INTERACTION OF ACTINIDES WITH NATURAL MICROPOROUS MATERIALS: A REVIEW

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Natural microporous materials include several types of minerals such as zeolites, clay minerals, micas, iron- and manganese-oxides/hydroxides/oxyhydroxides present in various geological environments and soil formations. Their crystal structure is characterized by the presence of intracrystal micropores (channels or interlayer void spaces) providing high microporosity - surface area and distinguished physicochemical properties such as sorptive/ion-exchange and catalytic. For this reason these materials have found a wide spectrum of industrial and technological applications. The investigation of the interaction of the actinide elements with natural microporous materials is of special significance for the nuclear industry because of the suitability of these materials for the treatment of liquid effluents and the final storage of radioactive waste (sorbents, backfill materials, constituents of disposal host rocks) produced in the nuclear fuel cycle. On the other hand, the environmental geochemistry of the actinides is of increasing importance because of their high radiotoxicity and their involvement in different geochemical and biogeochemical cycles. The transport of the actinide elements in the environment is mainly performed through aquatic pathways (streams, rivers, underground waters) and their mobility is strongly related to the interaction of their dissolved species with geological materials and especially with the highly sorptive microporous minerals.

The existing studies mainly concern the sorption of Th, U, Np, Pu and Am from aqueous media by clay minerals (e.g. montmorillonite, kaolinite) and zeolites (e.g. heulandite/ clinoptilolite) as well as the determination of the corresponding chemical processes taking place at the mineral-water interface. The investigation techniques applied for this purpose include, except the conventional wet-chemical and radiochemical methods, advanced spectroscopic methods such as Extended X-ray Absorption Fine Structure Spectroscopy (EXAFS), Rutherford Backscattered Spectroscopy (RBS), X-ray Photoelectron Spectroscopy (XPS) and Raman Spectroscopy. These techniques significantly contribute to the characterization of the reacted mineral surfaces and to the explanation of the structural and compositional characteristics of the sorbed actinide species. Theoretical models regarding the aqueous chemistry and speciation of the actinides have also been developed aiming the elucidation of the complex actinide sorption mechanisms.

Finally, this contribution also includes some recently obtained data concerning the interaction of actinides with todorokite (a naturally occurring microporous manganese-oxide of technological importance) and granitic micas (biotite) correlated with the nuclear waste disposal in geological formations.