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Regeneration of Cesium-Exhausted Activated Carbons by Microwave Irradiation

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Abstract : Cesium-137 (^{137}Cs) is a major radionuclide in spent nuclear fuel processing, and it represents the most important cause of contamination related to nuclear accidents. Cesium-137 has long-term radiological effects representing a major concern for the human health. Several physico-chemical methods have been proposed for ^{137}Cs removal from impacted water: ion-exchange, adsorption, chemical precipitation, membrane process, coagulation, and electrochemical. However, these methods can be limited by ionic selectivity and efficiency, or they present very restricted full-scale application due to equipment and chemical high costs. On the other hand, adsorption is considered a more cost-effective solution, and activated carbons (ACs) are known as a low-cost and effective adsorbent for a wide range of pollutants among which radionuclides. However, adsorption of Cs onto ACs has been investigated in very few and not exhaustive studies. In addition, exhausted activated carbons are generally discarded in landfill, that is not an eco-friendly and economic solution. Consequently, the regeneration of exhausted ACs must be considered a preferable choice. Several alternatives, including conventional thermal-, solvent-, biological- and electrochemical-regeneration, are available but are affected by several economic or environmental concerns. Microwave (MW) irradiation has been widely used in industrial and environmental applications and it has attracted many attentions to regenerating activated carbons. The growing interest in MW irradiation is based on the passive ability of the irradiated medium to convert a low power irradiation energy into a rapid and large temperature increase if the media presents good dielectric features. ACs are excellent MW-absorbers, with a high mechanical strength and a good resistance towards heating process. This work investigates the feasibility of MW irradiation for the regeneration of Cs-exhausted ACs. Adsorption batch experiments were carried out using commercially available granular activated carbon (GAC), then Cs-saturated AC samples were treated using a controllable bench-scale 2.45-GHz MW oven and investigating different adsorption-regeneration cycles. The regeneration efficiency (RE), weight loss percentage, and textural properties of the AC samples during the adsorption-regeneration cycles were also assessed. Main results demonstrated a relatively low adsorption capacity for Cs, although the feasibility of ACs was strictly linked to their dielectric nature, which allows a very efficient thermal regeneration by MW irradiation. The weight loss percentage was found less than 2%, and an increase in RE after three cycles was also observed. Furthermore, MW regeneration preserved the pore structure of the regenerated ACs. For a deeper exploration of the full-scale applicability of MW regeneration, further investigations on more adsorption-regeneration cycles or using fixed-bed columns are required.

Keywords : adsorption mechanisms, cesium, granular activated carbons, microwave regeneration
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