Removal of radioactive Cs with MXene fiber fabric by electrochemical method

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1. Introduction

The main fission product of U-235, Cs-137, is the most troublesome radionuclide in the event of a nuclear power plant accident due to its high solubility in water and its potassium-like biochemical behavior. Ion exchange materials such as zeolites are widely used for Cs removal, but they have slow Cs adsorption kinetics. Therefore, various nanocomposite materials such as prussian blue/alginate composite beads [1] or hexa-ferrocyanide/reduced graphene composites [2] have been developed. However, Cs sorption performance based on physico-chemical equilibrium has still sensitively changed by concentration, pH, or temperature. Recently, the ESIX (Electrochemical Switchable Ion Exchange) concept suggested overcoming the limitation of the physicochemical sorption mechanism. By applying voltage, ion diffusion, adsorption rate, and adsorption capacity can be improved [3].

MXene ($Ti_3C_2T_x$), a new 2D nanomaterial, has been widely researched in various fields such as electronics, energy, and environment due to its high specific area, plenty of functional groups, and high electrical conductivity [4]. Also MXene has showed excellent performance for selective Cs sorption [5]. However, MXene itself is a nanomaterial, which can cause secondary contamination due to difficulty in recovery after use. Therefore, it should be made in form of a suitable macro scale assembly for real applications. In this paper, we manufactured MXene as a fibrous form of assembly and introduced the ESIX concept to overcome the limitation of existing physico-chemical sorbents.

2. Methods and Results

2.1. Synthesis of MXene solution

MAX phase (Ti_3AlC_2), the precursor of MXene ($Ti_3C_2T_x$), has been synthesized by powder metallurgy methods. And then, MXene was synthesized from the MAX phase with in-situ HF etching methods[6]. After washing and concentrating by centrifugation, a high concentration of MXene solutions was prepared.

2.2 Fabrication of MXene-based Fabrics

MXene fiber fabrics were fabricated by wet-laid method. Firstly, staple MXene gel fibers were fabricated by injecting MXene solution doped on a syringe in a rotating coagulation bath containing salt-free coagulation agent. After filtering and drying, the staple fibers were re-dispersed in water/ethanol mixture to make semi-soluble state and collected on a metal screen mesh. During the drying process, the semi-soluble staple fibers were interfused and formed a fabric structure.

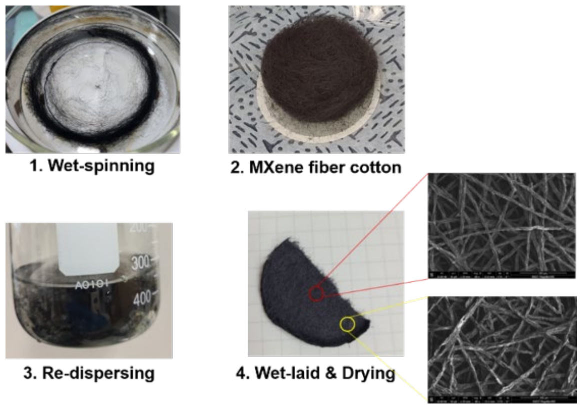

Fig1. Fabrication of MXene fiber fabrics and its microstructure

2.3. *Electrochemical sorption experiments*

The electrode cells were arranged in a flow-through type as shown in Fig. 3 [7]. Titanium mesh was used as a current collector, and the two MXene fiber faric electrodes were separated by a polypropylene membrane. The Cs contaminated water flows through the electrode cell by a peristaltic pump.

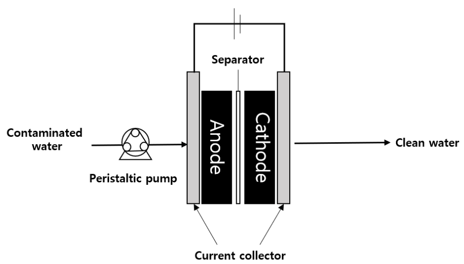

Fig 2. Flow-through type electrode cell configuration

3. Conclusion

To overcome the limitations of existing physico-chemical sorption processes, we designed an electrochemical sorption system that introduces the ESIX concept. As an electrode material, MXene fiber fabrics were manufactured. Currently, we are conducting electrochemical experiments, and its theoretical models will be presented in future work.

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