FT-IR measurements of generative gas from lithium-ion batteries at abuse temperature

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Lithium-ion batteries are opening up as energy source for vehicles and industrial applications. Most of the lithium-ion batteries equip safety valve for releasing inner pressure in an emergency. The valves rarely opens and commercially available battery have passed related standard including abuse test, but must be considered for unexpected conditions, such as suffering a fire. Batteries still have a possibility of venting the valve with thermal runaway, and then analyzing gas released from and/or generated gas inside of batteries are important to considering safety of users and firefighters. In this paper, we are focusing on analyzing the forming gases inside of lithium-ion batteries under high temperature condition at an assuming thermal runaway.

In house manufactured 18650 type cylindrical lithium-ion cells designed for high rate capability (presuming for power source of hybrid electric vehicle) were used for this study. These cells consisted of $Li(NiCoAl)O_2$/hard carbon with 1 mol dm^{-3} $LiPF_6$ in EC:DMC electrolyte. The cells were used for the experiment after conditioning and charge-discharge performance confirmations. The cell with pin hole was enclosed in a pressure resistant vessel then heating the vessel. Generative gas in the cell was sampled and measured IR spectrum at setting up temperatures.

FT-IR spectra of generative gas from the full charged cell (4.2 V) at regular using temperature (50 ºC) and abuse temperature (220 ºC) are shown in Fig. 1. Alkyl compound peaks (1462, 2891 cm^{-1} et al.) that related with electrolyte and trace CO_2 peaks (2337, 3714 cm^{-1} et al.) are observed at 50 ºC. At 220 ºC, the cell occurring thermal runaway, huge amount of CO_2 and other new alkyl compound related peaks are found. These gases are formed by electrolyte decomposition and electrode decomposition with thermal runaway that results are good agreement with our previous reported gas analyses data from crush test[1]. Result of generative gas measurements from the cell at pre thermal runaway temperature of 4.2 V cell and discharged cell (3.0 V)

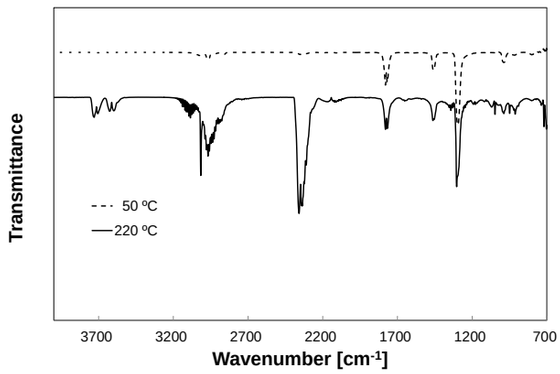

Fig. 1 FT-IR spectra of the gas sampled from inside of lithium-ion cells at 4.2 V. Broken and solid lines correspond to at 50 °C and 220 °C, respectively.

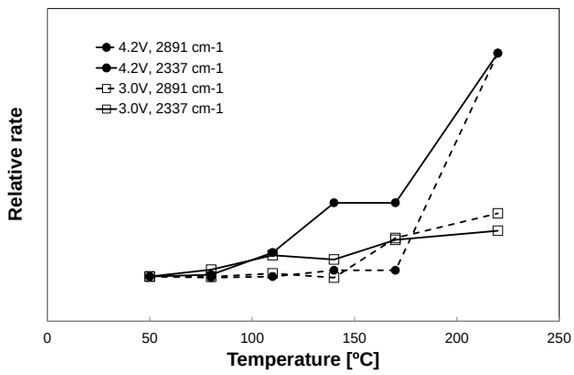

Fig. 2 Relative FT-IR peak intensity dependence of temperature comparing with 4.2 V (●) and 3.0 V (□). Broken and solid lines correspond to at 2891 cm^{-1} and 2337 cm^{-1}, respectively.

which in no thermal runaway are shown in Fig. 2. Peak height at 2891 cm^{-1} and 2337 cm^{-1} is employed for as represent of electrolyte decomposed alkyl compounds and CO_2, respectively. Each peak height is normalized by the height of 4.2 V at 220 ºC. Electrolyte decomposed alkyl compounds are find at 80 ºC and gradually increasing with temperature. In contrast CO_2 is sudden generate at high temperature. These results are considered reflecting in electrolyte decomposition with electrode and positive electrode decomposition with oxygen release.

References

[1] S. Koike, M. Shikano, H. Sakaebe, H. Kobayashi, PRiME 2012, #222.