Novel Renewable Resource-Based Nanocomposites for Removal and Recovery of Phosphates from Contaminated Wastewaters

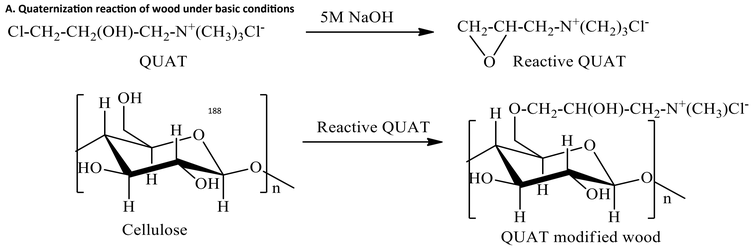
Rebecca Moreira, Amita Nakarmi, Tito Viswanathan

Department of Chemistry, University of Arkansas at Little Rock, 2801 S. University Ave, Little Rock, 72204

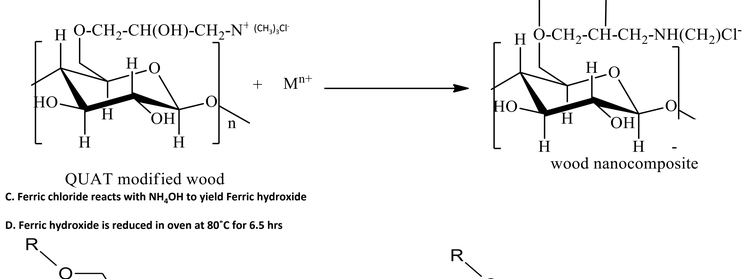
Abstract: Runoff water containing phosphates pollutes large water bodies such as lakes, rivers, and oceans. This results in the growth of algae, which consumes oxygen as it dies. Hypoxic conditions then lead to death of aquatic animals and disruption of the natural ecosystem in a process called eutrophication, an environmental problem almost exclusively induced by pollution of phosphorus. Additionally, phosphorus is a non-renewable resource with no reasonable method known for commercial production. Phosphorus sources from the earth's crust are estimated to be depleted within 50 to 100 years. This necessitates a method for removal of phosphorus from runoff water for the purpose of decontamination and reuse in the agricultural industry. The combination of Cerium and Aluminum oxide nanoparticles in wood has shown to be excellent for phosphate remediation. The results are better than using single metal oxides alone in the nanocomposites. There are no harmful chemicals or petroleum reagents used during the synthesis making the process straightforward, economically feasible, and environmentally friendly. The results of this study indicate that phosphorus levels in contaminated water can be reduced from 1000 parts per billion to 10 parts per billion or less. Additionally, the phosphorus can be desorbed and the media can be regenerated for repeated use without loss of efficiency.

Synthesis

A. Quaternization reaction of wood under basic conditions

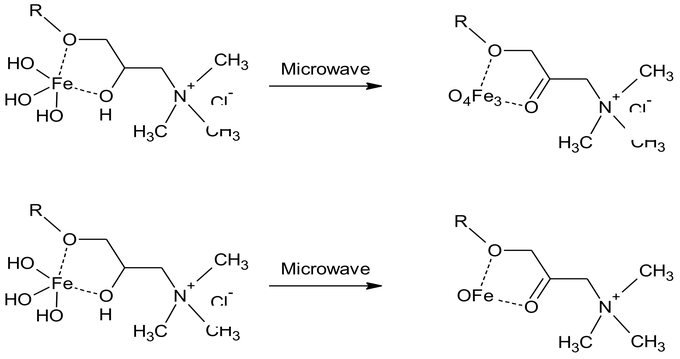


B. Complexation of QUAT modified wood with metal ion



C. Ferric chloride reacts with NH_4OH to yield Ferric hydroxide

D. Ferric hydroxide is reduced in oven at 80˚C for 6.5 hrs



Procedure

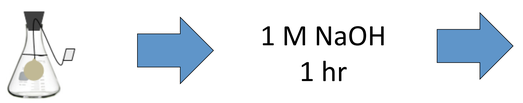
Kinetic Studies

Teabags of media placed in P stock solution of known concentration.
Aliquots taken at 05, 1, 2, and 4 hours

Kinetic Studies

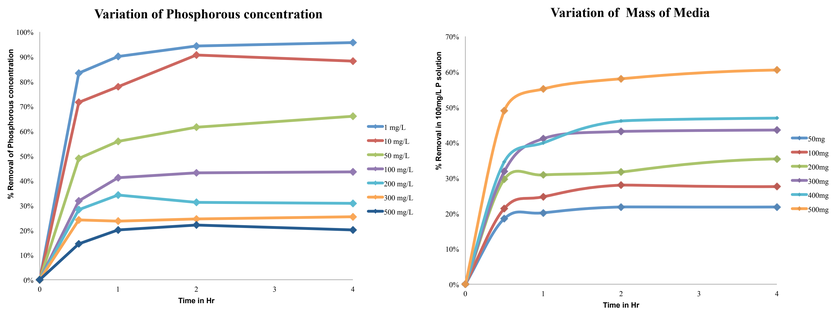
Sample dilutions treated with acid reagent:
50% 5M Sulfuric acid, 5% Ammonium tartrate
15% Ammonium molybdate, 30% Ascorbic acid

Regeneration

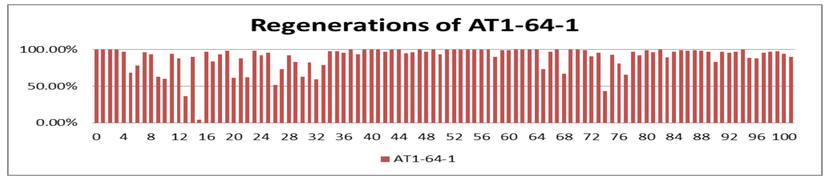


Results

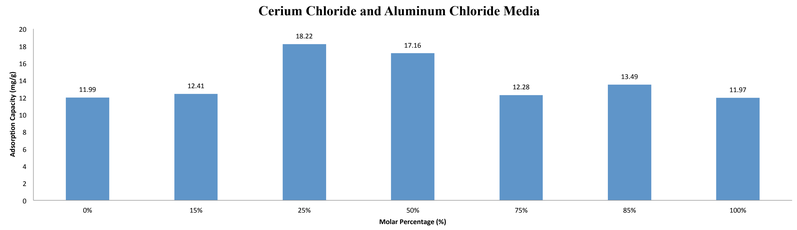
Kinetic Studies of Iron Oxide Media



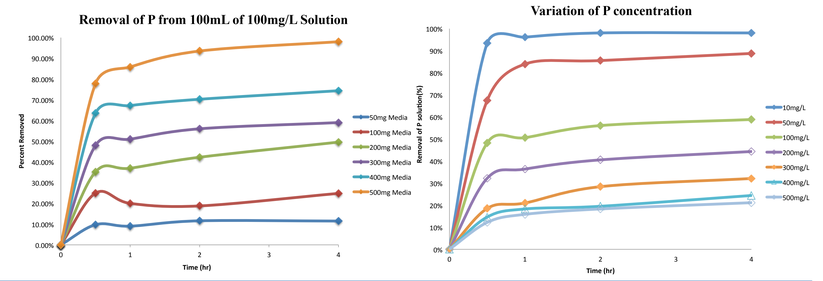
Regeneration of Iron Oxide Media



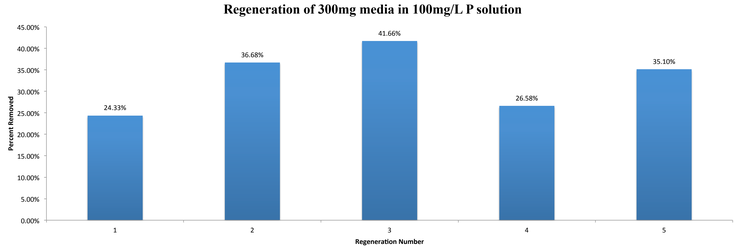
Comparison Studies



Kinetic Studies of Bimetallic Oxide Media

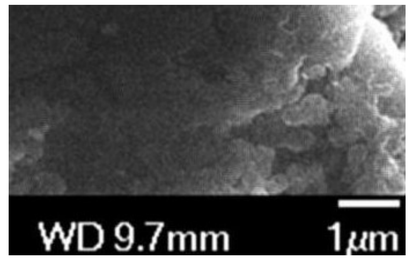


Regeneration of Bimetallic Oxide Media



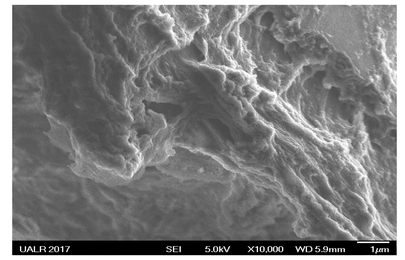
Characterization

Iron Oxide Media



Magnified SEM Image of Nanocomposites on Quat-modified Wood with Iron-oxides Fixation

Bimetallic Oxide Media



Magnified SEM image of Nanocomposties on Bimetallic media

Conclusion

Iron oxide-containing media showed that 100% Phosphorus removal is possible with 300mg media in 1 mg/L P solution. SEM imaging showed the iron oxide nanoparticles in the media to be approximately 100nm in diameter. Another novel media with a 3:1 ratio of Cerium and Aluminum oxide demonstrated a high P removal capacity of 18.22 mg P/g of media. Studies that included variation of P concentration and mass of media showed that capacity is highest when the concentration of P is high or the mass of media is low. Kinetic studies confirmed chemisorption, monolayer formation, and heterogeneous adsorption system. Regeneration studies showed that the media can be regenerated multiple times without significant loss of capacity, although further regeneration studies of the bimetallic media should be conducted. This media can take P concentration from 1000 ppb to 10 ppb or less in accordance with EPA guidelines.

References

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