Preparation of Highly Porous Carbon from Resins after the Treatment of Wastewater Containing Heavy Metal Ions for Supercapacitors

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The most commonly used electrode materials for supercapacitors are carbon, including porous activated carbon, carbon aerogels, carbon nanotubes , carbon nanofibres, graphenes and so on.[1] Owing to their high specific surface area, low cost and easy processing ability, porous activated carbon has attracted much attention compared to other carbon materials.[2]Heavy metals are widely employed in many industrial applications, such as chemical manufacturing, electroplating, mining, nuclear and other industries. These procedures have been producing a large amount of waste solution containing heavy metals ions which are toxic and pollutants of the environment.[3,4] Considering the deleterious impact of heavy metal ions on ecosystem and public health, it is highly desirable to find a low-cost and green alternative technology to treat those industrial wastewater containing heavy metal ions before they are released to the river. Ion exchange by resins is one of the most rapid, cheap, and effective techniques that demand less skill than others.[5] In addition, the process is quite eco-friendly because the adsorbed heavy metals can be collected by a simple treatment and the resins can be easily recycled by acid washing while producing no new pollutants. Here we reported a novel method to prepare highly graphitized porous carbon for supercapacitors in combination with removal of heavy metal ions from wastewater.

We have proposed a facile strategy to produce energy materials in combination with industrial pollutant treatment. A commercial ion exchange resin (styrene, macroporous) D001 was used to remove $M_2O_7^{2-}$(M=Cr, Mo, W) from industrial wastewater, respectively, which were then carbonized to prepare porous carbon possessing very high graphitic degree and large specific surface area. During the carbonization process, the absorbed $M_2O_7^{2-}$ played a role as templates to form a highly porous structure as well as catalyst to promote the graphitization of carbon at moderate temperature. The adsorption content of $M_2O_7^{2-}$ in the resins after three cycles of treatment was estimated to be around 1.05 mmol/g. It indicates that the $M_2O_7^{2-}$ pollutant was almost removed after successively adsorbed by D001 for three cycles (6 h per cycle). The specific surface areas of the produced carbon materials were measured using the Brunauer–Emmett–Teller (BET), The specific surface area of the Cr-treated sample is about 2116.3 $m^2 g^{-1}$, and both the N_2 adsorption–desorption isotherm and TEM suggest that the produced carbon materials owing highly mesoporous structure. The Raman spectroscopy and HRTEM both show produced carbon materials possessing very high graphite degree. Symmetric supercapacitors based on this porous carbon exhibited superior electrochemical performance with a good combination of high specific capacitance (122.5 F g^{-1} at the current density of 1 A g^{-1}), stable cycling, and particularly remarkable high rate capability (with a remaining capacitance of >100 F g^{-1} at 10 A g^{-1}). The method presented here provides an excellent platform taking advantage of environment protection and developing sustainable energy materials as well.

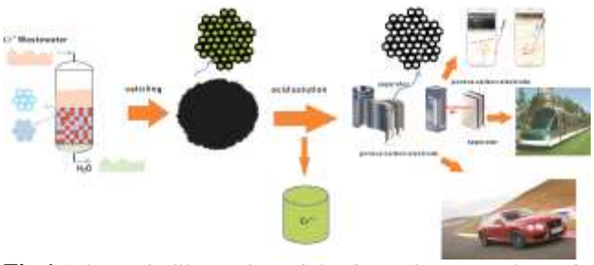

Fig.1 Schematic illustration of the formation procedure of the Cr-treated sample with highly graphitized porous structure.

References

(1) Arunabha Ghosh et al., *ChemSusChem*, 2012, **5**, 480-499.
(2) Yingying Lv et al., *J. Mater.Chem*, 2012, **22**, 93-99.
(3) Cristina Quintelas et al., *Chem. Eng. J,* 2009, **149**, 319-324.
(4) P. L. Smedle et al., *Appl. Geochem.* 2013, doi:org/10.1016/ j.apgeochem.2013.03.014.
(5) Syed Mustafa et al., *Air. Soil. Poll*, 2010, **210**, 43-50.

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