Is it possible to remove polymeric nanoparticles from aqueous paints during the activated sludge treatment?

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The market for emulsion polymers (latexes) is large and growing at the expense of other manufacturing processes that emit higher amounts of volatile organic solvents. The paint industry is not an exception and solvent-borne paints have been gradually substituted by aqueous paints.

In their life-cycle, much of the aqueous paint used for architectural or decorative purposes will eventually be discharged into wastewater treatment facilities, where its polymeric nanoparticles (mainly acrylic and styrene-acrylic) can work as xenobiotics to the microbial communities present in activated sludge.

It is well established that these materials are biocompatible at macroscopic scale. But is their behaviour the same at nanoscale? What happens to the polymeric nanoparticles during the activated sludge process? Do nanoparticles agregate and are discharged together with the sludge or remain in emulsion? How do microorganisms interact with these nanoparticles? Are nanoparticles degradated by them? Are they adsorbed? Are these nanoparticles toxic to the microbial community?

To study the influence of these xenobiotics in the activated sludge process, an emulsion of cross-linked poly(butyl methacrylate) nanoparticles of ca. 50 nm diameter was produced and used as model compound.

Activated sludge from a wastewater treatment plant was tested by the OCDE's respiration inhibition test[1] using several concentrations of PBMA nanoparticles. Particle aggregation was followed by Dynamic Light Scattering and microorganism surfaces were observed by Atomic Force Microscopy.

Using sequential batch reactors (SBRs) and continuous reactors, both inoculated with activated sludge, the consumption of carbon, ammonia, nitrite and nitrate was monitored and compared, in the presence and absence of nanoparticles.

No particles were detected in all treated waters by Dynamic Light Scattering. This can either mean that microorganisms can efficiently remove all polymer nanoparticles or that nanoparticles tend to aggregate and be naturally removed by precipitation. Nevertheless respiration inhibition tests demonstrated that microorganisms consume more oxygen in the presence of nanoparticles, which suggests a stress situation. It was also observed a slight decrease in the efficiency of nitrification in the presence of nanoparticles. AFM images showed that while the morphology of some organisms remained the same both in the presence and absence of nanoparticles, others assumed a rough surface with hilly like shapes of ca. 50 nm when exposed to nanoparticles.

Nanoparticles are thus likely to be either incorporated or adsorbed at the surface of some organisms, increasing the overall respiration rate and decreasing nitrification efficiency. Thus, despite its biocompatibility at macroscopic scale, PBMA is likely to be no longer innocuous at nanoscale.

[1] OECD Guidelines for the Testing of Chemicals, 209 (2010)

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