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Nanotechnological processes, materials and products holds big promises for reducing environmental impacts of energy production and use, reduced use of chemicals, stronger and lightweight materials etc. Examples are the applications of nanotechnology for improving solar cells and fuel cells. On the downside of nanotechnology, many nanotechnological materials require vast amounts of energy in their production, involve the use of hazardous substances and/or scarce resources, and especially for the nanoparticles considerable concern is raised related to the potential toxic effects of these.

The most suitable methodology for evaluating the benefits and impact is Life Cycle Assessment (LCA). LCA consider the environmental impacts of a whole production chain, from the acquisition of raw materials to the final disposal of a product after the end of useful life. The aim is to consider all environmental impacts in order to make the assessment as holistic as possible. A detailed LCA requires information on physical inputs and outputs in all processes throughout the life cycle. Due to the relative immaturity of nanotechnological processes and materials such information is still difficult to obtain, in part because of confidentiality issues. Therefore not many LCAs have yet been performed on nanotechnological products. At the time of writing little less than 20 studies of environmental impact through the life cycle have been published. Several projects in the EU FP7 programmes include workpackages addressing the environmental life cycle assessment and/or risk assessment of nanomaterials. A recent meeting in Brussels (Life Cycle Assessment (LCA) & Risk Analysis in Nanomaterials-related NMP projects, www.eumat.eu) illustrated that even though many projects include LCA, there are different perception of what LCA is. Also many of the studies in literature addressing some life cycle aspects focus on the production of nano particles and or the release of nano particles during the life cycle. Som et al. (2010) provides an overview of different life cycle perspectives and concepts.

Generally, LCA-studies reported in literature show that the production of nanomaterials entails a large energy consumption and that different methods of production vary considerably in their impact. The basis for these studies, in term of inventory data, is often uncertain as the used data are generic and and based on assumption due to a lack of representative and available data for this technology domain. It is also clear from many of these studies that the definition of a functional unit (as done in the formal LCAs) is very important for the assessment of products involving nano materials since the functionality of these often results in reduction of weight or other ways of product enhancement that out weights the added impact of the nano materials production. However, the impact assessment of the systems generally focus on impacts that are related to energy consumption and production disregarding the potential (eco)toxic effects of nano materials commencing mainly in the life cycle use and disposal stages. Especially in these stages there is a lack of exposure data and evidence on how the particles affect biota and humans through the technosphere and the environmental compartments of water soil and air. The potential risks of nano particles has been and is the major concern from authorities and scientists and this exemption is therefore of significant importance for the interpretation of LCA-results.

(Eco)toxic impacts are normally considered in LCA through calculating a characterization factor for each potentially (eco)toxic substance. The characterization factors are comprised by a fate, an exposure and an effect component, each modeled according to principles applied in Risk Assessment. These models rely on inherent properties of chemicals and are not yet well suited to address the complexity of nano particles due to these materials having a different functionality. An example of this complexity is the aggregation of nanoparticles, where single nanoparticle often can pass cell membranes and the aggregates usually cannot.

It is therefore an urgent need for the assessment of potential impacts of nano materials in LCA to become able to model the potential fate, exposure and effects. Current knowledge on fate, exposure and toxicology of nano materials is rooted in aerosol and colloid science – but is it possible to model mechanisms based on particle properties and in that case which particle properties are relevant. There is a need for systematic studies to be undertaken on different types of nanomaterials using a range of different physico-chemical parameters (e.g. size, shape, surface area and –chemistry) in order to generate data which will support relevant and reliable models that will be useful not just for LCA but also for risk assessment generally.

References

[1] Som, C., Berges, M., Chaudhry, Q., Dusinska, M., Fernandes,T.F., Olsen, S.I., Nowack, B., 2010: Life Cycle Concepts for the Development of Safe Nanoproducts: State of the art, existing gaps and challenges, Toxicology **269 (2-3)** 160-169, doi:10.1016/j.tox.2009.12.012