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Zinc nanoferrites synthesized by different routes for phosphate adsorption in aqueous solutions

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Phosphorus has often been found in aquatic environments due to indiscriminate human activities. Even at low concentrations, this nutrient can lead to eutrophication, causing excessive algae growth and impairing water usage[1]. Removing phosphorus by adsorbents has been considered effective, as it can remove phosphate from low concentrations and still possess regeneration capability for use in multiple adsorption cycles[2]. Ferrites, iron oxides in the cubic spinel structure, have demonstrated adsorptive and magnetic properties and can be synthesized by different routes[3]. Studying different synthesis methods allows for evaluating the most suitable approach and its influence on nanoparticle properties[4]. This work aimed to synthesize and characterize magnetic materials based on zinc ferrite ($ZnFe_2O_4$) using conventional ceramic (CC) and co-precipitation (CP) methods, testing them for phosphate (PO_4^{3-}) adsorption and reuse in adsorption/desorption cycles. In the CC method, precursors were solubilized under heating until dry and then calcined at 500, 700, and 900 °C for 2 h. In the CP method, NaOH was added to the precursors until pH 12-13, followed by heating, washing with water/ethanol, and calcination at 500 °C for 2h. The materials were characterized by XRD, SEM/EDS, and Mössbauer spectroscopy. XRD and Mössbauer's results confirmed the presence of $ZnFe_2O_4$ phases by the CC and CP methods, the latter before and after calcination. The samples exhibited magnetization. Adsorption tests were conducted by contacting the material with a 50 mg-PO_4^{3-}/L solution. Subsequently, desorption was performed with NaOH (0.5 mol L^{-1}) extraction, resulting in 90% phosphate recovery. ZnFeCP and ZnFeCP5 samples, obtained by the CP method, showed the best adsorption results in the first cycle, 23 and 11 mg-PO_4^{3-}/g, respectively, while the ZnFeCC9 sample, obtained by the CC method, showed 2 mg-PO_4^{3-}/g. ZnFeCP exhibited regeneration capacity after five cycles, while the others did not show adsorption capability after the fourth cycle. Ferrites obtained by co-precipitation proved to be better adsorbents, with crystallinity at lower calcination temperatures and smaller particle sizes. In conclusion, zinc ferrites synthesized by different methods are promising for reuse in multiple adsorption cycles and can be easily recovered due to their magnetic properties.

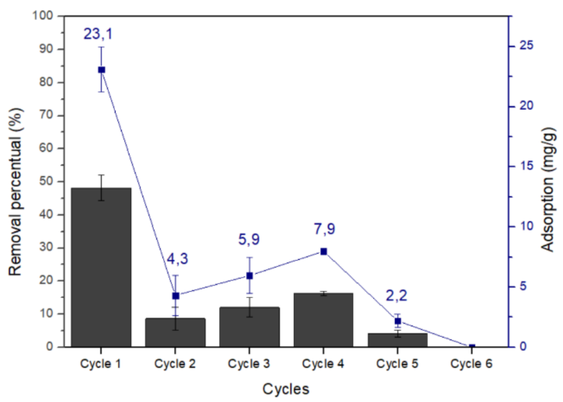

Figure 1 – Adsorption cycles of the synthesized material by coprecipitation (ZnFeCP)

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