Abstract

Glucosamine is a nitrogen-containing (N-doped) carbon source which is synthesized via hydrothermal method. After HTC process, the hydrochar is characterized by X-ray diffraction (XRD). Further carbonization is performed at two different temperatures 750 (GA-750) and 1000°C (GA-1000) and calcination temperature effect is investigated. Surface morphologies of the obtained carbonaceous materials are characterized by Scanning Electron Microscopy (SEM). Calcinated sample was mixed with ketjen black carbon and PVDF binder so as to obtain a slurry. This slurry is coated on graphite electrode and used as anode material for aqueous electrolyte battery. Carbonaceous material calcinated at 750°C (GA-750) performs better capacity than GA-1000 as 50 F/g and 10 F/g, respectively.

2. Experimental

Glucosamine was used to synthesize carbonaceous anode material via HTC under mild temperature (180°C) and short time (20h). After HTC process the sample was washed with pure water and ethanol, separately, by using soxhlet extraction method shown in Figure 1. Washed sample was dried in oven at 80°C over a night.

Figure 1. Soxhlet extraction setup for glucosamine.

Moreover, electrochemical performances of electrodes, both anode and cathode, can be improved by using some types of binders which are poly (vinylidene difluoride) (PVDF), carboxymethyl cellulose (CMC), styrene butadiene (SBR) etc [13, 14].

Organic electrolytes (ethylene carbonate, methylene carbonate, dimethyl carbonate, etc.) which have high voltage stability could be used in Na-ion batteries as in Li-ion batteries. However, they are not only toxic and flammable but also expensive electrolytes. Aqueous electrolyte would be good alternative to organics, since it is abundant, cheap and higher ionic conductivity (more than 10 times) [15]. Thermodynamic stability of aqueous electrolytes is the biggest disadvantages because it results low energy density. Theoretically, aqueous electrolytes are not stable thermodynamically over 1.23 V, it was increased up to 2.0-2.15 V in practically [16]. In this study, carbonaceous material was prepared from glucosamine via hydrothermal carbonization method in order to investigate electrochemical performance for aqueous electrolyte battery.
and 1000°C) under N₂ atmosphere for 6h to improve structural order. The product materials (GA-750 and GA-1000) firstly mortared then were mixed with Polyvinylidene fluoride (PVDF) binder and Ketjen black carbon in a suitable ratio to prepare the slurry in order to improve electrochemical performance of the active mass. The overall procedure steps were given in Figure 2.

2.1. Electrochemical Measurement

The electrochemical performances after ethanol washing were performed by galvanostatic test in aqueous electrolyte half-cell system. Saturated calomel electrode (SCE) and graphite sheet were used for reference and counter electrodes, respectively. 1M Na₂SO₄ was used as an electrolyte. Current density and voltage window are 1C and 0-0.8 V, respectively.

3. Result and Discussion

Carbonaceous anode material derived from glucosamine was firstly characterized by XRD which is given in Figure 2. XRD pattern shows broad carbon peak around 24 °C. The distinct peak at 30 °C in Figure 3, which is washed with pure water, was disappeared when it was washed with ethanol via soxhlet extraction method. By doing this, impurity was purified, thereby electrochemical measurement were maintained with the sample washed with ethanol via soxhlet extraction method. Figure 4, displays the SEM images of the as synthesized N-doped hydrothermal carbons derived from glucosamine. As can be seen, micron size granules have been obtained by assembling smaller size particles formed after the nucleation of the glucosamine during hydrothermal carbonization process.

Electrochemical measurements of N-doped carbonaceous anode material derived from glucosamine, which is calcinated at 750 and 1000°C, is given in Figures 5 and 6, respectively. Up to 400 cycles around 40 F/g have been obtained which was then reached to 50 F/g presumably after wetting the particles by aqueous electrolyte.
In Figure 5, shows that GA-1000 electrochemical capacitance is less than GA-750 capacitance. The calcination temperature 1000 °C may influence the carbon ordered structure, thus Na intercalation might not be happen properly leading a very low capacitance of 10 F/g.

Electrochemical performance of glucosamine as aqueous electrolyte anode was moderately law. In our similar study, chitosan was also hydrothermally synthesized and passed through same procedures. It had better capacitance as 160 F/g and it was stable for 800 cycles which is the subject of another study. This result can be considered successful for carbons synthesized via HTC method.

4. Conclusion

In summary, carbonaceous materials were synthesized via hydrothermal carbonization which is simple, low cost and effective method. Then, the hydrochar calcinated at two different further temperatures and effect of calcination temperature on electrochemical performance of aqueous electrolyte glucosamine anode was investigated.

Calcination temperature increased from 750 °C to 1000 °C resulted much order carbon structure, as a result of this the capacitance decreased from 50 F/g to 10 F/g.

Acknowledgements

Financial support from TUBITAK 1001 Project (project no: 114Z920) was acknowledged.

References
