CONCEPTS FOR CATEGORIZING NANOMATERIALS TO PREDICT THEIR ENVIRONMENTAL HAZARD AND RISK INCLUDING PROOF OF PRINCIPLE

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Introduction & objectives

Grouping nanomaterials (NMs) on the basis of their physico-chemical (PC) properties is discussed as an approach to reduce the ecotoxicological testing effort as part of a hazard assessment. Two approaches with different perspectives have been developed and evaluated using a set of 25 NMs.

Procedure

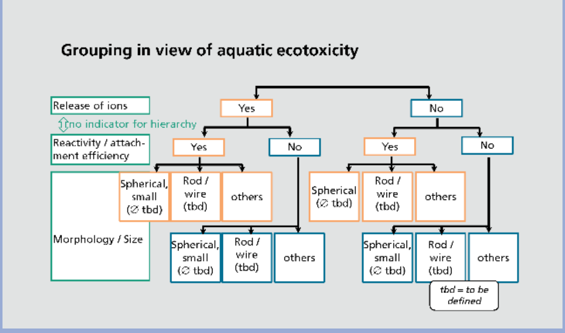
1. Systematic investigation using aquatic tests (algae, daphnids, fish embryo: OECD 201, 202, 236) and terrestrial tests (microflora, earthworm: ISO 15689, OECD 222).
2. Applied NMs
   Ion-releasing: ZnO (NM-110; NM-111); Ag (three NMs differing in morphology and size), nCu; CuO.
   Non-ion-releasing: CuPhtalo compounds (two NMs differing in surface charge), SiO_2 (three NMs differing in surface modification); Fe_2O_3 (three NMs differing in morphology and size); CeO_2 (four NMs differing e.g. in surface charge, size); TiO_2 (five NMs differing e.g. in crystalline structure, doping).
3. Comprehensive characterization of NMs in test media.

Results

1. Two pragmatic approaches based on relevant PC-parameters of the investigated NMs; questions mainly to be answered "yes" or "no".
2. Aquatic test systems
   - ✓ Ion release and morphology are of high priority.
   - ✓ Indications that reactivity is relevant for toxic ion releasing NMs.
   - ✓ Indications that attachment efficiency to (at least) algae is important for non-ion releasing NMs.
   - ✓ Zeta-potential was considered to be less important.
   - ✓ Algae: very sensitive for spherical NMs.
   - ✓ Daphnids: very sensitive for fibers.
3. Terrestrial test systems
   - ✓ The soil matrix seems to reduce the effect caused by the toxic properties of the NM.
   - ✓ Differentiation into two groups: (i) ion releasing NMs; (ii) non-ion releasing NMs.
   - ✓ Further differentiation of the group of ion-releasing NMs not yet possible.

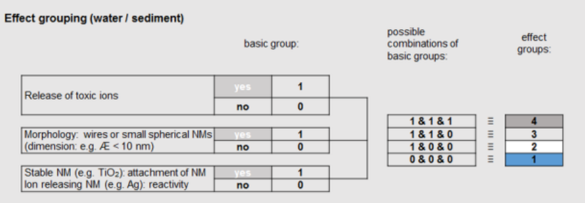
Approach I:

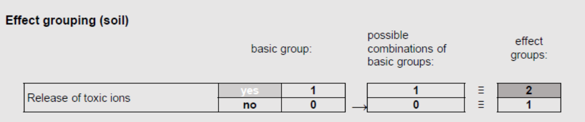
1. Flow-chart identifying groups with similar ecotoxicity towards the most sensitive organism.
2. Basis for comparison of ecotoxicity in view of developing safer NMs.



Approach II:

1. Simplified scheme based on approach I.
2. Comprises a scoring system resulting in an aggregated information on effect groups (effect groups 2 and 3 can result from different combinations of PC-properties).
3. Hazard tool for risk assessment (→ Poster: T085)





Conclusion

1. First project strategically investigating the correlation of PC-parameters and ecotoxicity. Two approaches focusing on different grouping perspectives are presented. Successful proof of principle.
2. Only a few PC-properties required for classification.

Sponsored by: German Federal Environment Agency (nanoGRAVUR), German Federal Ministry of Education and Research, German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Project No. 3714 67 417 0).

Concepts for nanomaterial categories regarding environmental hazard and for prediction of their environmental risk as well as proof of principle

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The grouping of nanomaterials (NMs) is being intensively discussed in order to develop approaches that allow an adequate hazard assessment of NM while reducing the testing effort or to rank them regarding their environmental hazard.

Two approaches differing in their focus have been developed and evaluated with a set of 25 NMs. Based on systematic testing using aquatic test designs used in regulatory testing, the physico-chemical (PC) properties, ion release, morphology and reactivity as well as ecotoxicity of the chemical were identified as relevant parameters. The zeta-potential was considered to be less important. Regarding the parameters ecotoxicity of the bulk chemical, solubility and reactivity we decided upon a pragmatic approach with questions which have to be answered “yes” or “no”.

Approach I (ecotox flow-chart) is characterized by maximum 24 groups where the property morphology is defined by three categories i.e. fibers, small spherical NMs, others. The ecotoxicity of the NMs of a specific group is attributed to similar PC-properties thus support discussion on grouping with the final objective of read across.

Approach II (ecotox-bond) was developed for risk assessment by using an approach similar to control banding. For risk assessment the hazard information has to be combined with properties influencing environmental fate. For the parameter “morphology” only fibers and small spherical NMs are considered. In the ecotox-bond every “yes” for an answer gives one point. The points are added together resulting in five groups in a range or band of 1 to 5 which is used for further assessment. The same number of points can be achieved by different properties resulting in groups of NMs which can differ significantly in their PC-properties. This procedure is considered suitable for the initial prediction of risk. It is more important that the outcome can be combined with environmental fate.

Both approaches are considered to be a suitable starting point for further discussions and developments. Besides the definition of threshold values for solubility, fiber morphology and size of small spherical NMs, further parameters (e.g. attachment of NMs to algae) have to be explored to improve the consistency of the groups. Regarding the terrestrial ecotoxicity, soil properties seem to reduce the impact of the toxic properties of the NM. Currently the prediction of terrestrial toxicity is not satisfactory.