

Electrochemical Behaviors of Nickel Hexacyanoferrate-Graphene Oxide Nanocomposite for Cesium Ion Separation

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1. Introduction

Recently, environmental concerns related to nuclear power energy are one of the most important issues. After the Fukushima Daiichi nuclear power plant accident, the oceans and soils were severely contaminated with radionuclides including radioactive cesium (^{137}Cs). A great deal of efforts have been ongoing to remove the radionuclides [1]. Especially, the removal of ^{137}Cs from contaminated environments has become more highlighted since the Fukushima nuclear disaster [2]. In this study, we fabricated an electrode with nickel hexacyanoferrate-graphene oxide (NiPB-GO) nanocomposites and improved ion selectivity and long term stability for electrochemical cesium ion separation over a pristine NiPB electrode.

2. Experimental

2.7 g of $\text{Ni}(\text{OAc})_2 \cdot 4\text{H}_2\text{O}$ was dissolved in a mixture of 175 mL of H_2O and 25 mL of DMF. (Solution A). 4.8 g of $\text{Na}_4[\text{Fe}(\text{CN})_6 \cdot 10\text{H}_2\text{O}]$ and 7 g of NaCl were dissolved in 175 mL of H_2O (Solution B). Solution A was added dropwise to Solution B with stirring at room temperature. The precipitates were separated by centrifugation and then washed with MeOH. The greenish solid was dried in an oven at 60°C for overnight. Finally, nano sized NiPB was obtained.

9.6 mg of NiPB and 0.4 mg of GO (manufacture?) were suspended into a 0.01wt % poly vinyl alcohol aqueous solution. The mixture was irradiated by ultrasonic wave for 10 min. A NiPB-GO nanocomposite modified indium tin oxide (ITO) electrode (10×30 mm) was prepared by drop-casting the NiPB-GO nanocomposite solution (0.2 mL, 0.5 mg/mL). A NiPB-modified ITO electrode as a control was also prepared by the same method. All

electrochemical experiments were performed in a three-electrode system using a potentiostat/galvanostat: the NiPB-GO modified ITO Ag/AgCl, and platinum mesh electrodes were used as working, reference and counter electrodes respectively. The morphology of NiPB, NiPB-GO nanocomposite was observed using a field-emission scanning microscopy (FESEM: JEOL JSM-7000F). The X-ray diffraction patterns were obtained by Bruker D8 advance.

Table 1. Conditions of electrochemical experiment

| | |
|---------------------|--------------------------------------------------------------------|
| Working electrode | NiPBGO/ITO |
| Reference electrode | Ag/AgCl |
| Counter electrode | Platinum mesh |
| Potential window | 0 – 1 V |
| Scan rate | 5 mV/s |
| Electrolyte | 1 M LiNO_3 , 1M NaNO_3 , and 1 M CsNO_3 |

3. Results and Discussion

3.1 Confirmation of NiPB and NIPBGO

The NiPB-GO nanocomposite was characterized by Raman spectroscopy (Raman), powder X-ray diffraction (XRD), and scanning electron microscopy (SEM) analyses. In the NiPB-GO nanocomposite, two prominent D and G bands from GO were observed at 1321 and 1590 cm^{-1} , respectively. The XRD analysis of NiPB-GO shows peaks at $2\theta = 17.4, 24.6, 34.9, 38.4, 42.4, 49.1, 53.6,$ and 56.8° , which were indexed as the face-centered cubic structure of NiPB with a lattice of 10.28\AA . The morphologies of NiPB and NiPB-GO nanocomposite are observed by FESEM. NiPB shows an aggregated form of spherical shape with an average diameter of 18 nm

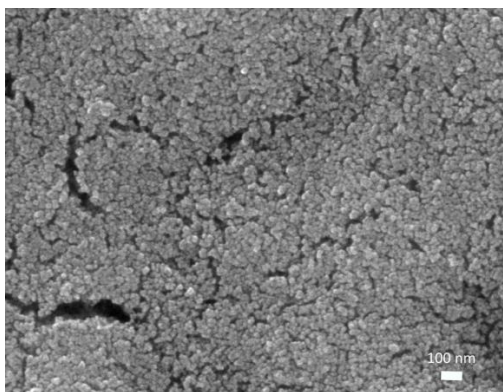


Fig. 1. SEM image of NiPB-GO on ITO electrode.

3.2 Electrochemical behaviors of NiPB and NiPBGO

The NiPB modified ITO electrode shows different redox peak potentials in various alkali metal electrolytes. However the intercalation onset potential of Cs^+ was very close to that of Na^+ . Fig. 2 shows the CVs of the NiPB-GO nanocomposite modified ITO electrode in 1 M CsNO_3 . The redox reaction peak potentials were well separated as observed with the NiPB modified electrode. The intercalation onset potential of Li^+ , Na^+ and Cs^+ in NiPB-GO nanocomposite appeared at 0.524, 0.611 and 0.711 V respectively. More positive potential of the intercalation onset of Cs^+ over the other alkali cations indicates that the NiPB-GO modified electrode improves the selectivity for Cs^+ compared to the pristine NiPB electrode [3].

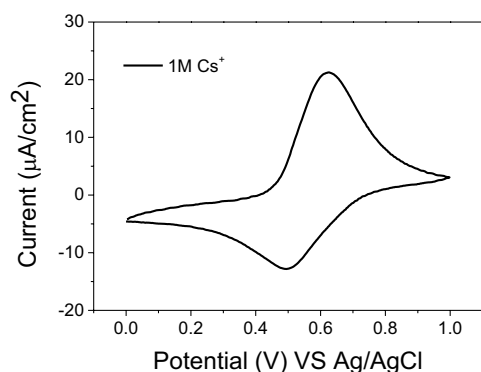


Fig. 2. Cyclic voltammograms of and NiPB-GO in in 1 M CsNO_3 electrolyte solution at a scan rate of $5 \text{ mV}\cdot\text{s}^{-1}$.

4. Conclusion

The NiPB-GO nanocomposite has been prepared via a facile process in order to address current severe drawbacks of prussian blue and to efficiently separate the cesium by using electrochemical method.

The electrochemical properties of the NiPB-GO nanocomposite for Cs ion-exchange were evaluated in the present study. The NiPB-GO nanocomposite shows an excellent selectivity for Cs^+ over other alkali metals. Therefore, we expect that the NiPB-GO nanocomposite is effectively removal of Cs ion in aqueous environments.

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