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Aggregation and Attachment of the $nTiO_2$ in Presence of Ca^{2+} and Phosphate Ions

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Many studies have investigated the aggregation and stability of nanoscale titanium dioxide particles ($nTiO_2$) under simple water chemistry conditions. In natural aquatic systems, water chemistry could be complicated and $nTiO_2$ could encounter multiple water components simultaneously, yet the combined effects of some multiple components have not been investigated. In this study the aggregation of $nTiO_2$ and its attachment to quartz sand was studied in the presence of phosphate (0.02 mM) and calcium ions (0.5 mM) at different pH and under low ionic strength conditions (1.5 mM). The results, obtained from the batch experiments, indicated that the hydrodynamic diameter of the $nTiO_2$ was strongly influenced by phosphate and calcium ions, both of which modified $nTiO_2$ surface charges. At pH 5, zeta potential of the $nTiO_2$ particles decreased to nearly zero in the presence of phosphate. Calcium cations had a substantial effect on the zeta potential of $nTiO_2$at pH 9 where the particles were positively charged for any phosphate concentration up to 0.02 mM. Similarly, the attachment of $nTiO_2$ to quartz sand was affected by phosphate and calcium. At pH 5 in the absence of phosphate, substantial amounts of $nTiO_2$ attached to the sand due to attractive forces between the positively charged $nTiO_2$ and the negatively charged sand; however, the presence of the phosphate decreased the positive charges on the surface of the $nTiO_2$ and inhibited their attachment. At pH 9, the surface charge of $nTiO_2$ reversed to positive due to the existence of calcium and a substantial amount of $nTiO_2$ was observed to attach to the sand even in the presence of phosphate. This study revealed that the combined effect of calcium and phosphate on the aggregation and attachment of the $nTiO_2$ can be different from that of their individual influence. These findings are important for understanding of the fate and transport of $nTiO_2$ in natural aquatic systems where various anions and cations coexist.