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Source: Hjorth, R., Hansen, S.F., Jacobs, M., Tickner, J., Ellenbecker, M. & Baun, A. (2017). The applicability of chemical alternatives assessment for engineered nanomaterials. *Integrated Environmental Assessment and Management*, 13(1): 177–187. DOI: 10.1002/ieam.1762.

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Nanomaterial alternatives assessment: a powerful tool for identifying safer options

Judging whether to replace a hazardous conventional chemical in a product with a nanomaterial — i.e. to assess which is the safer alternative — is challenging for many reasons. A new study suggests that chemical-alternative assessment frameworks could be adapted to better assess engineered nanomaterials with the help of new tools which provide data on hazards of, and exposure to, nanomaterials.

Alternatives assessments provide a process for identifying safer and greener alternatives to conventional chemicals of concern used in products and processes. Engineered nanomaterials may, in some cases, be considered a safer alternative to some more conventional chemicals, as well as themselves being hazardous substances which could carry environmental and human health risks.

This study assessed the suitability of two existing alternatives assessment methods for nanomaterials — the Interstate Chemical Clearinghouse's *Alternatives Assessment Guide* (2013 version), and the National Research Council's *A Framework to Guide Selection of Safer Chemicals* (2014). They both evaluate various environmental and health risks of chemicals, including potential carcinogenicity, hormonal disruption and toxicity to aquatic wildlife, and both include components that address life-cycle impacts; the researchers consider them to be the most comprehensive alternatives assessment frameworks.

While the general approach of these frameworks is appropriate for nanomaterials, the study says, they need some adaptations to overcome some of the particular challenges posed by nanomaterials, either due to the novel character of many of them, or due to specific challenges related to hazard and exposure assessment.

For example, the huge number of nanomaterials — or, rather, the huge number of variant (nano)forms — complicates assessments; properties of nanomaterials may not only differ greatly from their 'bulk', non-nano, form, but also between different nanoforms of the same chemical substance. To illustrate, carbon nanotubes are being considered as an alternative for halogenated flame retardants; these come in a number of sizes, shapes and particle configurations, meaning that there are tens of thousands of possible carbon nanotubes, or carbon nanotube mixtures, to consider — all are, however, termed 'carbon nanotubes'. Individual forms of a nanomaterial may potentially carry different hazards. There is often a lack of data on these characteristics, which increases the difficulty of alternatives assessment.

In addition, it is challenging to characterise exposure to nanomaterials. Their behaviour depends not only on their individual physical and chemical properties, but also on the environment into which they are released. The study suggests that it is often more important to understand the properties of nanomaterials after they have been released and transformed by the environment, than it is to understand a nanomaterial's properties in its 'pristine' or initial condition.

Existing models used to predict the environmental fate and transport of chemicals may, therefore, not be appropriate for nanomaterials. New models are in development for nanomaterials, which could prove useful for alternatives assessment.

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Nanomaterial alternatives assessment: a powerful tool for identifying safer options *(continued)*

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'Control banding' is one tool that could also be incorporated into alternatives assessments, to make them more suitable for nanomaterials, the researchers suggest. It provides a generic approach to risk management where detailed information on exposure is lacking, by making best use of available, if limited, data. They propose a range of control measures, such as ventilation or containment, based on an estimated range of 'bands' of hazard and the range of 'bands' of exposure.

The researchers encourage future case-study evaluations of nanomaterials and use of specialised tools to further develop the necessary methods for alternatives assessment. The researchers also recommend that alternatives assessment should be based on results from actual toxicity tests, rather than extrapolation. They conclude that nanomaterial users and researchers should consider the intrinsic potential for exposure of a particular (nano)form of a nanomaterial and consider different, safer alternatives. They also posit that alternatives assessment — with a few modifications — is well suited to generating optimal solutions, since it asks the crucial question 'is this (nano)material even needed?', and in addition, through its comparative nature, facilitates more efficient application of some methods, such as high-throughput screening[1].

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1. A method for scientific experimentation which allows a researcher to quickly conduct millions of chemical tests.