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Objectives

Lithium-ion batteries (LIBs) are used in various applications due to their high energy density, lightweight, and good charge-discharge efficiency. The commonly used anode material in LIBs is graphite. However, graphite has a low specific capacity of only 372 mAh g⁻¹, which still needs further development. One of the materials that has gained attention as an anode for LIBs is porous carbon. Its high specific surface area offers higher specific capacity and better electrochemical performance. Therefore, this research aims to synthesize porous carbon from agricultural waste garlic peels. Their thin physical characteristics could facilitate pore formation more easily. The porous carbon was prepared simply, rapidly, and at low cost using a microwave technique with potassium hydroxide as the pore activator. Physical characterization, including X-ray diffraction (XRD), scanning electron microscopy (SEM), and surface area analysis, showed that the material was amorphous carbon and the resulting pores were mostly mesopores which help increase the surface area up to 718.96 m²/g. The electrochemical performance tests showed that the material had a specific capacity up to 588.77 mAh g⁻¹ at 100 mA/g after 150 cycles, which was higher than the theoretical capacity of graphite, making it suitable as an anode material for LIBs. This could be beneficial for the future production of anode materials for LIBs.

Introduction

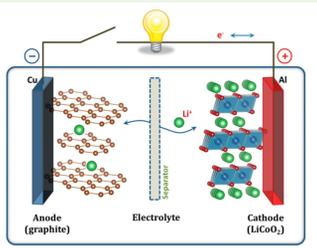


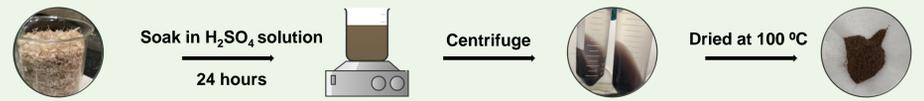
Fig. 1 Lithium-ion battery diagram

Lithium-ion batteries (LIBs) are used in various applications due to their high energy density, lightweight, and good charge-discharge efficiency. The commonly used anode material in LIBs is graphite. However, graphite has a low specific capacity of only 372 mAh/g, which still needs further development.

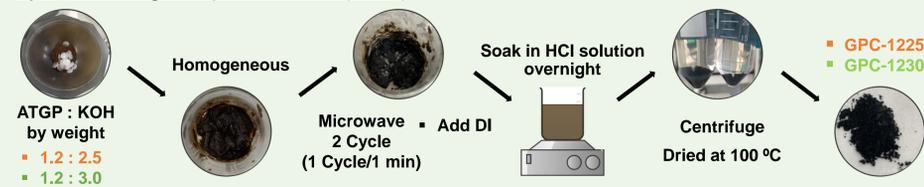
One of the materials that has gained attention as an anode for LIBs is porous carbon. Its high specific surface area offers higher specific capacity and better electrochemical performance. This research will focus on the use of biomass materials. The use of porous carbon from biomass not only enhances the efficiency of Li-ion batteries but also reduces environmental impact and creates new pathways for sustainable resource use.

Experimental procedure

Preparation acid treated garlic peel (ATGP)



Synthesis of garlic peel carbon (GPC)



Results and Discussion

XRD

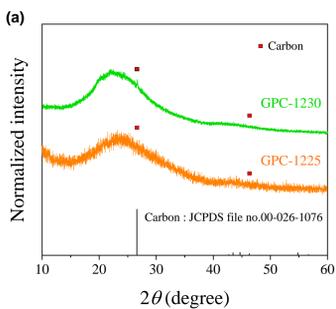
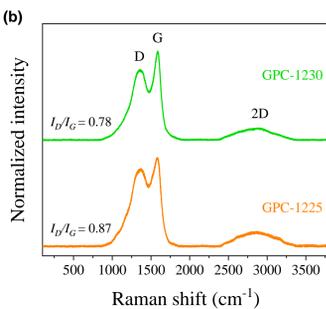


Fig. 2 (a) XRD pattern and (b) Raman of different cases of GPC.

XRD pattern in Fig. 2a shows broad peaks at 2θ of ~26.0° and ~43.0° are seen in all the two case. These peaks correspond to the (002), (100) planes of graphite.

Raman



Raman spectra in Fig. 2b shows D-band at ~1350 cm⁻¹, G-band at ~1580 cm⁻¹, and 2D-band at ~2700 cm⁻¹, indicating the graphene structure.

SEM investigation

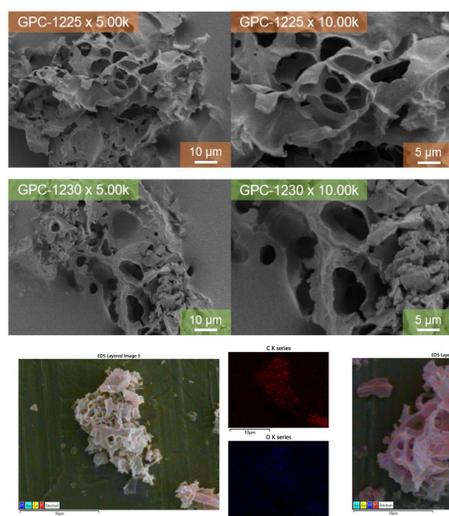


Fig. 4 SEM-EDS images of different cases of GPC.

SEM images Fig. 3 shows that GPC-1230 has a larger pore size than GPC-1225, which corresponds to the amount of KOH used in the pore activation.

The elemental mapping in Fig. 4 reveals uniform distribution of carbon and oxygen on the surface.

TEM investigation

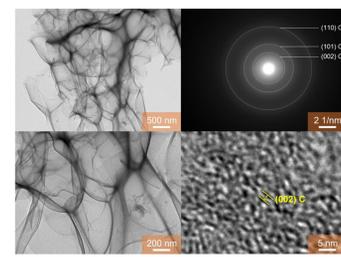


Fig. 5 TEM images of GPC-1225

TEM images in Fig. 5 shows the thin sheets of the synthesized GPC-1225 sample. Ring pattern corresponds to the (002), (101) and (110) planes of graphite.

TEM images in Fig. 6 shows the more thick sheets than GPC-1225. Ring pattern corresponds to the (002), (101) and (110) planes of graphite.

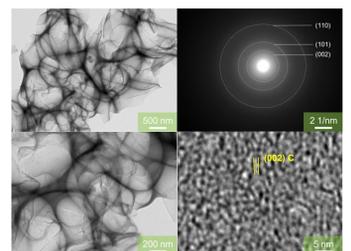


Fig. 6 TEM images of GPC-1230

BET

Table 1. shows results of the surface area and porosity

Sample	S (m ² /g), BET Theory	V _p (cc/g)
GPC-1225	718.96	0.8319
GPC-1230	282.78	0.4364

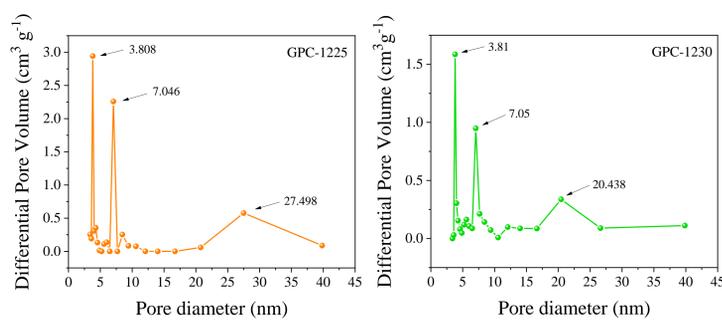


Fig. 7 N₂ adsorption-desorption of different cases of GPC

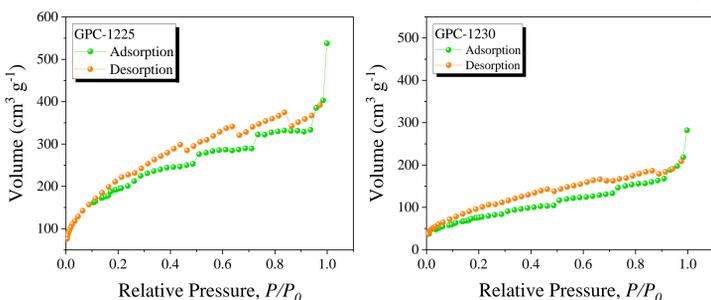


Fig. 8 N₂ adsorption-desorption of different cases of GPC

Fig. 8 shows the N₂ adsorption-desorption isotherm as a Type IV isotherm according to IUPAC, which shows the adsorption-desorption of gas with a hysteresis loop. This is characteristic of mesoporous materials.

Electrochemical performance

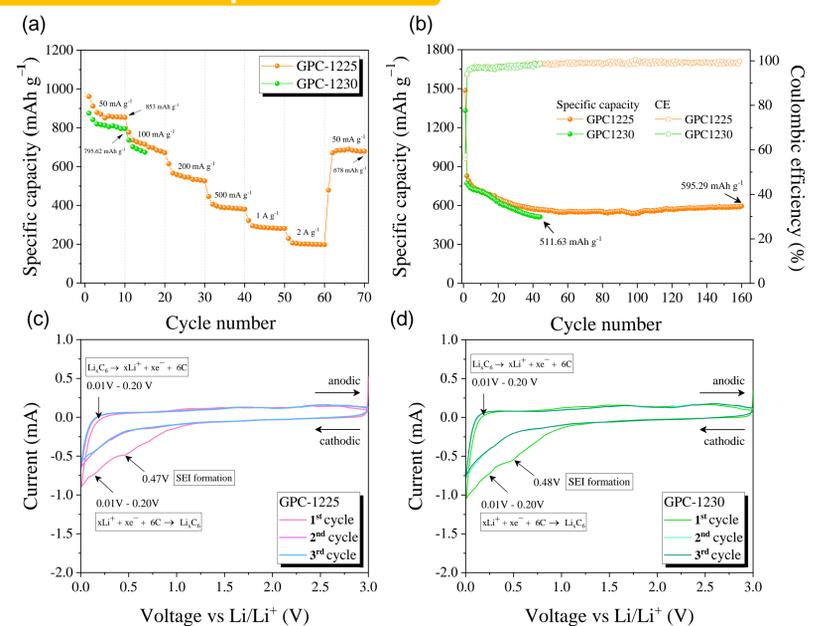


Fig. 9 (a) Rate performance, (b) Cycle performance, and (c-d) Cyclic voltammetry of different cases of GPC

Fig. 9a Rate performance
 GPC-1225 can operate well at high current densities, indicating the stability and long-term usability of the material.

Fig. 9b Cycle performance at 100 mA g⁻¹
 GPC-1225 had a specific capacity of 595.29 mAh g⁻¹ at cycle no. 160.
 CE of 98% for 160 cycles

GPC-1230 had a specific capacity of 511.63 mAh g⁻¹ at cycle no. 44.
 CE of 96% for 44 cycles

The CV curve peak position of the two electrode materials is similar, indicating that the electrochemical reactions are the same. Cycles 2 and 3 have similar peak characteristics, indicating stability in charging and discharging.

Conclusion

Porous carbons derived from garlic peel were prepared using a microwave-assisted technique, which is simple, rapid, and cost-effective. Experimental results showed that KOH can help produce porous carbon with a high specific capacity of up to 595.29 mAh g⁻¹ at 100 mA g⁻¹ after 160 cycles, which can be used as an anode material for lithium-ion batteries. This may be beneficial for future anode material production.

Acknowledgements

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