ENGINEERED NANOMATERIALS IN PLASTIC PRODUCTS - A MATERIAL FLOW ANALYSIS USING THE EXAMPLE OF CARBON BLACK CONTAINING TIRES

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Due to the demand for constantly improving plastic products the benefits of engineered nanomaterials (ENMs) have been increasingly recognized by research and industry. Thus, the number of polymer nanocomposites (PNCs) available on household level is continually rising [1]. Since ENMs may also pose hazards to humans and the environment, it is crucial to know about their disposition and release behavior during the whole product life cycle as well as about possible and final sinks of these ENMs [2]. This work aims at generating an overview of the current state of knowledge in the field of PNCs as well as of material flow analysis (MFAs) for ENMs. MFAs can serve as a tool to represent the release behavior and the remaining of ENMs along a selected product life cycle.

Based on a comprehensive scientific literature research diverse ENM-types used in plastic products were analyzed and are summarized in Figure 1.

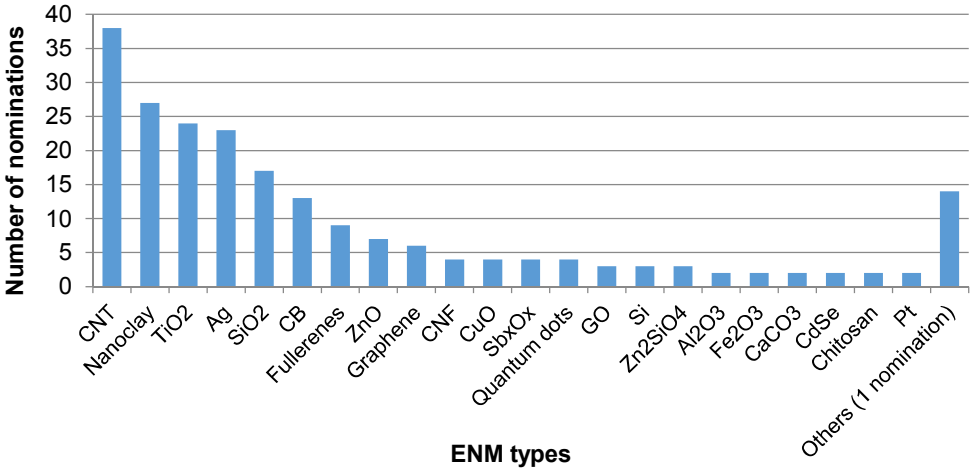

Figure 1: Types of ENMs contained in plastic products and number of their nominations in scientific articles. ENMs with only one nomination have been summarized as "others (1 nomination)". Basis: 40 international scientific articles, Σ different ENM types: 36, Σ nominated ENMs: 215.

Figure 1 shows that carbon nanotubes (CNT), nanoclay, TiO_2, Ag, SiO_2 and carbon black (CB) are the most frequently used ENMs in plastic products. They count for about two thirds of the whole nominations. Secondly, possible release mechanisms of ENMs from polymeric host materials are presented as an important step to localize ENMs along a product life cycle. In terms of release mechanisms, it is crucial to know that embedded ENMs can be released from the polymeric host

material as micro-/nanoscale fragments or (not so likely) as free nanoparticles that should be avoided regarding environmental health and safety (EHS). In general, the release mechanisms of matrix degradation, diffusion, desorption or dissolution are most relevant for EHS aspects [3, 4].

For this study, a nano-specific MFA for the year 2018 is conducted focusing on nCB-laden tires in Austria as representative nano-enabled products. A special focus is set on end-of-life stages. As data availability is limited, a data uncertainty analysis is included to characterize input data in a transparent manner [5]. The results indicate that free nanofillers are mainly released through mechanical exposure, as it is the case during the use-phase and different recycling steps. However, in recycling plants the emissions are retained by filter systems. Overall, during several life cycle stages a particle release into environmental compartments is possible. Especially during the use-phase a large quantity of particles is emitted into the air. Within an indefinite period of time these airborne particles are then deposited either to surface water or soil. The particles of the surface water can furthermore be transferred to a waste water treatment plant (WWTP) over the sewage system to a certain extent. Generally, the major part of all released particles is in the size range of µm. In the long run final sinks of nCBs and larger particles from tires are primarily landfills as well as to a smaller extent surface waters and soils.

In summary, there is still little quantitative information on ENMs for the performance of a MFA available. Nevertheless, with inputs from expert discussions and adequate uncertainty analysis, approximate values can be achieved which can serve as a basis for further investigations as well as for the assessment of potential risks of ENMs that are released along the product life cycle.

References

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