Short Communication

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# Microstructure Engineering Towards Porous Carbon Materials

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## Abstract

For desired energy storage and conversion applications, microstructure regulation is crucial for carbon-based materials. In this, we report the microstructure designing towards permeable carbon materials from a similar forerunner empowering numerous energy stockpiling applications. One biomass waste of peanut dregs can yield graphene-like carbon materials (GLCMs) and highly disordered carbon materials (HDCMs). The as-resulted HDCMs have a high hydrogen uptake of 3.03%, a high specific capacitance of 449 F g1 at a current density of 0.5 A g1, outstanding rate capability, and remarkable cycling performance due to their disordered structure, ultrahigh surface area, and relative small pore size. Due to their high graphitization, lamellar structure, and predominant mesoporosity, the resulting GLCMs have a reversible capacity of 731 mAh g-1 at a current density of 100 mA g-1 and excellent cycling stability as anode materials for LIBs. Based on these findings, it can be concluded that this method of microstructural engineering is both effective and promising for the design of porous carbon materials and their controllable preparation for a variety of desirable energy storage applications.

**Keywords: Carbon materials • Graphitization**

## Introduction

Consumption of fossil fuels and pollution are unavoidable issues in the not-too-distant future because of the rapid expansion of the global economy and the growing human population. As a result, in order to meet the demands of portable electronic devices and hybrid electric vehicles, there has been an ever-increasing and pressing need for the energetic development of not only abundant, pollution-free, and carbon-free energy sources (hydrogen, solar, and wind energy), but also equipment for high-performance, cost-effective, safe, and environmentally friendly energy conversion and storage. Because of its high combustion value, carbon-free emission, and abundance, hydrogen as an energy source has been extensively studied. Yet, the incredible deterrent of gigantic execution for hydrogen as a fuel is the profoundly proficient capacity. Supercapacitors and lithium-ion batteries (LIBs) are two examples of energy storage devices that have been widely used in a variety of fields in recent decades. However, LIBs and supercapacitors continue to have a number of drawbacks. Low power density, poor rate performance, and unsatisfactory cycling stability plagued the LIBs. The energy density of the supercapacitors is low, particularly the energy density of commercial supercapacitors, which is limited to less than 5 Wh/kg. As a result, developing cutting-edge materials with high hydrogen uptake and excellent electrochemical performance for LIBs and supercapacitors is very appealing [1-5].

## Discussion

Permeable carbon-based materials are planned materials for hydrogen capacity, LIBs, and supercapacitors, attributable to the minimal expense, high unambiguous surface region (SSA), incredible electrical conductivities, and reasonable pore size appropriation. Numerous efforts have been made to reveal the effect of the SSA and pore size distribution in supercapacitors in order to enhance their electrochemical performance and hydrogen storage. It has been demonstrated that SSA plays a significant role in enhancing supercapacitor specific capacitance and hydrogen storage. However, because the specific capacitance or hydrogen uptake of porous carbons is not inversely proportional to the SSA, the effect of SSA on performance will gradually

decrease at higher SSA values (>2000 m2 g1) 5. Then again, it is likewise demonstrated that the pore size conveyance plays a crucial part on hydrogen take-up and supercapacitors. The nano-pores with size under 1 nm have been shown to be proficient for hydrogen take-up, particularly the pores size from 0.5 to 0.7 nm are wanted to hydrogen capacity at 77 K due to the cross-over of likely fields from each pore walls. Additionally, it has been reported that pores between 2 and 3 nm can enhance hydrogen uptake at high pressure. In a similar vein, an abnormal rise in carbon capacitance has been demonstrated at pore sizes below 1 nm, which hinder the rapid movement of electrolyte ions and increase desolation process resistance. In contrast to micropores, where electrolyte ion diffusion can occur more quickly, mesopores can store more ions and have a better rate capability. The commercial graphite anode has a low rate capability and a low theoretical capacity for LIBs (372 mAh g1). The presence of mesopores and a high degree of graphitization are said to facilitate rapid ion transfer and increased ion intercalation in order to achieve high energy storage and rate performance. To achieve high hydrogen and electrochemical energy storage (supercapacitors and LIBs), porous carbon materials must have a reasonable SSA design, pore size distribution, graphitization degree, or heteroatom content. Porous carbon materials derived from the same precursor using the same method for multiple desired applications are rare, however, due to the different requirements of carbon-based materials for various energy storage applications. We report the microstructure designing towards carbon materials understanding different wanted energy capacity applications. One biowaste of peanut dregs yields graphene-like carbon materials (GLCMs) and highly disordered carbon materials (HDCMs). The HDCMs can be used in hydrogen uptake and high-performance supercapacitors, while the GLCMs can be used as LIB anode materials.

The controllable preparation of porous carbon materials derived from a single precursor for a variety of energy storage applications is made possible by the microstructure engineering approach described in this paper. Nut residue, one result from eatable oil handling, was utilized as a financially savvy and effectively accessible forerunner to create exceptionally cluttered carbon materials (HDCMs) and graphene-like carbon materials (GLCMs). The peanut dregs, in contrast to the peanut's outer and inner shells, are abundant in proteins, carbohydrates, and lipids. The high specific surface area, abundant micropores, highly disordered structure, and specific nitrogen doping of the as-prepared HDCMs make it possible for HDCMs to perform better in hydrogen uptake and supercapacitors. The high degree of graphitization, lamellar structure, and dominant mesopores of the resulting GLCMs help LIBs' electrochemical performance. As electrode materials for supercapacitors, the assembled HDCMs-based supercapacitor possesses the high energy and power density (19.9 Wh kg1 at 4240 W kg1) and superior cycling performance in $Na_2SO_4$ electrolyte. The as-prepared HDCMs obtained at a temperature of 700°C exhibit a high hydrogen uptake of 3.03% in one bar at 77 K. When evaluated as anode materials for LIBs, the 900°C-prepared GLCMs also have a reversible capacity of 731 mAh g-1 and excellent cycling stability. Based on these findings, microstructural engineering can be used to precisely prepare porous carbon materials for a variety of energy applications [6-10].

## Conclusion

As shown schematically in Scheme 1, simple carbonization and chemical activation at different temperatures were used to prepare microstructure engineering for the controllable preparation of porous carbon. As a carbon precursor, peanut dregs, a byproduct of the edible oil refining process, were utilized. HDCMs have a structure that is extremely disordered, have a narrow distribution of pore sizes, and exhibit a low graphitization degree at low temperatures. In conclusion, a variety of energy storage applications can be served by porous carbon materials made from peanut dregs that have a tunable microstructure and an extremely high specific surface area. High hydrogen uptake and excellent supercapacitive performance are made possible by the extremely high specific surface area and highly disordered structure of the HDCMs that were produced as a result.

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