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A Polyimide derivative containing different carbonyl groups for flexible lithium ion batteries

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1. Material

Single-wall carbon nanotubes (～90% purity; Chengdu Organic Chemicals Co. Ltd.) was purified before use. N-Methyl-2-pyrrolidone (NMP) was distilled under vacuum prior to use. 2, 6-Diaminoanthraquinone(AQ, TCI), m-cresol, and N,N-Dimethylformamide (DMF) were used as received. Pyromellitic dianhydride (PMDA, Sinopharm Chemical Reagent Co.,China) were purified by sublimation.

2. Synthesis of Materials

Fabrication of SWNT aqueous dispersion: In order to prepare SWNT aqueous dispersion, sodium deoxycholate was used as a surfactant to stabilize SWNT. At first, sodium deoxycholate was dissolved in deionized water in weight percent of 0.1%. Purified SWNT was added into the surfactant and then the suspension was sonicated for 2h by a probe sonicator. The concentration of SWNT in the aqueous dispersion was 0.5 mg ml^{-1}.

Influence of reaction solvent: to ensure the solvent, the concentration, reaction time and the reaction temperature was fixed on 0.10 mmol ml^{-1} ,12h and 200℃, respectively. The reaction solvent is NMP, DMF, and m-cresol, respectively. As shown in S3, chose NMP as the solvent is better.

Influence of reaction temperature: In the influence of reaction temperature, the reaction concentration, the reaction time and the reaction solvent was fixed on 0.10 mmol ml^{-1}, 12h and NMP, respectively. The reaction temperature was 160 ℃, 180 ℃, 200 ℃, and 220 ℃, respectively. The experiment indicate that when reaction temperature is 200 ℃, the result is better (shows in S4).

Influence of reaction concentration: In the polymerization process of PMAQ, in order to ensure

the influence of reaction concentration, the PMDA concentration varied as 0.05, 0.10, 0.15 mmol ml^{-1} and the reaction time was fixed on 12 h, the solvent was NMP, the reaction temperature is 200℃. The results as S5 shows, when the concentration is 0.10 mmol ml^{-1} is better.

Influence of the content of SWNT: First, PMAQ 27 mg, 24 mg and 21 mg, were put into three beakers, respectively. And then the SWNT aqueous dispersion 6ml, 12ml and 18ml were added. Each mixture was further ultrasonicated for 1h at 300W under ice-bath. Then the thin film was prepared trough vacuum filtration.

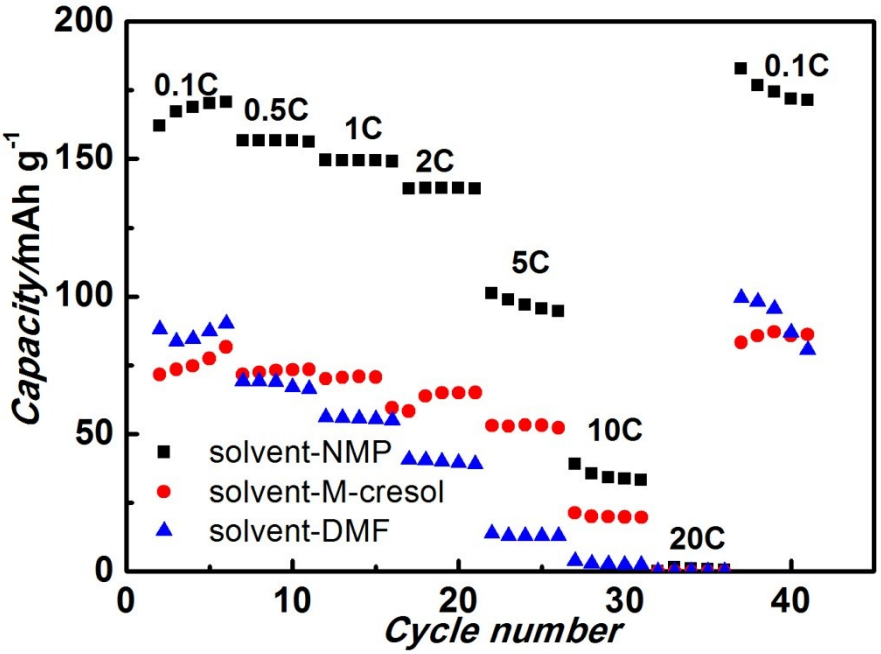


Figure S1. Influence of reaction solvent.

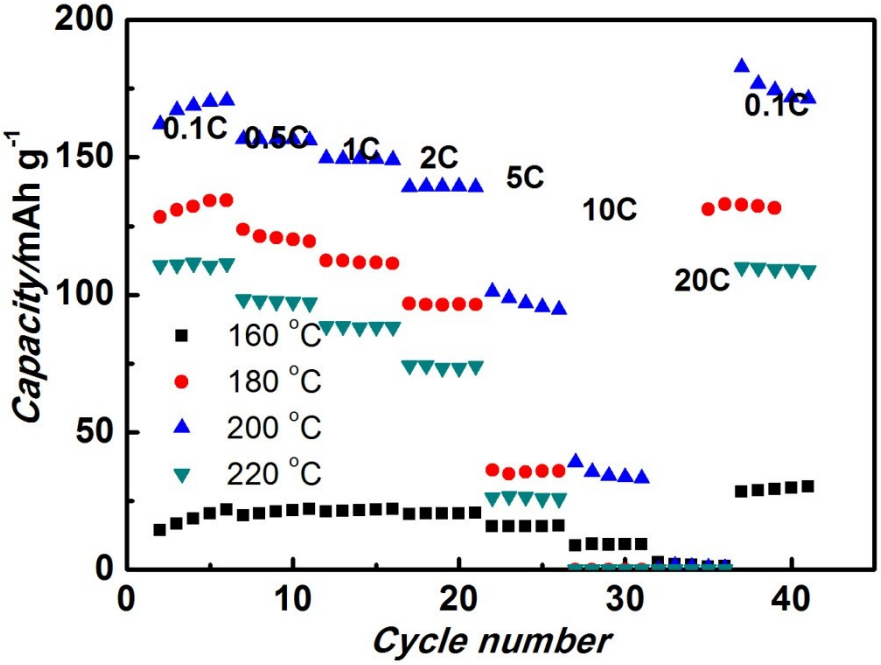


Figure S2. Influence of reaction temperature

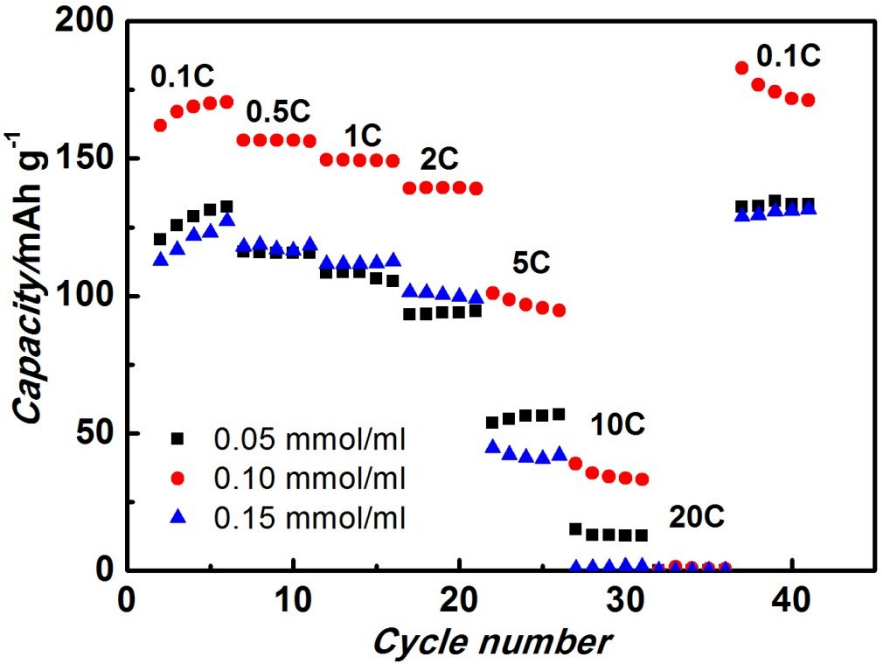
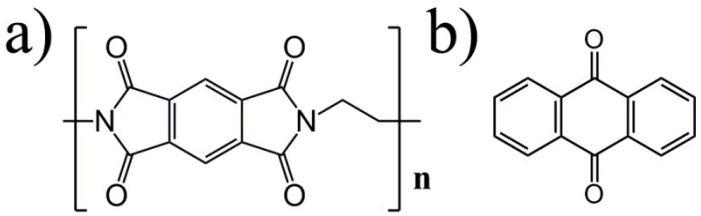
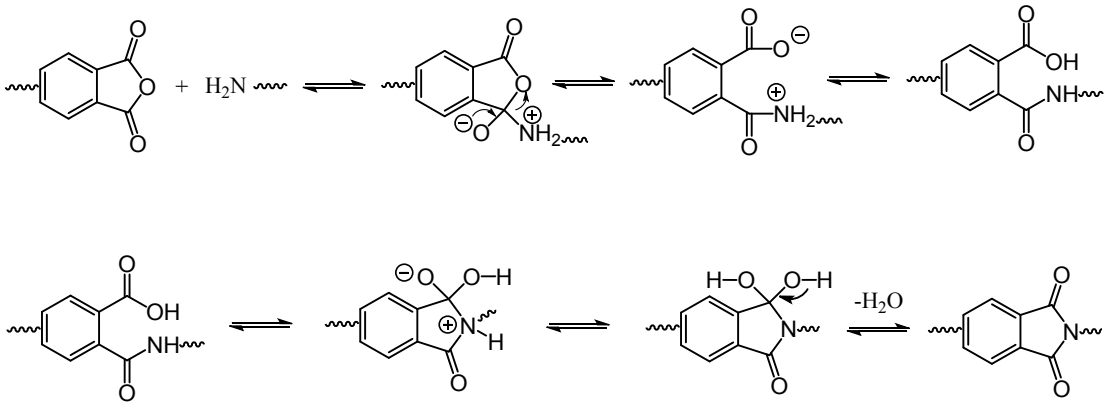


Figure S3. Influence of reaction concentration



Scheme S1. The molecular structure of (a)PI and (b) AQ monomer.



Scheme S2. A mechanism that describes the formation of polyimide.[1]

3. Electrochemical performance test

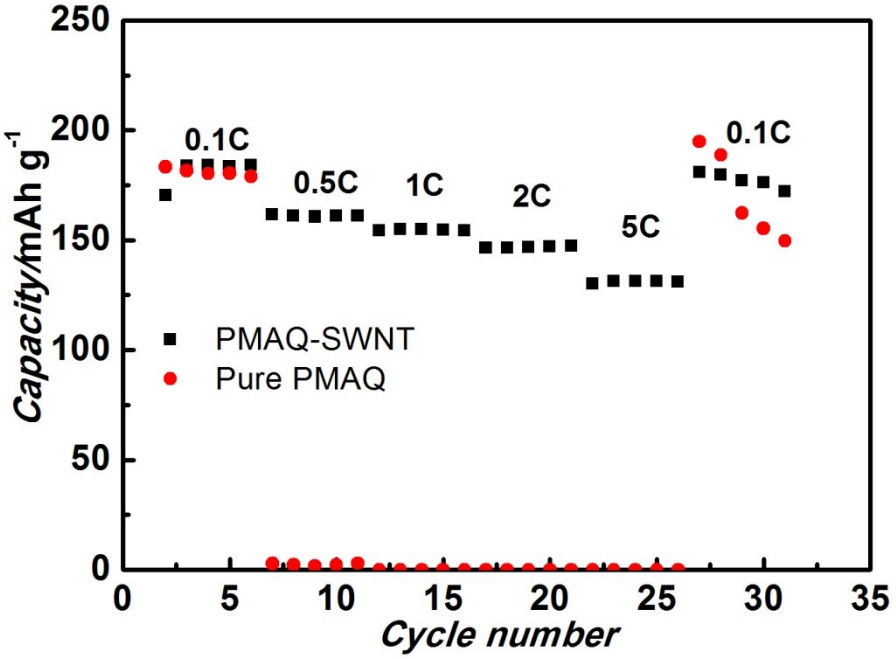


Figure S4. the rate performance of PMAQ-SWNT and pure PMAQ

In order to study the influence of the SWNT, we also did the rate performance test of the pure SWNT.

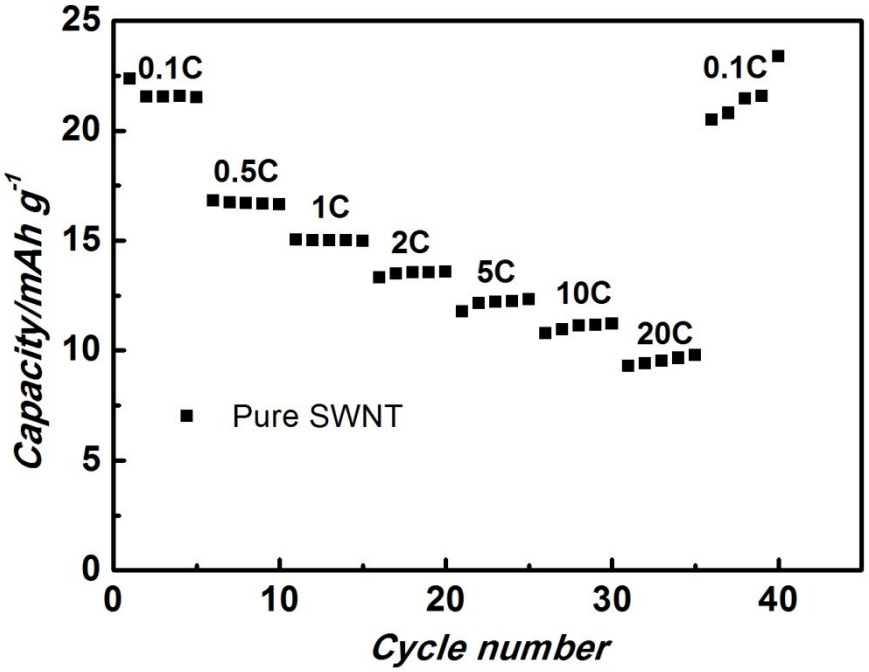


Figure S5. The rate performance of pure SWNT

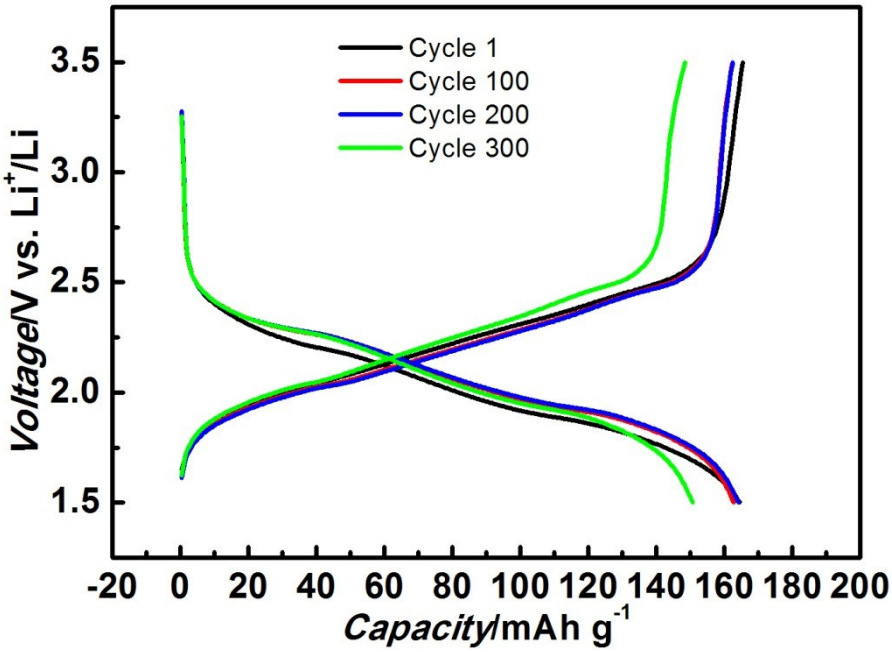


Figure S6. Galvanostatic charging/discharging curves of the PMAQ-30% SWNT film

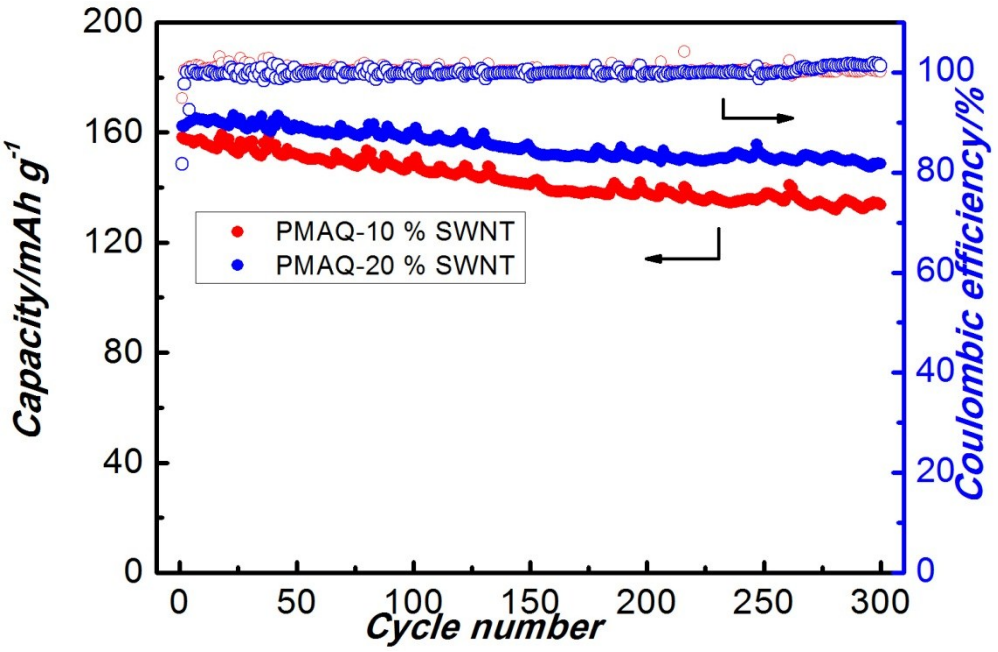


Figure S7. Cycling performance of PMAQ-10 % SWNT and PMAQ-20 % SWNT

4. Mechanical tests

The film was cut into rectangle, the breadth was fixed on 2 mm and the length must be larger than 5 mm.

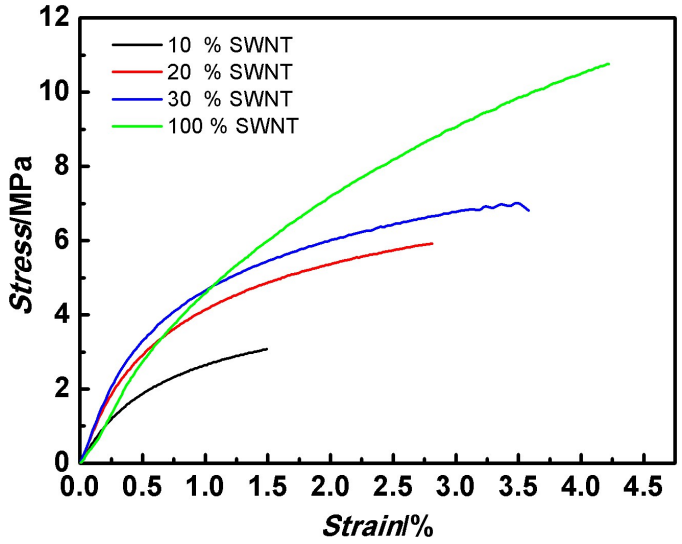


Figure S8. Typical stress-strain curves of PMAQ-SWNT film with different content of SWNT.

Reference

1 D. Wilson, H. D. Stenzenberger and P. M. Hergenrother, *Polyimides*, Springer, 1990.