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On the exposure assessment of engineered nanoparticles in aquatic environments

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Abstract

The socio-economic benefits anticipated with the use and production of nanomaterial and nanoparticles in consumer products are linked to the fulfillment of the requirement for sustainability during the whole material life cycle. Engineered nanoparticles (ENP) can be of environmental concern, both due to the possible hazardous effects but also due to the differences in properties compared to regular chemicals, e.g. elevated surface area per mass of nanoparticle, the possibility for enhanced mobility and trespassing biological membranes and other emerging novel properties at the nanoscale. There is a scientific consensus that nanoparticles, nanomaterials and their transformation products have a high probability to be released in the environment. ENP in the aquatic environment present a very dynamic behavior that has to be understood in order to perform a physicochemical-based risk assessment that elucidates their transformation and transport leading to the possibility to predict environmental concentrations and exposure. Therefore, there is a need for adequate theoretical and experimental platforms that can be used for supporting the adequate assessment of fate processes of ENP in the environment.

The main results achieved in the thesis were reflected in: 1) identification of theoretical platforms that can provide solutions for the evaluation of fate processes of ENP in aquatic environments 2) improvement in the application of a novel particle tracking method for characterizing natural nanoparticles and ENP in different matrices; 3) identification of the effects of well-characterized NOM and counterion valence on the aggregation rates of TiO_2 nanoparticles 4) developing a geographically distributed water classification for Europe based on river water chemistry, 5) use the geographical water classification to evaluate the aggregation and sedimentation of Au NP in in-situ quiescent-water microcosms.

The physicochemical characteristics of the receiving water were found to be very influential on the fate of the ENP tested. The ionic concentration, presence of divalent counter ions (specifically calcium), the type of NOM and mass-ratio between NOM and the particles are among the most important parameters. NP coating, surface charge, material properties and shape will also play very important roles. NP number concentrations determine the degree of transport and transformation due to the different dynamic processes in the environment.