Neutron aided battery analysis: status and prospects

Hajime Arai[1#], Masao Yonemura[2], Kazuhiro Mori[3], Takashi Kamiyama[2], Toshiharu Fukunaga[3], Yohei Onodera[3], Akio Mitsui[1], Takahiro Naka[1], Makoto Morishima[1], Hidetaka Sugaya[1], Hideyuki Komatsu[1], Yuki Orikasa[4], Yoshihisa Ishikawa[2], Dyah Sulistyanintyas[1], Keiji Shimoda[1], Yoshiharu Uchimoto[4], and Zempachi Ogumi[1]

[1]Office of Society-Academia Collaboration for Innovation, Kyoto University
Gokasho, Uji 611-0011, Japan
[2]Institute of Materials Structure Science, High Energy Accelerator Research Organization
Tokai, Ibaraki 319-1106, Japan
[3]Research Reactor Institute, Kyoto University
2-1010 Asashiro-Nishi, Kumatori-cho, Sennan-gun, Osaka 590-0494, Japan
[4] Graduated School of Human and Environmental Studies, Kyoto University,
Yoshida-nihonmatsu-cho, Sakyo-ku, Kyoto 606-8501, Japan

 # E-mail h-arai@saci.kyoto-u.ac.jp

Rechargeable batteries such as lithium ion batteries (LIB) are widely used for portable devices and electric vehicles. For enhancing their performances, it is necessary to elucidate phenomena occurring inside the batteries under operating conditions and to design new batteries based on the analytical results, instead of empirical methods.

Neutron as a highly transparent probe is promising to capture the phenomena inside the batteries that are generally sealed in the metallic container. The ability to detect light elements such as lithium and oxygen is also useful, when compared with X-ray based analysis. To clarify the structural changes of LIB materials during battery operation (*operando*), high resolutions of time and *d*-spacing are both indispensable, which has been challenging for neutron aided methods. If the battery is discharged at 0.5C rate (full discharge in 2 h) and information in each 10% of the discharge process is required, a single measurement should be ended in 12 min. Moreover, insertion-extraction type materials used for LIBs shows small structural changes, for example, 1% per full discharging (0.1% in each 10% of the process), demanding high *d*-spacing precision to clarify the changes.

Thanks to the recently developed strong neutron beam facilities, dynamic behavior of the electrode materials such as graphite is now available, showing its non-equilibrium behavior on discharging/charging. Other applications including the use of isotopes will be also presented, demonstrating the importance of neutron-aided battery analysis.

Acknowledgment: This work was supported by RISING Project of NEDO.