Bio-based Polymer Derived Anode Material for Fast Charging and Long-cycle Life Lithium-ion Battery

(Graduate School of Advanced Science and Technology, Japan Advanced Institute of Science and Technology) ○Rajashekar Badam, Kottisa Sumala Patnaik, Yueying Peng, Tatsuo Kaneko, Noriyoshi Matsumi.

Keywords: *Polybenzimidazole, Nitrogen Doped Carbon, Anode Material*

Currently graphite is the most commercially used anode material for lithium-ion batteries (LIB), however its limited theoretical capacity of 372 $mAhg^{-1}$ and slow kinetics cannot satisfy the requirements for EVs. Hence, alternative high energy density anode materials with fast kinetics are need of the hour. Extreme fast charging, with a goal of 15 minutes fast charging, is poised to accelerate mass market production of electric vehicles. Key strategies for improving the rate capability of carbonaceous materials are (a) heteroatom doping, especially nitrogen doping and (b) increasing the d-spacing for accessing more active sites. So, our objective is to use nitrogen rich Bio-based polymer as a single source of nitrogen and carbon to prepare heavily nitrogen doped carbon with nearly 20 at% of nitrogen with increased d-spacing and understand its effect on Li ion storage.

Poly (2, 5-benzimidazole) (PBI) was synthesized by homo-polycondensation method using a bio derivable starting material 3, 4-diaminobenzoic acid[1]. The as prepared PBI was pyrolyzed at 800 ℃ in nitrogen atmosphere. The obtained material was systematically characterized before preparation of anodes for Li ion battery application. The SEM-EDX data revealed the content of nitrogen was as high as 18 at%. Further, long cycling studies were performed for >1000 cycles at 0.4, 0.8 and 1.8 Ag^{-1} rates. Results indicated that PY PBI 800 can deliver highest de-lithiation capacity of~ 260 $mAhg^{-1}$ at specific capacity of 0.4 Ag^{-1} rate with nearly 88% capacity retention after 1000 cycles (Figure 1). At higher current rate of 0.8 Ag^{-1}, and 1.8 Ag^{-1}, it showed highest discharge capacity of 165 $mAhg^{-1}$ and 135 $mAhg^{-1}$ with 90% and 75% capacity retention after 1000 cycles respectively. Further, full cell was studied with $LiCoO_2$ as cathode and PY PBI 800 as anode. Full cell studies also revealed the promising nature of PY PBI 800.

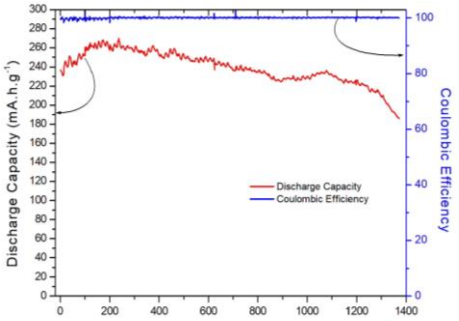

Figure 1:Long cycling studies for 1000 cycles at 0.4Ag^{-1}.

1) A. Nag, M.A. Ali, A. Singh, R. Vedarajan, N. Matsumi, T. Kaneko, *J. Mater. Chem. A*, **2019**, *7*, 4459.

Acknowledgement: K. S. P. is thankful to financial support by MEXT. Financial support from Strategic Innovation Promotion Program (SIP), Technologies for Smart Bio-Industry and Agriculture, Japan is gratefully acknowledged.