Sustainable nanotechnology: a combined life cycle and risk assessment approach

As the development of nanomaterials increases, a recent study recommends combining life cycle analysis and risk assessment to improve our understanding of the potential environmental and human health impacts of products containing nanomaterials.

The manufacture of products using nanomaterials is a rapidly expanding business that benefits many sectors, for example, medicine, automotive, energy and agriculture. Environmental applications include wastewater treatment and air purification. However, it is necessary to balance the potential benefits that nanotechnology brings with the potential harm to the environment and human health, including risks to workers in manufacturing plants.

Nanomaterials are often used in manufacturing processes to produce certain nanomaterials and large quantities of water and toxic solvents are frequently used. In addition, manufacturing processes often create excessive waste by producing low quantities of nanomaterials from large amounts of, often rare, resources.

The researchers suggest greener alternatives are needed for nanomanufacturing processes, such as using renewable stocks of raw materials and less harmful solvents. They recommend a life cycle approach to evaluating the environmental impact of all stages of the product's life. This is especially important when developing new nano-products and manufacturing processes. Until now, life cycle analyses have been successfully applied in only a handful of cases. Because manufacturing processes are new and often confidential, there is lack of inventory data for analyses, as well as a lack of information on nanomaterials' potential health and environmental impacts, as they are not yet known.

This study suggests a more comprehensive approach would be to combine life cycle analysis and risk assessment methods. This would evaluate the impact of nanomaterials entering the environment with the risk of exposure to nanomaterials. Two methods using this combined approach are the Nano LCRA (Life Cycle Risk Assessment) and a Comprehensive Environmental Assessment.

To date, no studies appear to have used this combined approach. Reasons for this include: the lack of inventory information, as the development and manufacture of nanomaterials is still in the early stages; the health and environmental effects of nanomaterials are not sufficiently understood; and methods to assess the impact and risks of exposure to nanomaterials have not been fully established.

As a case study, the researchers considered the life cycle energy requirements of replacing vehicle exterior closure panels, traditionally made of steel, with different lightweight materials, including carbon nanofibre reinforced polymer composite material. The panels considered for substitution were the four doors, bonnet and boot door. Lighter motor vehicles are more fuel-efficient to use, and it was estimated that the fuel energy accounted for by the panels in the case of the car with nanofibre materials would typically amount to just 14.40 million British Thermal Units (MMBTU) during its use, compared to the steel car’s 35.35 MMBTU.

However, the energy required to produce carbon nanofibres, particularly extraction and processing of materials, far outweighs any savings associated with reduced fuel use from lighter vehicle weights. Extraction and processing of materials for the panels in the case of the nanofibre car required an estimated 43.67 MMBTU compared to just 1.19 MMTBU for the steel car.

The researchers estimated that over a car’s entire life cycle, taking into account extraction and materials processing, production, use and end-of-life treatment, a steel car’s closure panels would use 44.24 MMBTU, while those of a car with nanofibre materials would need 61.26 MMBTU.


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