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Research Paper

Highly efficient porous carbons for the removal of W(VI) oxyanion from wastewaters

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ABSTRACT

Pyrolysis chars derived from rice wastes were chemically activated and used in W(VI) oxyanion adsorption assays in synthetic and mining wastewaters. For comparison purposes, a commercial activated carbon (CAC) was also used. Different experimental conditions were tested in the adsorption assays: solid/liquid ratio (S/L), initial pH, contact time, and initial W concentration. The porous carbon P2C+KOH presented the overall best performance in both media, due to its high surface area (2610 $m^2\ g^{-1}$), mesopore volume (1.14 $cm^3\ g^{-1}$), and neutral pH_{pzc} (6.92). In the synthetic wastewater, the highest uptake capacity of P2C+KOH (854 mg g^{-1}) was found in the assays with an S/L 0.1 g L^{-1}, an initial pH 2, and an initial W concentration of 150 mg L^{-1}, for 24 h. This value was almost 8 times higher than the one obtained for CAC (113 mg g^{-1}). In the mining wastewater, P2C+KOH showed an even higher uptake capacity (1561 mg g^{-1}) in the assay with the same experimental conditions, which was almost 3 times higher than for CAC (561 mg g^{-1}). These results suggest that P2C+KOH seems to be an efficient alternative to CAC in the W(VI) adsorption from liquid effluents.

1. Introduction

The strong industrial development of the last century has determined a very high demand for natural resources and leading to considerable amounts of wastes released in all environmental compartments. Metals assume particular relevance due to their many industrial applications and consequent high demand for mineral extraction and derived high flows of metal-contaminated wastewaters (Demirbas, 2008). The threat posed by metal contamination in water bodies is particularly relevant, due to the general solubility in water or lipids that characterise these pollutants, and the tendency to be adsorbed and bioaccumulated in living organisms (Song and Li, 2015; Hsu et al., 2011).

Regarding tungsten source, primary tungsten is obtained from the dissolution of ore concentrates in the wolframite and scheelite minerals by alkaline pressure digestion, using either sodium carbonate or a concentrated sodium hydroxide solution. The sodium tungstate (ST) solution is then purified before its conversion into high purity ammonium paratungstate (APT) ($(NH_4)_{10}(H_2W_{12}O_{42})\cdot 4H_2O$). Secondary tungsten comes from the recovery of tungsten-bearing scraps, such as used drill bits and tools, which are oxidized and then chemically digested to form APT as well. This tungsten species is, in fact, the main form traded in the market and the main tungsten intermediate (Lemus and Venezia, 2015). Consequently, APT is mostly processed to obtain, by calcination, tungsten oxides (WO_{3-x}), "tungsten bronze" [$(NH_4)_nWO_3$ ($0.06 < n < 0.33$)], and tungsten carbides powders (WC or WCCo) by carburisation and consequent milling and blending (Trasorras et al., 2016). The relevance of this heavy metal for several industrial applications is due to its remarkable properties and low substitutability. Historically, its most widely known application has been in filaments of incandescence bulbs, due to its very high melting point. However, tungsten compounds are employed also in various production processes such as superalloys for blade turbines or steel tools (Xu et al., 2020),

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