GROUPING OF NANOMATERIALS REGARDING AQUATIC ECOTOXICITY – HYPOTHESES FOR SELECTED NMS AND EXPERIMENTAL PROOF

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Introduction & objectives

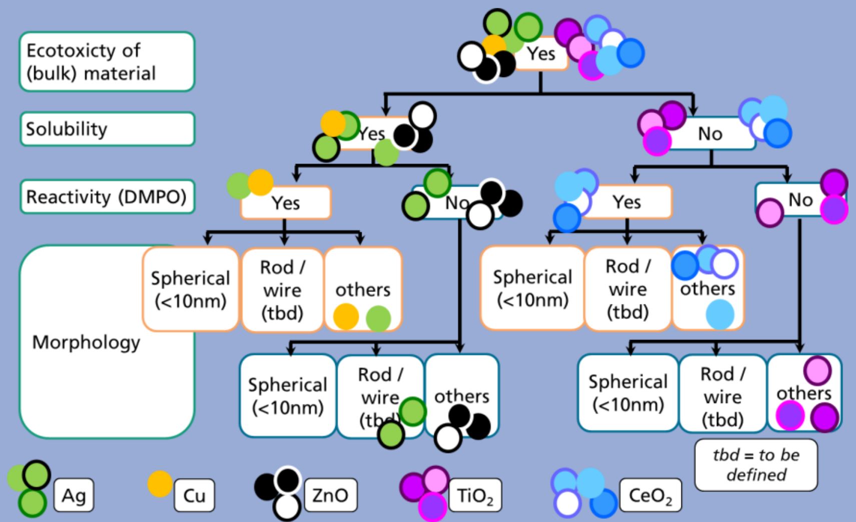
Due to the large variability of nanomaterials (NMs) the information gathering process needs to be efficient and read-across and category approaches are a pragmatic way to reduce the amount of testing and to characterise the hazards. We aimed to develop a concept for the grouping of engineered nanomaterials (NMs) with regard to their ecotoxicological effects on algae, daphnids and fish embryos. By this, the grouping approach should not be specific for an organism but it should be general.

Approach

1. Selection of fifteen NMs which were different subtypes of Ag, ZnO, TiO2, CeO2 and Cu.
2. Determination of their physical-chemical properties in water and in all test media.
3. Testing in the OECD tests on algae, daphnids and fish embryos and calculation of EC10 / EC50 values.
4. Identification of relevant PC-parameter by statistical approaches and expert knowledge.
5. Proposal of a grouping concept..

Conclusion

1. It is impossible to build meaningful grouping hypotheses based on one physical-chemical parameter.
2. Sets of parameters need to be considered.
3. The same PC-parameter can have different impacts on the toxicity to the three test organisms (e.g. sedimentation can result in lower availability for daphnids but higher for fish embryo).
4. Based on various statistical approaches solubility, reactivity, zeta potential, morphology, size seem to be relevant for the observed effect.
   Based on the ecotoxicity results the impact of the zeta-potential is less obvious.
5. Based on the parameters a scheme was developed (Fig. 1) and applied to the selected NMs. There is no hierarchy between solubility and reactivity intended.



Groups of NMs	EC50 [mg/L] (lowest value)	Affected organisms	NM-characterization
1. Ag 1340 Ag 110525	0.0016 - 0.0085	Algae, daphnids, fish	Wires, ion releasing NMs
2. Cu, Ag NM300K	0.01 – 0.043	Algae, daphnids, fish	Spherical, ion releasing NMs
3. ZnO	0.09 – 0.11	Algae, daphnids	Spherical, ion releasing NMs
4. TiO_2	0.38 – 3.6	Algae	"stable" NMs
5. CeO_2	3.2 – 43.8	Algae	"stable" NMs

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Grouping of nanomaterials regarding aquatic ecotoxicity – hypotheses for selected NMs and experimental proof

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Due to the large variability of nanomaterials (NMs) the information gathering process needs to be efficient and read-across and category approaches are a pragmatic way to reduce the amount of testing and to characterise the hazards. So far, various parameters relevant for the grouping of NMs are discussed, but they are not specified, combined, ranked, and no further decisions are drawn yet.

To promote the discussion and to support the implementation we applied a systematic testing regime and identified some relationships between ecotoxicity and NM-properties. Ion-releasing and inert NMs such as Ag, ZnO, CeO_2 and TiO2 were included. Several forms per NM-type were considered differing mainly in size, shape, crystalline structure, surface area, solubility and zeta-potential. Specific surface modifications where excluded. Aquatic ecotox-tests with algae, daphnids and fish embryos according to the OECD test guidelines 201, 202 and 236 adapted for the testing of NMs were performed. NM properties influenced by the medium composition were determined in the test media.

It was obvious that mono-causal relationships do not exist. For ion-releasing NMs the solubility is discussed as relevant parameter. However, due to significant discrepancies between solubility and ecotoxicity, we propose that for ion-releasing NMs mechanical and morphological properties as well as the test organism have to be considered. Solubility as single basis for grouping and read-across seems to be suitable only in certain cases.

The crystal structure is also discussed as relevant parameter regarding ecotoxicity. This seems to be of particular relevance for inert NMs such as TiO_2 and CeO_2. Doping of NMs with a small amount of additional non-toxic elements can modify the structure. Although this modification was not obvious with measurements such as ROS activity and CPH reactivity, toxicity was modified by a factor of about 10. For CeO_2 additional parameters such as surface area seem to be of relevance.

From the results a rough grouping approach in ion-releasing and inert NMs seems to be justified. There are indications that ion-releasing NMs are more toxic than inert NMs, whereby the material specific toxicity of the ion-releasing NMs has to be considered. A simple grouping of NMs (same chemical composition) or read-across considering just one parameter does not seem to be possible. Various physico-chemical parameters and the dependence of data on the test organisms have to be considered.