# A gel Li-ion capacitor constructed by $Li_4Ti_5O_{12}$ anode and 3D porous graphene macrofoam cathode based on in-situ polymerized gel electrolyte

Min Mao [a,b], Feiyu Kang [a,b,*], Yan-Bing He [a,*]

[a] *Engineering Laboratory for Next Generation Power and Energy Storage Batteries, Graduate School at Shenzhen, Tsinghua University, Shenzhen 518055, China.*

[b] *School of Materials Science and Engineering, Tsinghua University, Beijing 100084, China*

E-mail: mamo17@mails.tsinghua.edu.cn

Lithium-ion capacitor (LIC) is a kind of hybrid device which combines an electrode of lithium-ion batteries (LIB) and an electrode of supercapacitors (SC), possessing high energy density of LIB and high power density and good cycle stability of SC. $Li_4Ti_5O_{12}$ has been known as a promising anode material of LIB because it has the advantages of abundant three-dimensional ion diffusion channels, almost no volume change during the charging/discharging process and stable charge-discharge platform. Three-dimensional porous graphene macrofoam has a large specific surface area, superior conductivity and large tap density, which acts as a new type of electric double layer capacitor material in recent years. In this paper, a kind of monodisperse $Li_4Ti_5O_{12}$ nanospheres with a diameter of about 100 nm is synthesized via a robust strategy using titanium nitride (TiN), $LiOH{\cdot}H_2O$ and polyvinyl pyrrolidone (PVP) as titanium source, lithium source and carbon source respectively[1]. The 3D porous graphene macrofoam is prepared by hydrothermal method using commercialized graphene oxide as precursor, and then high-density porous graphene macrofoam (HPGM) and porous graphene macrofoam (PGM) are obtained by drying in 60 °C and freeze-drying respectively[2]. The 3D porous graphene macrofoam is used as positive materials of LIC and $Li_4Ti_5O_{12}$ is used as negative electrode, and a gel type LIC is assembled by adding polymer monomer of PETEA and initiator of AIBN to the liquid electrolyte, which will be subjected to in-situ polymerization reactions in the electrolyte when the cells are heated[3]. In comparison to LIC assembled with commercial activated carbon (AC), the electrochemical performance results show that the gel-type LIC with 3D porous graphene macrofoam delivers a maximum energy density of 69.6 Wh/kg, and the energy density could also maintain 48 Wh/kg when the power density reaches 4.8 kW/kg, which is much higher than that of commercial LIC with AC

**References:**

[1] Wang C, Wang S, Tang L, He Y, Gan L, Li J, Du H, Li B, Lin Z, Kang F. A robust strategy for crafting monodisperse $Li_4Ti_5O_{12}$ nanospheres as superior rate anode for lithium ion batteries. Nano Energy 2016, pp. 133.

[2] Tao Y, Xie X, Lv W, Tang D, Kong D, Huang Z, Nishihara H, Ishii T, Li B, Golberg D, Kang F, Kyotani T, Yang Q. Towards ultrahigh volumetric capacitance: graphene derived highly dense but porous carbons for supercapacitors. Sci Rep-UK 2013;3.

[3] Liu M, Zhou D, He Y, Fu Y, Qin X, Miao C, Du H, Li B, Yang Q, Lin Z, Zhao TS, Kang F. Novel gel polymer electrolyte for high-performance lithium–sulfur batteries. Nano Energy 2016, pp. 278-289