ZEOLITE TEMPLATE CARBON MATERIALS: PREPARATION AND APPLICATION AS SUPERCAPACITOR

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INTRODUCTION

Nanostructured carbon materials continuously receive an increased interest for both environmental and energy application. Among carbon materials, zeolite template carbon (ZTC) are proving out to show unique properties due to well-defined molecular-scale structure that offers high surface area usable for several applications, such as gas storage (e.g. hydrogen), energy storage, and catalysis[1]. Several methods have been reported for the synthesis of tailored ZTC showing the effect of zeolite scaffold, carbon precursors and synthesis conditions on physicochemical properties of final material. Y zeolite is the most used scaffold for ZTC synthesis adopting a two-step process consisting of (i) filling of zeolite pore with furfuryl alcohol followed by (ii) carbon vapor deposition (CVD) of ethylene at about 700-800 °C. Other zeolites, such as mordenite and ZSM-5 are not able to lead to the formation of ZTC, whilst high ordered porous carbons may be obtained via direct CVD of ethylene over beta zeolite [1]. The high specific area and the good conducibility of ZTC make them suitable for the realization of electrodes for supercapacitors. Supercapacitors store energy in the electric field of the electrochemical double-layer, and have attracted considerable attention in recent years because they can provide higher power density than batteries and higher energy density than conventional dielectric capacitors [2]. The pores size of ZTC presents an ideal distribution between micropores and mesopores that joined to the interconnected channel structure, improves the storage and the diffusion of the ions [3].In this work, zeolite templated carbons were synthesised via direct CVD of ethylene by using a home-made beta zeolite and the obtained materials were used in electrochemical tests.

EXPERIMENTAL

Beta zeolite with a Si/Al=25 wassynthesised via hydrothermal crystallization using tetraethyl ammonium as structure directing agent using the following gel synthesis molar composition:

$$0.10\ Na_2O - 0.2\ TEAOH - 1\ SiO_2 - 0.02\ Al_2O_3 - 10\ H_2O$$

The crystallization was carried out for six days in a static oven kept at 150 °C. About 1.5 g of zeolite template (Na-beta) was placed in a fused quartz reactor and heated at 700 °C (heating rate, 10 °C/min) under nitrogen flow. Afterwards, a mixture of ethylene and nitrogen was feed to the reactor for 4 hours. The obtained carbon/zeolite solid was washed with hydrofluoric and chloride acids with the aim to remove zeolite and impurities from the carbon. The resulting materials were studied by N2 adsorption isotherms, transmission electron microscopy (TEM), scanning electron microscopy (SEM) and X-ray photoemission spectroscopy (XPS). Electrochemical tests were carried out on CR2032-type coin cells fabricated in an argon-filled glove box. A slurry was prepared by mixing 80 wt % ZTC, 10 wt % Super P carbon black and 10wt% polyvinylidene fluoride with DMF. The cathode was prepared by coating the slurry onto an aluminium foil with a Dr. Blade, while the anode was a disc of metallic lithium. The electrolyte consisted of 1 M LiPF6 in a mixture of ethylene carbonate and ethyl methyl carbonate (50:50 vol %). Celgard 2400 was used as separator.

RESULTS AND DISCUSSION

The obtained ZTCs show a B.E.T. surface area of about 2800 m^2/g with a micropore volume up to 70 % of total volume with pore openings around 1 nm. The performance of the asymmetric supercapacitor was tested by cyclic voltammetry (CV) (shown in Figure 1) and electrochemical impedance spectroscopy (EIS). The device exhibited a specific capacitance of 78 Fig -1 and an excellent cycling stability.

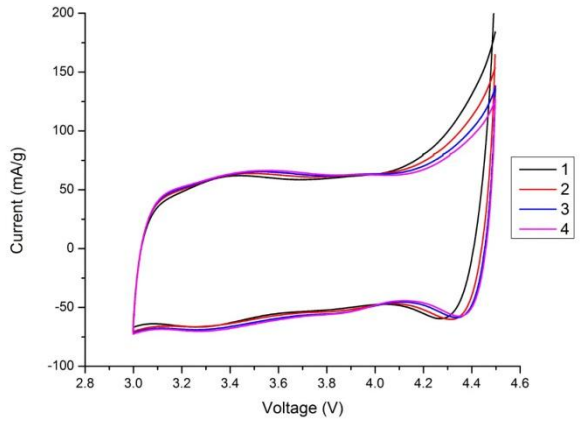

Figure 1. Current vs. Voltage curve at a scan rate of 1.0 mV/s.

CONCLUSION

In this work, the synthesis of ZTC via direct carbon vapour deposition of ethylene over home-made beta zeolite is carried out and discussed. The obtained materials show high surface area and a good crystallinity. Electrochemical tests suggest that such materials may be used in super capacitors. Actually, we are studying the effect of post-synthesis treatment on physicochemical properties of beta-ZTC materials.

REFERENCES

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