Support information

A novel rechargeable Li-AgO battery with hybrid electrolyte

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Experimental

Material synthesis

AgO was prepared by a chemical oxidation method: 0.015 mol Na\textsubscript{2}S\textsubscript{2}O\textsubscript{8} and 0.030 mol NaOH were dissolved in deionized water. The mixture solution was added drop by drop to another solution contained 0.005 mol AgNO\textsubscript{3} under vigorous stirring at 60 °C. A dark suspension was obtained and kept on stirring for another 30 min at the same temperature after the addition of Na\textsubscript{2}S\textsubscript{2}O\textsubscript{8}. Then the formed precipitate was filtrated and washed by deionized water for several times. The washed precipitate was dried at 60 °C for 12 h under vacuum environment to get the final AgO sample used for further research.

Characterizations

The phase structure of the prepared AgO sample was analyzed using a Bruker D8 Advance X-Ray Diffractometer (XRD) with CuKa radiation. The morphology of AgO was examined using scanning electronic microscope (SEM) on a JSM-6700F instrument. Thermogravimetry-Differential thermal analysis (TG-DTA) was conducted on a MTC1000 thermal analysis system interfaced to a 2000S TG module. Samples were run in aluminum boats over a temperature range of 25–600 °C with a heating rate of 5 °C/min in a flowing atmosphere (100 ml/min) of dry nitrogen.

Electrochemical measurement

The cathode electrode was prepared by mixing of AgO sample, acetylene black, and polytetrafluoroethylene (PTFE) in an agate mortar in a weight ratio of 80%: 15% : 5%. The above
mixture was pressed onto a titanium grid (100 mesh) which served as the current collector. The mass load of cathode electrode was about 5 mg/cm$^2$; excessive amount of Li metal was used in the anode. A rudimental Li-AgO battery with a cell structure shown below was assembled by using 1 M LiClO$_4$ in ethyl carbonate (EC)/diethyl carbonate (DEC) (EC/DEC = 1 : 1 in volume) as the organic electrolyte for Li anode and an aqueous solution contained 1 M LiOH and 1 M KOH as the electrolyte for AgO cathode.

![Schematic cell structure of the rudimental Li-AgO battery](image)

The two electrolytes were separated by a water-stable superionic conductor glass ceramic film (LISICON, Li$_{1-x+y}$Al$_x$Ti$_{2-x}$Si$_y$P$_{3-y}$O$_{12}$) with a thickness of 0.15 mm. It should be noted that only lithium ions can pass across the LISICON film during charge/discharge processes. The LISICON film was provided by Ohara Inc., Japan and its conductivity was about $10^{-4}$ Scm$^{-1}$ at ambient temperature. All the electrochemical tests were performed on a Solartron Instrument Model 1287 & 1255 controlled by a computer. For galvanostatic charge/discharge tests, the cell was discharged to a voltage end of 2.7 V and charged to a constant capacity of 455 mAh/g (105% of the theoretical capacity of AgO). All the capacities were calculated based on the weight of active AgO in cathode electrode except otherwise specified.
The TG-DTA curve demonstrated a two-stage weight loss curve in which the first weight loss was detected in the range of 130 ~ 200 °C, which can attribute to the decomposition of AgO to Ag₂O. The second weight loss was detected in the range of 400 °C ~ 450 °C, which can attribute to the decomposition of Ag₂O to Ag. The occurred reactions during the TG thermal process can be described as following:

\[ 4 \text{AgO} = 2\text{Ag}_2\text{O} + \text{O}_2 \] \hspace{1cm} (S1)

\[ 2 \text{Ag}_2\text{O} = 4\text{Ag} + \text{O}_2 \] \hspace{1cm} (S2)

Correspondingly, the DTA curve exhibits two endothermic peaks centered at 175 °C and 444 °C, respectively. If assuming that pure AgO is tested, \( W_1 \) and \( W_2 \) are the remaining weight fractions after reaction (S1) and reactions (S1) + (S2), respectively. Then \( W_1 \) and \( W_2 \) could be calculated as 93.5% and 87.0%, respectively. According to the above TG curve, the detected \( W_1 \) and \( W_2 \) were 93.3% and 86.8%, very close to the theoretical values, which confirmed the high purity of the synthesized AgO sample.
**Fig. S2** CV plot of AgO electrode at a scan rate of 0.1 mV/s in aqueous solution containing 1 M KOH and 1 M LiOH, the test was conducted using a three-electrode system in which AgO electrode served as the work electrode, SCE served as the reference electrode and Ti grid served as the counter electrode.

**Fig. S3** Cycle performance of the rudimental Li-AgO cell at a constant charge/discharge current of 0.5 A/g.