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Research area: General aims
Environmental technology // Water

Key words:
Effluent treatment, nano-materials, elimination, emission

Title: Studies to safeguard the purification efficiency of biological stages in the treatment of paper mill effluents containing nano-particles

Background/Problem area

The rapid developments in the field of nanotechnology go hand in hand with the growing use of nano-particles in the paper industry. The overriding goal is to improve product properties, especially in specialty papers. Enhancement of the paper surface by coating it constitutes the main field of application for nano-materials, thereby influencing both optical and converting properties or the special functionalities of the papers. In the wet-end, retention systems using nano-particles are under development and promise to improve retention, dewatering and the dry strength of the products. The use of products on a nanoscopic scale, however, allows them to enter the water circuit directly via the white water, since retention is always incomplete. Nano-particles used in surface coating may be introduced into the water circuits when broke is disintegrated. The same applies to the use of recovered paper if it has components containing nano-particles in it. In addition to these technically related sources, nano-particle input may also result from malfunctions (leakage, overflow, etc.), cleaning operations and production changeovers. There have been as yet no in-depth studies on whether and to what extent nano-particles in aqueous systems retain their nano-character or change it. Similarly, there is only little information about the behaviour of nano-particles in biological treatment processes and their impacts on microorganisms. Both adsorption onto the activated sludge as well as inhibition of the biological activity of the activated sludge can be expected.

Objectives/Research results

The objective of this research project is to assess the consequences of nano-particle use in papermaking for effluent treatment, in particular for the biological stages, and the derivation of suitable measures to ensure stable process conditions. The potential entry of nano-particles into water systems in paper mills is to be determined and the property changes (size distribution) of these substances are to be described. The nano-materials load in effluents, the possibilities of eliminating them and the disruptive potential for biological stages are to be determined and suitable countermeasures developed.

As a first step 17 typical nano-materials respectively products (coating colour pigments, binders, retention aids, antimicrobial agents) used in paper production were selected, suspended (by disintegration) in water and characterised by particle size distribution with optical light scattering methods. These measurements under ideal conditions showed that particle size below 100 nm was observed only for a part of the tested nano-products, some products presented a particle size distribution of 100 – 500 nm.

Depending on the physico-chemical conditions (in order of decreasing influence: electrical conductivity, pH, temperature, concentration of nano-products) nano-particles agglomerate and loose their “nano-characteristics”. If the nano-products will be disintegrated in paper making process water they show a similar behaviour.

The input of nano-particles in process can be expected by disintegration of nano-particles containing coated broke or by the use of retention aids. 15 – 50% of the nanomaterial from disintegrated broke was found in the filtrate by chemical analysis, however the size of this particles was in the range between 130 and 900 nm. Nano-retention aids were nearly complete retained, particles below 100 nm were not detected.

The impact of 4 selected nano-products (Al-, Si-, Ti-, Ag-based) on biological effluent treatment processes was studied in laboratory tests (aerobic and anaerobic static degradation tests and respiratory test). It was found that only nano-silver in extremely high concentrations (0,1 g/l Ag) resulted in inhibition of activity. In practice these concentrations will be not realised unless wrong application or in case of damage/accident. The elimination of the investigated nano-particles by sedimentation, flocculation and adsorption onto activated sludge was almost complete.

The use of the tested nano-products, except nano-silver at extremely high concentrations, seems to be not critical, however nano-products show specific characteristics. In case of use of new products their behavior should be monitored.

Application/Economic benefits

At the same time that nanotechnology is spreading into virtually all industrial and commercial sectors, discussion also focuses on the associated risks that lurk in nanotechnology. The envisioned studies on the entry, action and impact of nano-particles in process water and papermaking effluents are set to break new ground. The results are intended to form the basis for an initial evaluation of the situation regarding on-site consequences of the use of nano-materials for effluent treatment in the paper industry. Possible emissions will have to be pinpointed in order to be able to react head-on to possible problems as the use of these materials continues to grow. This is important in so far as the paper industry continues to discharge considerable volumes of water into lakes and rivers despite all attempts at intensive water management.

Period of time: 01.07.2008 – 30.06.2010

Remarks

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