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The optimization and comparison of a cerium salt-based phosphate filtration system to industry standard phosphate removal water filtration systems

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**Background**

Phosphorus is one of the fundamental building blocks for biological molecules. Phosphorous removal from water is required at many wastewater treatment plants as phosphate helps encourage growth of cyanobacteria and algae. To adhere to federal regulation on phosphate, most industrial waste water treatment facilities rely on either aluminum or iron based systems to remove the excess phosphorus in the form of reacted phosphate. The main drawbacks of these traditional systems is that they require a large amount of floculants to process their phosphate-metal products. In this experiment our team evaluated the reactivity of the cerium chloride and phosphate ions in multiple conditions to optimize the yield and flocculating of cerium phosphate crystals.

\[
\text{CeCl}_3(aq) + \text{PO}_4^{3-}(aq) \rightarrow \text{CePO}_4(s) + 3\text{Cl}^-(aq)
\]

**Concentration & Filtration Analysis**

The ideal reaction conditions for cerium phosphate generation would be at a 1:1 ratio in a basic environment at approximately 8 pH. Filtration can be avoided with the use of coagulants and floculants.

- Identify the most significant reaction variables for cerium phosphate production.
- Evaluate the effect reagent concentration, filtration and pH has on cerium phosphate production.
- Evaluate the success of coagulants and floculants on cerium-phosphate crystals in lab-grade, municipal and industry waste water.
- Conduct a financial analysis on the cost of a cerium salt based phosphate removal system to standard industry phosphate removal methods.

**Methods**

The concentration studies were conducted with the use of 1000ppm solutions of CeCl₃ and Na₂HPO₄. The reactions were evaluated after mixing and a 10-20 minute settling time. The reacted solutions were analyzed through Inductive Coupled Plasma Mass Spectrometry (ICP-MS). The filtration experiments were conducted with the use of Thermo Scientific syringe filters. Both the filtration and concentration studies utilized a Design of Experiment and JMP software to determine the best reaction parameters. Standard water treatment floculants were tested on reacted cerium phosphate solutions to evaluate the settling properties of the produced flock.

**Conclusions**

- The optimal concentration ratio between was roughly 2:1.
- Cerium phosphate crystals are filtered out with a 1.5mm filter.
- The rate of reaction increased exponentially when the pH > 5.
- The coagulant analysis concluded that coagulants were necessary depending on the water to generate micro-flock in the samples.
- The floculent analysis demonstrated that the anionic polymer was the most successful.
- The analysis with the ChemTreat account water demonstrated that the cerium chloride treatment is greatly influenced by the presence of other chemicals.

**Next Steps**

For the continued development of the cerium salt phosphate removal system, the reaction flocking agents need to be continually analyzed with each different water source. To support this system, investigation into the recycling of cerium from cerium phosphate should be investigated.

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