Synthesis and Application of Cellulose/Zinc Oxide Nanocomposite Fabricated from Agricultural Residues for the Removal of Organophosphate Flame Retardants from Aqueous Media

Anna E. Ivbanikaro
Department of Environmental, Water and Earth Sciences, Tshwane University of Technology, Pretoria, North, Private Bag X680, Pretoria, South Africa

Abstract

Organophosphate flame retardants (OPFRs) are emerging contaminants that are environmentally persistent and bioaccumulative with toxic tendencies. Cellulose fibers were extracted from maize tassel wastes, functionalized with Zinc Oxide nanoparticles and used to remove four halogenated OPFRs [Tris(2-chloro-ethyl phosphate (TCEP), tris(2-chloroisopropyl) phosphate (TCPP), tris(2,3-dibromopropyl) phosphate (TDBPP), and tris (2-chloro-1-(chloro methyl)ethyl phosphate (TCDPP)] from water. Scanning electron microscopy (SEM), Fourier transformed infrared (FTIR) spectroscopy, Brunauer Emmett–Teller (BET) analysis, Energy dispersive X-ray (EDX), and other equipment were used to characterize the nanocomposites. Batch experiments were performed to investigate the effect of solution pH, initial OPFRs concentration, adsorbent dosage, agitation time, and temperature on Cell-ZnO performance. FTIR result of Cell-ZnO showed two additional absorption bands at 437 cm^{-1} and 495 cm^{-1}, corresponding to O–Zn–O vibrations, and confirming ZnO incorporation. SEM and EDX results supported this finding. The surface area of cellulose (6.0170 m^2/g) increased to 37.1928 m^2/g after modification. A percentage removal of 73.68 % (TCEP), 85.41 % (TCPP), 80.47 % (TDCPP), and 88.21 % (TDBPP) was recorded under optimized conditions of pH 3, and adsorbent dosage of 0.08 g. It is evident from the performance of the synthesized Cell-ZnO that it offers great prospects for the remediation of OPFRs-contaminated water.

Keywords

Cellulose-Zinc oxide nanocomposite; maize tassels; OPFRs; Remediation; Water pollution.