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Studies on the Electrochemical Characteristics of K_2FeO_4 Electrode

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Abstract: Discharge performance of K_2FeO_4 electrode under different conditions was studied by the constant electric current discharge method. The electrochemical characteristics of K_2FeO_4 electrode were investigated for the first time by means of cyclic voltammetry. The results show that the K_2FeO_4 electrode made at moderate pressure (20 MPa) and discharged at lower current has better discharge performance. It is also found that K_2FeO_4 electrode is significantly rechargeable.

Keywords: K_2FeO_4 electrode, electrochemical performance, cyclic voltammetry.

The Fe (VI) species have been known for more than a century. Potassium ferrate (K_2FeO_4) is the best known member among the family of iron (VI) derivatives. It is prepared and purified more easily, and it is also used in synthesizing other ferrates such as $BaFeO_4$ and $SrFeO_4$, *etc*. The strong oxidizing nature of Fe (VI) has been suggested in the use of purifying water and the oxidative preparation of a variety of organic compounds in the past decades[1-5]. As generalized in ***Eq.* (1)**, Fe (VI) undergoes a three-electron reduction at favorable potentials. In addition, the rechargeable performance, abundant starting materials and the relatively environmentally benign discharge product (Fe_2O_3)[6] of Fe(VI) make it a promising battery material. Licht *et al* have prepared super-iron cells by opening alkaline button cells and replacing the cathode with K_2FeO_4, *etc*. and the performance of these cells have been preliminarily studied[6-10]. In this paper, the electrochemical performance of K_2FeO_4 electrode under different conditions is investigated.

$$FeO_4^{2-} + 5/2H_2O + 3e^- \rightarrow 1/2Fe_2O_3 + 5OH^- \qquad (1)$$

$$E=0.5 \text{ to } 0.65 \text{ V } vs. \text{ SHE}$$

Experimental

K_2FeO_4 was prepared according to reference [1]. Electrochemical measurements were carried out in a classical three-electrode glass cell. The working electrode was K_2FeO_4

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electrode (K_2FeO_4 and 30% graphite was pressed on silver lattice under a certain pressure). The counter electrode was a platinum foil, the reference electrode was a Hg/HgO electrode. Saturated KOH solution was used as electrolyte. The measurement system consisted of a model 273 potentiostat, a microcomputer and the M352 software. The CV plots were obtained in the scanning range from –0.2 V to 0.6 V with a scan rate of 10 mV/s. All measurements were taken at room temperature. All solutions were prepared by analytical reagents and deionized water.

Results and Discussion

The effects of the pressure of preparing K_2FeO_4 electrodes on the electrode discharge performance are interpreted in **Figure 1**. The experimental result shows that the electrode made at moderate pressure (20 MPa) has better discharge performance than those made at relatively low or high pressures. The increase of the preparing pressure is advantageous to lowering the ohm resistance of the electrode by improving the contact resistance between the grains of graphite and K_2FeO_4, however, too high pressure can increase the electrode polarization by blocking the diffusion of the electrolyte within electrode. This is the reason why K_2FeO_4 electrode made at 20 MPa has higher discharge potential and larger discharge capacity. In the following experiments all K_2FeO_4 electrodes are prepared under the pressure of 20 MPa.

Figure 1 Discharge curves of K_2FeO_4 electrodes prepared under different pressure at 1.5 mA

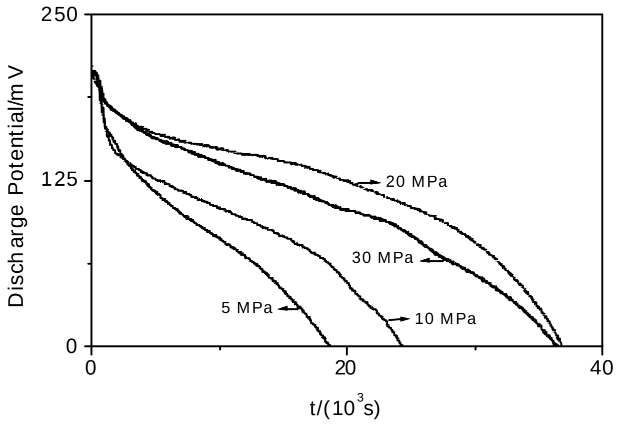


Figure 2 displays the discharge curves of K_2FeO_4 electrodes at different currents. The respective discharge efficiencies of K_2FeO_4 electrodes at different discharge currents are listed in **Table 1**. It can be seen that the electrode discharged at smaller current shows more positive discharge potential, larger electrochemical capacity and higher discharge efficiency. In general, the electrode polarization lowers with the decrease of discharge current, which leads to better electrochemical performance of the electrode with smaller discharge current.

Figure 2 Discharge curves of K_2FeO_4 electrode at different currents

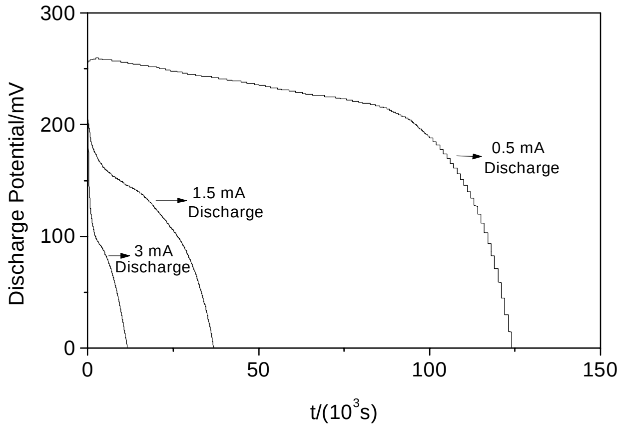


Table 1 Discharge efficiencies of K_2FeO_4 electrode at different currents

Discharge current (mA)	0.5	1.5	3
Discharge efficiency (%)	66.4%	45.8%	27.1%

Figure 3 First CV of a K_2FeO_4 electrode in a solution of saturated KOH with scan rate of 10 mV/s

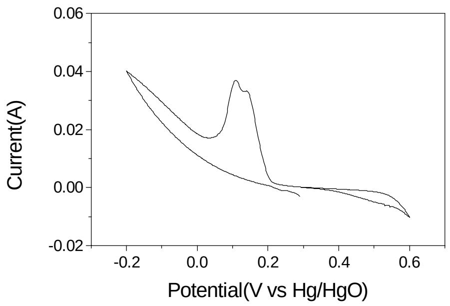
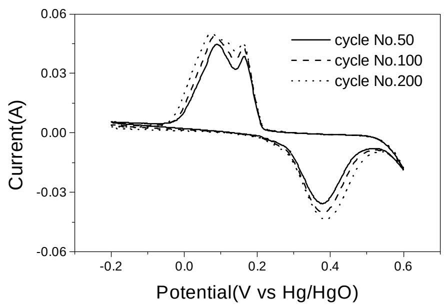


Figure 4 The 50th, 100th and 200th CV of a K_2FeO_4 electrode in a solution of saturated KOH with scan rate of 10 mV/s



The above experimental results indicate that K_2FeO_4 electrodes have better discharge performance. To obtain a thorough understanding of the electrochemical performance of K_2FeO_4 electrodes, cyclic voltammentry tests have been carried out. No oxidation peak is found on the first time CV of the K_2FeO_4 electrode (see **Figure 3**), which shows that no reductive ions such as Fe (III) ion *etc.* exist in the active material. However, two reduction peaks appear on the CV plot, which indicates that the electrode reaction may involve two electron transfer steps, that is, the reactive intermediate Fe (IV) or Fe (V) might exist. The CV plots of the K_2FeO_4 electrode at cycles No. 50, 100 and

200 are displayed in **Figure 4**. One oxidation peak and two reduction peaks appear on these CV plots, which reveals that the reaction mechanisms of anode and cathode processes may be different. The experimental results in **Figure 4** also show that the K_2FeO_4 electrode is significantly rechargeable and has better electrochemical cycling performance.

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