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DISSOLUTION, TRANSFORMATION AND (HETERO-)AGGLOMERATION OF NMs: NEW METHODOLOGIES TO ALLOW FOR STANDARDIZATION.

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The last decade has seen a tremendous increase in research efforts to develop and apply analytical techniques with the aim of investigating the environmental behavior of colloids (1-1000 nm in diameter) and nanoparticles (NPs, 1-100 nm in diameter). Many of these studies were triggered by the wide application of manufactured nanomaterials, as well as the implications of these products as potentially dangerous, particulate pollutants [1]. During their live cycle, these materials are transported to or within environmental compartments, potentially leading to adverse effects that need to be fully studied and understood. In the environment, NPs are subject to processes such as dissolution, transformation, (over-)coating and (hetero-)agglomeration. These changes can occur in variable time frames, from minutes to geological time scales, causing certain changes in the intrinsic properties that need to be monitored [2]. In this work, new methodologies to evaluate NPs dissolution, transformation and heteroagglomeration for the purpose of standardization are developed.

To develop standardized methods for NP dissolution batch experiments, different parameters such as the impact of pH, types of buffers, types of pH control, initial concentrations, types of agitation, and types of natural organic matter have been investigated. For NP transformation, assessments were undertaken in conditions simulating aquatic environments with realistic sulfide and phosphate concentrations in batch and flow-through reactors. For heteroagglomeration, a model suspended particulate matter (SPM) was designed for interaction with particulate contaminants (e.g., NP, colloids etc.). Furthermore, a system to investigate model SPM and NP heteroagglomerationto determine attachment efficiency was developed.

Methods to investigate NPs dissolution, transformation and heteroagglomeration were successfully developed for later standardization. The batch experiment set-up is practical and efficient for determining NP solubility and dissolution rates. Transformation of NPs via formation of protective layer which significantly decreased NP dissolution was observed. However, in some cases an increase in ion concentration could be related to the formation of amorphous compound in the nanoparticle surface showing a higher apparent solubility compared with high ordered phases. The versatility of results obtained corroborate the methodology effectiveness. For heteroagglomeration, the model SPM was generated, and the designed protocol is highly reproducible and is independent of the SPM component source. NP and model SPM heteroagglomeration attachment efficiencies were determined in different environmental conditions, illustrating system applicability and robustness in different matrix. The methods developed herein edges efforts towards standardizing methods to investigate the behavior and fate of NP in aquatic system.

[1] Bathi et al., Science of the Total Environment 793 (2021) 148560.

[2] Stetten et al., Nanomaterials 12 (2022) 519.