Synthesis and characterization of vanadium oxide nanotube electrode material for electrochemical capacitors

Yiying Wei[1,2], Guoxiu Wang[1], Jianguo Zhu[2]
1. Centre for Clean Energy Technology, University of Technology Sydney
2. Centre for Electrical Machines and Power Electronics University of Technology Sydney
Broadway, NSW 2007, Australia

1. Introduction

Among broadly available transition metal oxides, vanadium oxide is one of the most promising ion insertion materials for pseudocapacitor[1]. In this paper, we report a different, effective hydrothermal method to fabricate vanadium oxide nanotube which can utilize the electrolyte effectively for supercapacitor electrode.

2. Experimental

2.1. Material preparation

Vanadium oxide nanotube was synthesized by hydrothermal treatment with high-speed stirring. The preparation involved dissolution of V2O5 into H2O2 and high-speed stirring (10000r/min) with hexadecylamine. Then the solution was transferred to a Teflon-lined autoclave and kept at 180℃ for 6 days.

2.2. Material characterization

X-ray diffraction (XRD, Siemens D5000), field emission scanning electron microscope (Zeiss Supra 55VP), transmission electron microscope (TEM, JEOL JEM-2011), and thermogravimetric analysis (TA TGA/DSC) were conducted for the prepared material.

2.3. Electrochemical analysis

The electrode consists of 80 wt% prepared materials, 15 wt% acetylene carbon black and 5 wt% polyvinylidene difluoride (PVDF) in the presence of N-methyl pyrrolidinone (NMP) for three-electrode cell test.

3. Results and discussion

3.1. XRD and TGA

In the inset figure of Fig. 1a , the first 00l peak at around 2.8 degree indicated a basal distance d00l=3.2nm which means the long chain alkylamines have intercalated into the vanadium oxide layers. The TGA shows that the decomposition of the template mainly occurred at 150℃ to 350℃ leading to a weight loss of 44.2%.

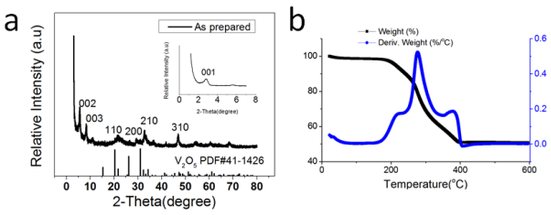

Figure1. (a) XRD pattern and (b) TGA curve of the as-prepared vanadium oxide nanotube

3.2. SEM and TEM

SEM and TEM images (Fig. 2) clearly show uniform vanadium oxide nanotube has 5 micrometers to several tens of micrometers. And it has open-ended cylindrical shape of tube which is also confirmed by the TEM image in Fig. 2c.

4. Electrochemical analysis

The CV curve shows a nearly rectangular shape which means it has good conductivity and good charge propagation within the electrodes[2]. As shown in Fig.3a, three pairs of obvious oxidation/reduction peaks were observed in 2M KCl. In LiCl, it also has three pairs of oxidation/reduction peaks as shown in Fig.3b. However, it obviously has degraded CV rectangle shape and less conductivity than that of electrode in 2M KCl. In 2M NaCl electrolyte, the material shows different CV curves sharp.

A capacitance of 297F/g was obtained at a scan rate of 2mV/s in 2M KCl, and it still maintained a high capacitance of 210F/g at a higher scan rate of 50mV/s. Even though the materials achieved the highest capacitance of 304F/g in 2M LiCl at the scan rate of 2mV/s, the specific capacitance degraded significantly as the increase of the scan rate.

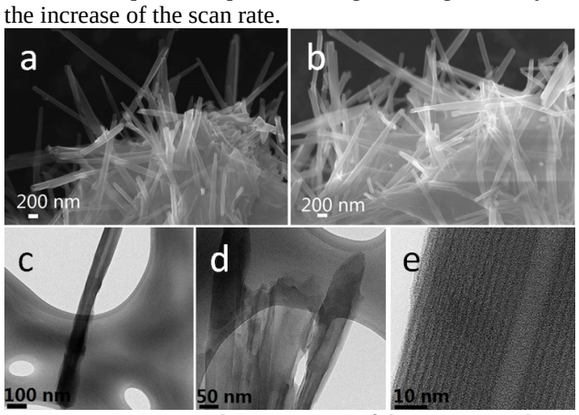

Figure2. SEM and TEM image of the as-prepared vanadium oxide nanotube

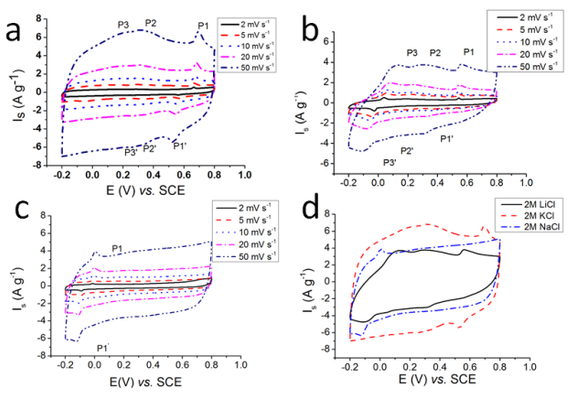

Figure3. CV curve of the material in (a)2M KCl, (b) 2M LiCl and (c) 2M NaCl

	2M KCL	2M LiCl	2M NaCl
2mV/s	297.84 F/g	304.11 F/g	275 F/g
5mV/s	275.87 F/g	253.65 F/g	220.36 F/g
10mV/s	253.58 F/g	150.87 F/g	198.19 F/g
20mV/s	235.42 F/g	127.59 F/g	167.68 F/g
50mV/s	210.63 F/g	105.71 F/g	140.93 F/g

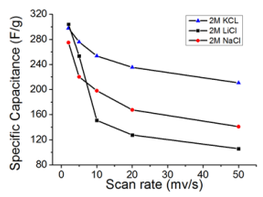

Table1. Specific capacitance in 2M KCl, 2M LiCl and 2M NaCl

5. Conclusion

The materials show a nearly rectangular shape of CV curve which means it has good conductivity and good charge propagation within the electrodes. The higher specific capacitance of the prepared vanadium oxide nanotube compared with the reported materials can be explained in term of the nanotube structure and the redox property of the fabricated material.

6. Reference:

1.Boukhalfa, S.; Evanoff, K.; Yushin, G. *Energy & Environmental Science*, 5, 6872(**2012**).
2.Stoller, M. D.; Park, S.; Zhu, Y.; An, J.; Ruoff, R. S. *Nano Letters*, 8,3498(**2008**).