

# New organic electrode spherical and chrysanthemum shaped materials for lithium-ion polymer battery



Escola Choi Nong Chi Tai  
Ngan Ka Chon, Ho Kai Meng

## BACKGROUND

With the popularization of electronic devices and the strengthening of the public's awareness of environmental protection, modern society is increasingly demanding rechargeable batteries with high performance and environmental values. As one of the highly commercialized batteries, lithium ion battery (LIB) has been widely used in various portable devices and electronic goods. However, the development of LIB is limited by its electrode materials, which cannot meet the increasing demand for battery performance. On the other hand, organic electrode materials have become a new trend of electrode materials because of their low cost and non-toxic characteristics. Therefore, we made Polyethyleneimine-Gallic acid-Copper chloride dihydrate polymer battery (PGC).

## FABRICATION AND ASSEMBLY

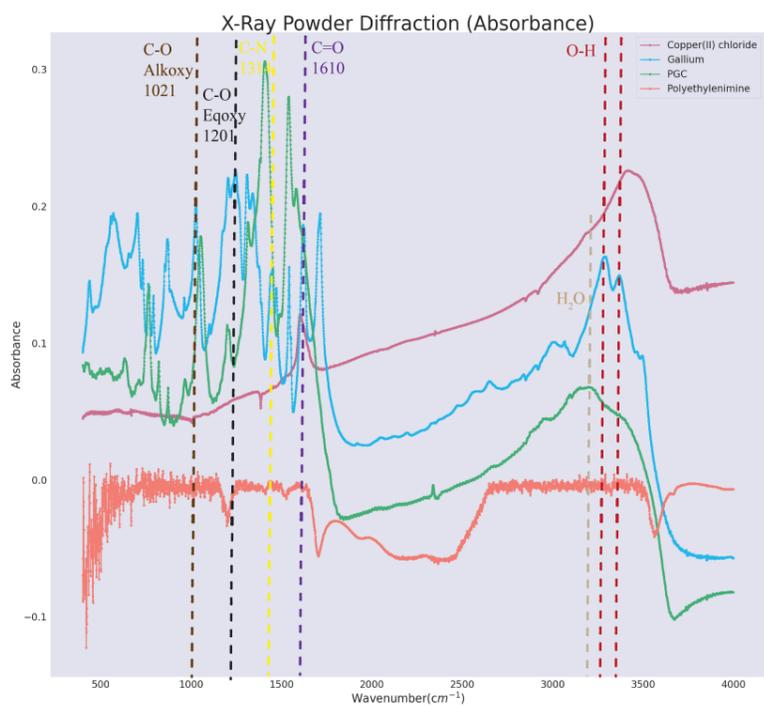
For electrode synthesis, we prepare the materials listed in the right table. Firstly, gallic acid and  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  were dissolved in 30mL of deionized water respectively at  $40^\circ\text{C}$ . Similarly, polyethyleneimine was dissolved in 70 mL of deionized water. Next, a solution of polyethyleneimine was added to a mixture of  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  and gallic acid. After the three substances were mixed, sodium hydroxide was added to adjust pH to 8. Cool the mixture at room temperature and precipitate the sediment. The spring plate is first placed on the anode cap, and then the gasket and lithium chip are placed. Then add three drops of electrolyte solution to the surface of the lithium wafer and put it into the diaphragm. After that, add three drops of electrolyte solution to the surface of the diaphragm. The electrode material is then placed on the diaphragm and covered with a cathode cover. Finally, seal the button battery with a hydraulic press.

| Materials  | Proportion           |
|--|----------------------|
| Copper chloride dihydrate ( $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ )    | 99.99%               |
| Gallic acid monohydrate [ $\text{C}_6\text{H}_3(\text{OH})_3\text{COOH}$ ] | 98%                  |
| Polyethyleneimine (M.W. 600)   | 99%                  |
| Sodium hydroxide (NaOH)  | 97% (diluted to 10%) |

Table (2.1.1): The Materials and their proportion.



## STRUCTURE(XRD)



The figure illustrates the XRD of the main materials and the PGC (Polyethyleneimine-Gallic acid-Copper chloride dihydrate polymer battery) electrode itself. Clearly, wide peaks in the  $3,200\text{--}3,500\text{ cm}^{-1}$  frequency range are attributed to O-H. The tensile vibration peaks of C=O, C-O and O-H are located at  $1,610\text{ cm}^{-1}$ ,  $1,201\text{ cm}^{-1}$  and  $1,021\text{ cm}^{-1}$ , respectively. These peaks indicate the presence of -COOH and excessive gallic acid in the PGC electrode. The results of this image are consistent with our speculation about the reaction mechanism.

## CHARACTERIZATION (TEM)

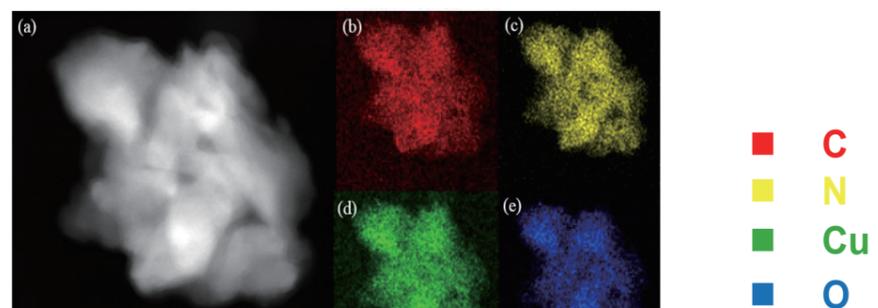


Figure (3.2.1): TEM images with the corresponding elemental mappings of C, Cu, N, and O of PGC.

The homogenization of PGC is very high.

## ELECTROCHEMICAL PERFORMANCE

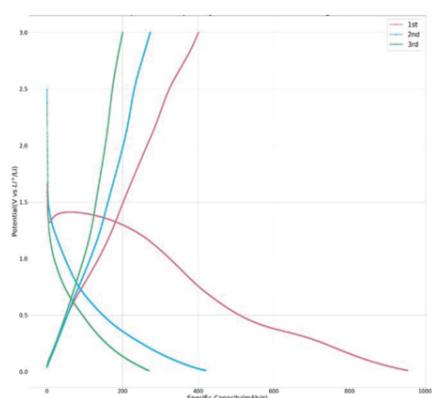


Figure (3.3.1.2): The charge-discharge curves of PGC with a current density of  $0.5\text{ C}$  and potential of  $0.01\text{ to }3\text{ V}$  in different cycles.

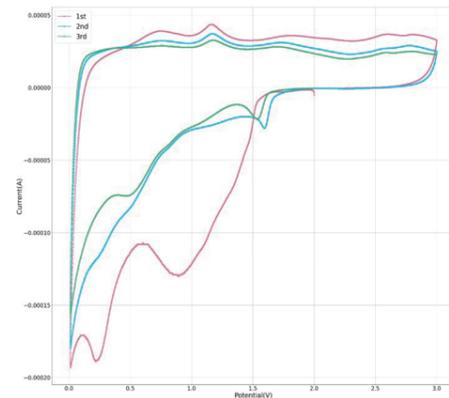


Figure (3.3.1.1): Cyclic Voltammogram of PGC in the range of  $0.1\text{ to }3.0\text{ V}$  with the scanning rate of  $1 \times 10^{-3}\text{ m/s}$ .

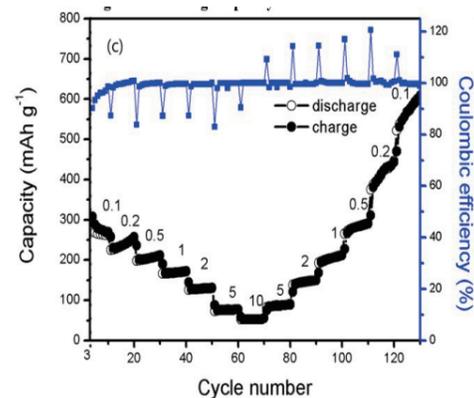


Figure (3.3.3.1): The rate performance of PGC electrodes

The above figure shows the platform in the discharge curve of the first cycle, corresponding to the irreversible reduction peak shown on the CV curve. The platform appearing at  $1.2\text{ V}$  shows the lithium process of phenolic, hydroxyl, amino and other groups in the PGC. As the number of cycles increases, the platform becomes less obvious, indicating that an irreversible reaction has occurred in the first cycle.

The CV curves of the first cycle in the figure above show strong reduction peaks at  $0.25\text{ V}$  and  $0.8\text{ V}$ . Secondly, there is another more obvious reduction peak at  $1.5\text{ V}$ . In addition, the CV curves of the second and third cycles have good coincidence. As a result, PGC has good cycle reversibility after the first cycle.

We can see that the capacity of PGC gradually decreases from low power density to high power density, and from high to low power density in the above figure. The battery capacity is increasing, even higher than the initial capacity, it demonstrates that PGC has good rate performance at low power density.

## CONCLUSION

In this study, the purpose is to develop a new organic material PGC and apply it to the battery because inorganic electrodes have large limitations, while organic electrodes have a lot of potentials for exploration. From the experimental data, we found that the capacity of the battery made of PGC can still maintain a high stability level after several cycles, so it can be shown that PGC as an organic electrode material can effectively display its characteristics of high capacity and high stability.

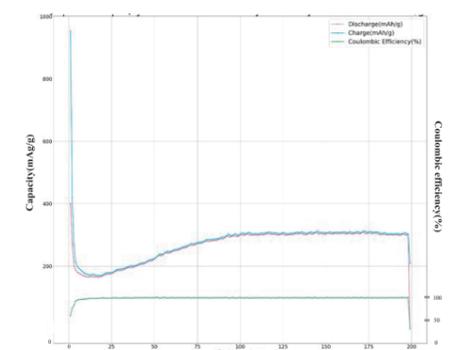


Figure (3.3.2.1): Specific capacity and efficiency across cycle numbers in  $0.1\text{ A/g}$

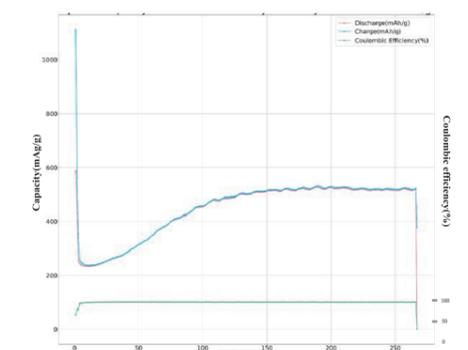


Figure (3.3.2.2): Specific capacity and efficiency across cycle numbers in  $0.5\text{ A/g}$

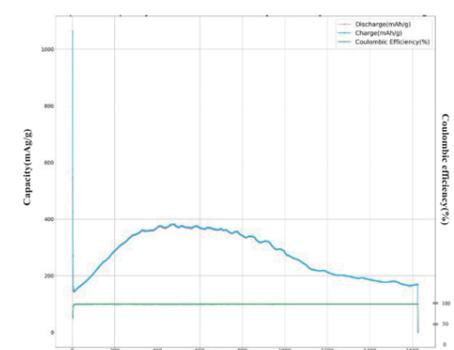


Figure (3.3.2.3): Specific capacity and efficiency across cycle numbers in  $2\text{ A/g}$

After 100 cycles of  $0.1\text{ A/g}$  charge and discharge cycle, the charge and discharge capacity of PGC is greatly improved.

The capacity of PGC continues to increase during multiple cycles of the  $0.5\text{ A/g}$  charge-discharge cycle.

In  $2\text{ A/g}$  charge-discharge cycle, its initial reversible capacity is  $258\text{ mAh/g}$  and reaches  $382\text{ mAh/g}$ . In the 472nd cycle, it remains at  $294\text{ mAh/g}$  during the 972nd cycle.

These phenomena indicate that PGC has very high cycle stability under high current capacity.