SEPARATION OF TITANIUM IONS AND TITANIUM DIOXIDE NANOPARTICLES IN VITRO

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Abstract: Metal oxide nanoparticles are widely used in both industrial and medical innovations. The need for understanding the properties and mechanism toxic effects has grown to prevent the detrimental effects on environmental and human health. In many instances, toxic effects are mediated by the metal ions released from nanoparticles. Therefore, the detection of particular metal ion concentration is critical to understand the sources of toxicity exhibited by accidental or environmental exposure. In this study we have investigated experimental conditions to separate metal ions and nanoparticles using commercially available titanium dioxide nanoparticles (TiO₂ NPs). The objective is to develop a less expensive yet efficient separation method for separating the titanium ions that allows understanding pathways of TiO₂ NP-nanoparticle-induced toxicity. Attempts for separating Ti ions from TiO₂ NPs were conducted under ultrasounds and heat-assisted extraction in different solvents. Water, dilute nitric acid (HNO₃), hydrochloric acid (HCl) and tetramethyl ammonium (TMAH) were examined. Aqueous suspensions of TiO₂ NPs were sonicated or digested in water, 0.5%, 1%, 5% HNO₃, 1% HCl and 25% TMAH. After treatment, 2-mL portions from suspensions were centrifuged at 13K rpm for different periods of time from 30 min to 3 h. TiO₂ NPs were not affected from digestion in water. Nanoparticles were also found relatively stable in dilute acids. Substantial solubilization occurred in TMAH resulting in release of Ti ions to solution. Centrifugation time was critical to eliminate fine particles from the solution. ICP-MS analysis showed that, TiO₂ nanoparticles were successful removed from the solution by 3 h of centrifugation. Ti signals dropped drastically to negligible levels for solution treated with dilute HNO₃. The results indicated that 1% HNO₃ provided the optimum conditions for separation of TiO₂ NPs from Ti ions. In vitro extraction studies were conducted by adding a known quantity of Ti ions into TiO₂ NPs suspensions. Separation efficiency was greater than 90% indicating the method afforded the quantitative separation of TiO₂ NPs and titanium ions.

Keywords: TiO₂ nanoparticles, separation, ICP-MS, sonication, digestion, dilute acid

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