

Ageing and speciation of Quantum Dots in soil: influence of iron and organic matter

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Quantum Dots (QDs) are engineered nanomaterials expected to accumulate in soils upon release in the ecosystem. Once in the environment, the fate of these chemicals will be dependent on their properties (e.g. composition, coating) as well as their interaction with the natural components. In particular, mineral surfaces and the presence of organic matter are expected to play an important role in determining the dissolution, aggregation and general speciation of these nanoparticles (NPs), thus affecting their overall stability and mobility. As such, limitations of previous studies consist of the use of relatively simple matrices, which may not be representative of complex real conditions, and the characterization of pristine nanoparticles only, without characterization of the transformation products.

In the present study we investigated the mobility and transformation of organic coated CdSe/ZnS QDs nanoparticles aged for 15 d in artificial soil columns at environmentally relevant pH and ionic strength. Porous media consisted of either quartz sand or iron-coated sand whereas calcium nitrate was used as background electrolyte. Further experiments included the addition of fulvic acids to the eluent in order to monitor the effect of organic matter in the processes. Analysis of the leachate solutions and soil extracts was achieved with ICP-AES, HR-ICP-MS and fluorescence measurements. In addition, sections of the soil columns were resin-embedded and analysed with SEM-EDX and XAS techniques.

After ageing, the QDs were completely retained in the columns at all the conditions tested. However, a fraction of the metals (Cd, Se, Zn) was recovered in the leachate, suggesting alteration of the pristine NPs structure. XRF maps showed that QDs and metals were predominantly accumulated onto the iron surfaces and that their mobility was enhanced in presence of organic matter. Eventually, XANES analysis on hotspots of accumulation displayed a substantial speciation of the pristine Se (II) toward more oxidized forms (IV).