New solvent-antisolvent nanoprecipitation method for the simple and low-cost production of polyethylene nanoparticles as nanoplastic models

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Nanoplastics (NPs) have a widespread presence as contaminants in aquatic environments and, owing to their nanometric size, can cross biological membranes and penetrate into cells. Consequently, extensive research efforts are focused on understanding the potential impacts of NPs on both human health and ecosystems. Polyethylene (PE) is particularly problematic because its extensive use in commercial plastic bags, becoming the major source of NPs in aquatic environments. For toxicological and environmental studies, well-defined PE nanoparticles are required as reference materials. However, the preparation of small PE nanoparticles with low polydispersity and precisely controlled size using a simple, low-cost, and reproducible method remains a challenge. Here, we present a very simple and easily scalable preparation method based on solvent–antisolvent nanoprecipitation, producing PE nanoparticles (Fig. 1) with smaller particle sizes and lower polydispersity than those obtained by methods based on toluene-in-water emulsions [1] or xylene-DMSO nanoprecipitation [2] . PE is first dissolved in a medium-chain fatty acid, in the absence of water, and subsequently nanoprecipitated by fast mixing with a highly alkaline aqueous solution. Finally, sample are purified using dialysis membranes. This method can produce PE nanoparticles with controlled sizes below 100 nm, and colloidal stabilization was achieved by adding a surfactant prior to nanoprecipitation, as nanoparticles with sodium octanoate alone were not colloidally stable after dialysis purification, most likely due to desorption of octanoate from particle surface. The formation of small (size < 30 nm) and stable nanoparticles required a molar excess of hydroxide ions relative to initial carboxylic acid (OH^-/RCOOH molar ratio ≈3) and the use of Tween 80 (polyoxyethylene (20) sorbitan monooleate) surfactant (Fig. 1a). The largest nanoparticles, obtained in similar conditions, were those prepared in the presence of Brij S100 (polyoxyethylene (100) stearyl ether) surfactant (Fig. 1b). SDS (sodium dodecyl sulfate) and Etocas 200 (polyoxyethylene (200) castor oil) surfactants resulted in intermediate sizes. To the best of our knowledge, this simple and straightforward method has not been reported before.

Keywords:
Polyethylene nanoparticles, solvent-antisolvent nanoprecipitation

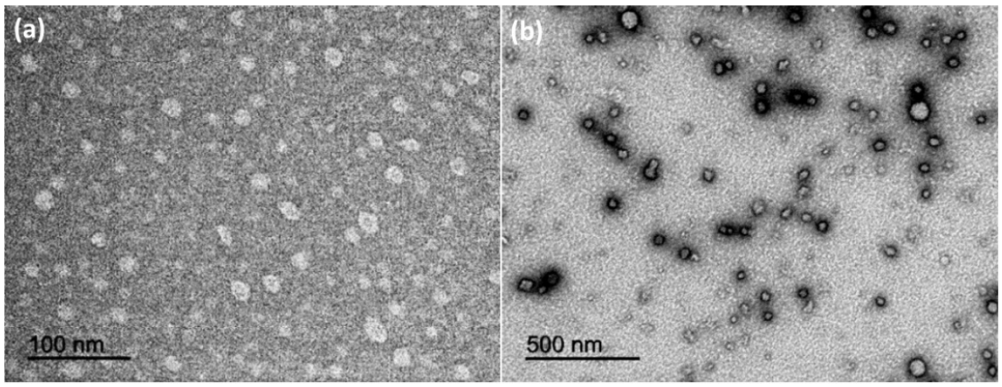

Fig. 1. Examples of TEM images of PE nanoparticles, stabilized by polyoxyethylene (20) sorbitan monooleate (a); and polyoxyethylene (100) stearyl ether (b) surfactants.

References:

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