires experience in using the method. That is why it is important that the RI&E is performed by or in consultation with the AMD. Details of the practical execution of the experiment may be critical to the risk level; this is why the AMD will schedule an interview with the researcher.

The most important exposure factors in the model are:

- the frequency of the activity
- the type of activity performed
- the amount of nanomaterial used

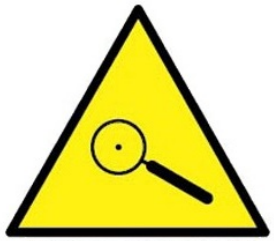
This means that, if you change your research, you must verify how the risks change. If you are going to perform certain activities more often, or if you are going to work with larger amounts, the chance of exposure (probability score) may increase. You will receive a detailed RI&E nano with the advices as an Excel-file, so you may determine the effect of the changes on the risk you run.
However, if you are going to work with a different nanomaterial, you will be dealing with other bulk and nano properties, and you will have to change the RI&E (and registration!) in consultation with the AMD.

When you want to start working with nanomaterials for the first time, please report to the AMD. We will first check if there is already an RI&E nano for this project, and if the substance used, the activities, and the frequencies are still correct. If that is the case, we can register you as a new nanoworker immediately, and inform you about the risks. Are you about to stop a project, is someone taking over, or are you going to work in another lab? Then please also contact us. This way we can keep the overall registration up to date.

2.2 Risk levels and measures

Based on the risk classification for each activity separately that follows from the RI&E nano, the AMD will discuss the necessary measures and applicable procedures. The risk levels (RL) run from RL1 to RL4, from low to high.

Risk level	Measures	Lab type
RL1	On a lab bench with local exhaust ventilation or in a fumehood	Chemistry/physics
RL2	Work in a fumehood	Chemistry/physics
RL3	Closed system or special measures	Classified nanolab, determined by RI&E
RL4	Special measures	Classified nanolab



If the RI&E nano indicates that risk level 3 or 4 activities take place, the laboratory may receive the designation of classified lab (AMD infosheet RhL021 *Room classification*). This happens when there is a high chance of dusting and dispersal, if large quantities of nanomaterials are used, or if the nanomaterial is fibrous or a CMR-substance. In that case, room signage has to be applied on the entry door with the magnifying glass and nanoparticle symbol as shown. **These classified nanorooms must have an emergency protocol that must be shared with the emergency response organization.**

2.3. General rules for working with nanomaterials

Experience has taught us that researchers do not think as much about the additional activities with nanomaterials, such as handling nanowaste, cleaning up spills, transporting through hallways, and regular cleaning, as they do about research activities. Therefore, there are general rules for handling nanomaterials, in addition to the specific rules for the activities that are assessed in your RI&E nano, which are shown below.

Use of analysis facilities

Please always inform the manager of the analysis equipment (XRD, SEM, etc.) that is going to be used, that your sample contains nanomaterials. Consult with them if there are additional requirements for your sample regarding fixation and cleaning. Those who come after you too would like to measure a clean sample in clean equipment, and any unwanted exposure of service mechanics in a later stage should be avoided as well!

Transport of nanomaterials

Please always use double packaging if you need to transport nanomaterials to an analysis facility or another lab, for example, in a sample container wrapped in parafilm. The aim is to prevent that, if the packaging falls, it will open, contaminating the hallway or lab and exposing anyone coincidentally passing by.
If you need to send nanomaterials to another lab or abroad, please see the AMD Information sheet RhL050 *Transportation and shipment of research material*.

Handling waste

Our waste disposal service has no separate waste routes for nanowaste. Therefore, there are no separate waste bins for nanowaste. However, we do want to prevent anyone in the disposal chain to be inadvertently exposed. This is why there are a few specific measures that apply to nanowaste.

Liquid waste may be put in the proper bin for the type of waste. See AMD Information sheet RhL090 *Waste collection guide*.
For **solid nanowaste**, please use a separate white solid waste bin and put a plastic bag within which you close by folding before closing the lid. This way you prevent dusting of the nanomaterial that is already present, when you open the bin the next time. Please only open the bin inside a fumehood, and do not use it for ordinary solid waste. Solid nanowaste is not limited to residues only, but includes all disposables that have come in contact with the nanomaterial or nanosolution, such as paper tissues, pipettes, (Eppendorf™) microtubes (“Epjes”), or gloves, as well. If you would dispose of these in an ordinary waste bin, anyone changing the waste bag might inadvertently cause the nanomaterial to become airborne, contaminate the lab, and be exposed.

Preventing of and cleaning up spills
Please always properly set up all required equipment and work carefully. If you do spill anyway, then always prevent the nanomaterials from (drying out and) dusting. Therefore, always immediately clean up any spills.
In case of solids: move slowly and take up with a wet tissue that you dispose of as solid nanowaste (white bin).
In case of liquids: absorb in a tissue and dispose of with solid nanowaste.
In both cases please clean the surface afterwards with water and soap.
It is best if you work on a cellulose pad. This way it is easy to clean up a spill, by rolling up the pad, properly taping it closed, and disposing of it. (May be disposed of in ordinary waste bin. No nanomaterials can escape this way.) Do not use a cellulose pad if this presents a fire hazard!

Cleaning up
All equipment and glass that have come into contact with nanomaterials, must be wet cleaned immediately. This may be done with water or a solvent, depending on the properties of the nanomaterial.
The working surfaces in the lab itself too must be wet cleaned regularly. This depends on the frequency of nanomaterial use: in case of regular use, weekly; in case of incidental use, immediately after use.

Use of personal protection equipment
The necessity of the use of additional personal protection equipment (PPE) – in addition to the obligatory labcoat and safety glasses – should be clear from the RI&E nano. In principle, the risk is lowered by using ventilation or working in a closed system (See 2.2). Extra PPEs are used only under special circumstances. Working with gloves may be necessary due to the chemicals used, but may also specifically lead to dusting of the nanomaterials due to the generation of static electricity. In some cases respiratory protection by way of a filter mask may be necessary.

Communication about possible risks
Most of the nanoworkers will work in an ordinary chemistry or physics lab. Therefore, it is important to inform your colleagues and any students or trainees about the risks of your work with nanomaterials and the measures taken. Let everyone know in which fumehood you are working with nanomaterials. Tell others what they should and should not do.

This AMD information sheet is based on the publication: "Use of Engineered Nanomaterials in Dutch Academic Research Settings. Good Practices. Part B". This is the result of a joint project by FOM, TNO, Nikhef, Delft TU, Leiden University and SoFoKleS. AMD participated on behalf of Leiden University. For more background information you can download the complete report in English or Dutch using the link at the bottom of this SoFoKleS webpage.