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Polyethylenimine-functionalized pyroxene nanoparticles embedded on diatomite for adsorptive removal of dye from textile wastewater in a fixed-bed column

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Providing clean and affordable water to meet the human needs is a big challenge in this century. Globally, the water supply for many industries struggles to keep up with the strong demand. This demand issue is exacerbated by industrialization, which led to water quality deterioration, forming polluted wastewater. Existence of treatment processes to overcome wastewater problems are not efficient and appropriate to maintaining the industrial effluent composition within the standard limits. Specifically, presence of dissolved organic compounds not properly eliminated during the wastewater treatment has a negative impact on human health and the environment. As a novel solution, nanotechnology holds great potential in water and wastewater treatment to improve water quality efficiently. Here, we introduce an innovative technique using environmentally friendly, multifunctional, and effective poly(ethylenimine)-functionalized pyroxene nanoparticles to provide an efficient removal of the dissolved total organic carbon from industrial wastewater in batch and continuous fixed-bed column studies under various conditions. Our study includes arrays of characterization techniques for the prepared nanoparticles and for diatomite (commonly used filter aid) before and after embedding it with the nanoparticles at a very low mass ratio (<5 wt%). Diatomite, on its own, has a very low adsorption capacity for the dissolved organic contaminants in field applications. Among these applications is the employment of diatomite with a rotary drum filter (RDF). Therefore, we embedded the nanoparticles to improve the performance of the diatomite employed with a rotary drum filter used for the removal of dissolved organic pollutants. This followed our bench scale adsorption experiment using a continuous fixed-bed column that is considered to be the best lab scale model for the rotary drum filter. The experimental results showed that, compared to using activated carbon and magnetic nanoparticles, the prepared nanoparticles were very effective in the removal of dissolved organic contaminants in batch and continuous fixed-bed column experiments. In continuous fixed-bed column experiments, the breakthrough behavior was described using a convection-axial dispersion model that had a good fit with the obtained experimental data. Interestingly, this innovative technique was successfully applied at Executive Mat Ltd, in Calgary in their rotary drum filter after optimizing some operational conditions.

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What do we know about nanomaterial properties that affect their toxicity?

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Safe-by-design (SbD) is not new, the method has been used for years by the industry to minimize the toxicity of products. The SbD concept is tuned towards timely identification of uncertainties and potential risks as well as timely measures to reduce or eliminate these uncertainties and risks during an innovation project. SbD is not a stand-alone concept: It is designed so that it can be seamlessly integrated into current industrially used innovation processes. In essence, designers and developers of new nanomaterials should include toxicological expertise in a very early stage, rather than waiting under risk assessment has to be performed prior to bringing a product to the market. More than a decade of research on the toxicological potential of nanomaterials will allow us now to give guidance with some general principles. For example, the aspect ratio of fibre like structures is very predictive for the development of mesothelioma (like the classical asbestos-induced cancer). Size, shape, solubility, number of particles that will be in contact with the biological system will all have their implications for the development of adverse health outcomes.

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