Perchlorate Sorption By Activated Carbon: Role of Surface Functional Groups

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Perchlorate has become a major groundwater contaminant and has attracted serious attention because of its harmful effects on human health. In this work, four commercially available activated carbons are tested for perchlorate sorption capabilities and the sorption mechanism elucidated. Based on the data on surface functional groups obtained from acid-base titrations, Fourier transform infrared (FTIR) spectroscopy, X-ray photoelectron emission spectroscopy (X-PEEM) and surface hydrophobicity from water contact angles, the materials can be divided into two types: type I materials with predominantly carboxylic surface functional groups and type II materials dominated by the phenolic surface functional groups. The plots of distribution coefficient $K_d$ vs pH fall into three categories, with two samples (type I) showing high sorption capabilities with the distribution coefficient $K_d$ varying from $6.8 \times 10^3$ to $1.8 \times 10^4$ ml/g as the solution pH changes from 8.5 to 3.8, and one sample (type II) showing slightly lower $K_d$ values ($4.8 \times 10^3$ and $1.04 \times 10^4$ ml/g at solution pH values of 8.5 and 3.8 respectively) and the fourth sample (type II) showing very poor sorption capability over a similar pH range. The slopes of the curves for all four samples are very similar and close to zero indicating a weak pH dependence of sorption, leading to the conclusion that the sorption mechanism is mediated by chemical interactions (inner sphere complexation) and the different distribution (carboxylic vs. phenolic) of surface functional groups rather than by pure electrical or ionic interactions. In conclusion, perchlorate removal by activated carbon can be greatly improved by tailoring the activation and treatment processes and modifying the distribution of surface functional groups.

Fig.1 X-PEEM spectra                  Fig.2 FTIR spectra of four carbon samples