Preliminary Study about Magnetic-Single Sheet Iron Hydroxide Phosphorus sorbent

Main area: Environmental Chemistry/Water Treatment

Target group: Environmental Chemistry

Educational level: Master

Project description:

**Introduction:** Phosphorus is one of the most understood nonrenewable available nutrients for fertilizers production. It is well known that the presence of certain amount of phosphate in treated wastewater from municipalities and industries is often accountable for eutrophication, which leads to short- and long-term environmental and esthetic problems in lakes, coastal areas, and other confined water bodies. P concentrations in agricultural drainage water is typically with a maximum of 1 mg P/L. In wastewater, it is much higher, but 10 mg P/L is typical or even higher. P concentrations to start algal growth is around 0.05 – 0.1 mg P/L. On the other side, phosphorus derived from phosphate rock is a valuable, non-renewable and irreplaceable limited resource, which the fertilizer industry and modern agriculture heavily depend on. It is said that the phosphorus reserves will be used up in next 100 year. In 2014, the European Commission declared phosphate rock as one of the 20 critical resources for European Union. Therefore, developing a phosphate removal and recovery technology from wastewater has been considered as an important research area for environmental and economical sustainability concern around the world.

Generally speaking, there are three kinds of methods to remove phosphate including chemical precipitation, biological treatment, and adsorption. Chemical precipitation method was first used to resolve the problem of rich nutritional pollution. However, the cost was expensive and the recovery of phosphorus from chemical sludge was very difficult. Biological treatment was widely used in the removal of organophosphorous chemicals in food and domestic wastewater. But, this method had disadvantages of slow treatment speed, complex operation process and requiring considerable infrastructure investment. Furthermore, it was unsuitable for treating wastewater containing high concentration of phosphate. On the other side, adsorption method was found to be superior to above techniques for removal of pollutants from aqueous solution in terms of flexibility and simplicity of design, ease of operation and insensitivity to toxic pollutants. The adsorption capacity and efficiency were greatly dependent on the materials of adsorbents.

Among various sorbents, anionic clays, so-called layered double hydroxides (LDHs), have been used in phosphate adsorption for their large surface areas, high anion-exchange capacity, and flexible interlayer region accommodating various anionic species. And the iron oxides are well known for their strong phosphate binding affinity and capacity, so an iron rich LDH materials could be very promising for phosphate sorption. In recent years, our group has already developed the method to synthesis the dodecanoate anions interlayered green rust (GR, a FeII-FeIII LDH materials). Due the dodecanoate anions can act as structure stabilizer, the GR can be oxidized and exfoliated into single sheet iron hydroxide (SSI) layer. The obtained SSI shown excellent phosphate sorption affinity, capacity as well as the structure stability. However, due to its flakes structure, it is almost impossible
to regenerate them by traditional filtration or sedimentation method, which normally be used in real waste water stream.

Our motivation in this project is to develop a magnetic-SSI sorbents, study its phosphate removal and recycle property. In our lab, we are trying to make the magnetic nanoparticles anchor on the SSI materials, which could make the whole system easily separated with external magnetic field together with high phosphate sorption capacity and affinity. A SSI template assisted synthesis and followed by oxidation process will be used to synthesize the magnetic-SSI materials. In this project, various characterization techniques will be applied including X-Ray diffraction (XRD) and transmission electron microscope (TEM) etc.

Experiment scheme of the synthesis of magnetic-SSI

Objective of this project

1. Obtain an introduction to SSI for phosphate removal and recovery by reading key papers/reports on the subject and come up with ideas about which experimental procedures are commonly used.

2. Design an experimental setup to synthesize magnetic-SSI materials with different magnetic particles/LDH ratios and phosphate removal experiment. The phosphate adsorption isotherms, kinetics and removal efficiency will be investigated.

3. Select appropriate experimental procedures, analytical approaches and produce a lab protocol. Learn the knowledge about various characterization techniques such as XRD, TEM, SEM, UV-vis, FTIR and AAS etc.

4. According to the results of removal efficiency, the most efficient magnetic-SSI will be choose to study the reusability of this kind of sorbent material.

5. Data treatment and statistics. Present the project work in the form of a short scientific paper.