Life Cycle Assessment of Functionally Enhanced Polymers-Engineered Nanomaterials or Conventional Additives? - DTU Orbit (17/12/2018)

Engineered nanomaterials, where at least one dimension is within 1-100 nm, are produced and used in many consumer products, with the purpose of enhancing specific material properties (e.g., in plastic products). Conventionally, organic and inorganic non-engineered nanomaterial additives are also used to enhance material properties. The aim of this study is to perform life cycle assessments (LCAs) on 5 polymer products (polypropylene air-conditioner part for cars, polypropylene garden chair, polypropylene small electrical box for houses, polyvinylchloride-wood outdoor flooring and polystyrene insulation panels for buildings). Antibacterial, ultraviolet ray protection or flame retardancy properties of these products have been improved through the addition of either Ag, ZnO or Mg(OH)$_2$ engineered nanomaterials, or conventional organic/inorganic polymer additives. The study also presents new industrial production inventories of the considered engineered nanomaterials as well as the quantification of potential changes in impacts when the LCA functional unit is adjusted according to material functionality (antibacterial, ultraviolet-protection and flame retardancy).

The LCA results show that in all cases the products with engineered nanomaterials generate higher potential environmental impacts than products with conventional additives. However, when considering the improved material functionality results differ more. The polyvinylchloride-wood outdoor flooring and polystyrene insulation panels for buildings with engineered nanomaterials perform better than with the use of conventional additives, while the polypropylene products with engineered nanomaterials have slightly higher environmental impacts than products with conventional additives. In the case of polypropylene small electrical box the needed large content of micro-Mg(OH)$_2$ makes the engineered nanomaterial case far less favourable, but if Mg(OH)$_2$ substitutes halogenated flame retardants the potential toxicological impacts are shown to be significantly lower. This study shows that the consideration of enhanced material functionality in LCA can favour some of the engineered nanomaterial based products, versus conventional additives, by reflecting the potential increase in use quality and potentially the use time. Also in this study, based on assumed release amounts, freshwater ecotoxicity caused by engineered nanomaterial release from products is quantified showing a novel approach.

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