Characterisation of Mg Species Formed in Mg-Based Rechargeable Batteries by X-ray Absorption Spectroscopy

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The current storage system for natural energy resources (renewable energy) is dominated by lithium-ion batteries (LIBs). For the secure and sustainable development of our energy system, the current dependence of energy storage systems on LIBs must be minimised. The battery based on magnesium (Mg) is one of the potential candidates for the backup of LIBs. In order to develop and realise Mg-based batteries, the chemical states of charge carriers (i.e. Mg^{2+}) in the battery system must be analysed and described adequately. X-ray absorption spectroscopy (XAS) is a powerful analytical tool to investigate the chemical states of target elements in a highly element-selective and non-destructive manner. Given this background, this study aims at analysing the chemical states of Mg species in the currently developing Mg-based battery system by measuring X-ray absorption near edge structure (XANES), one of the spectral regions of XAS.

Samples measured and analysed in this study were metallic Mg, a promising candidate for the cathode material of the Mg-based battery, soaked in different solvents. The original Mg metal was commercially supplied from Fujifilm-Wako. The Mg metal was soaked in a glyme solvent (dimethoxyethane, G2 or G3) with an electrolyte ($Mg[TFSA]_2$; TFSA: bis(trifluoromethylsulfonyl)amine, or $Mg[B(hfip)_4]_2$; hfip: 1,1,1,3,3,3-Hexafluoro-2-propanol) for 19 hours in an inert glove box. Some samples were further charged and discharged with 0.05 mA of current density for 10 hours × 10 cycles in the inert glove box. The prepared samples were sealed and packed right after the treatment in the glove box and transferred to an inert glove box at the SR center of Ritsumeikan Univ., where the samples were attached on a carbon tape for XAS measurements. X-ray absorption spectra were collected at Mg K-edge (1.305 keV) on the beamline BL-10, Ritsumeikan Univ. SR center. The spectra were collected by the total electron yield (TEY) mode. The collected spectra were treated and analysed with the program code WinXAS.[1]

The XANES spectra of Mg metal soaked in G2 solvent with different electrolytes are given in Fig. 1-(a). The spectra are well comparable to that of pristine Mg metal (black data), suggesting that mere soaking of Mg metal in the solvent does not change

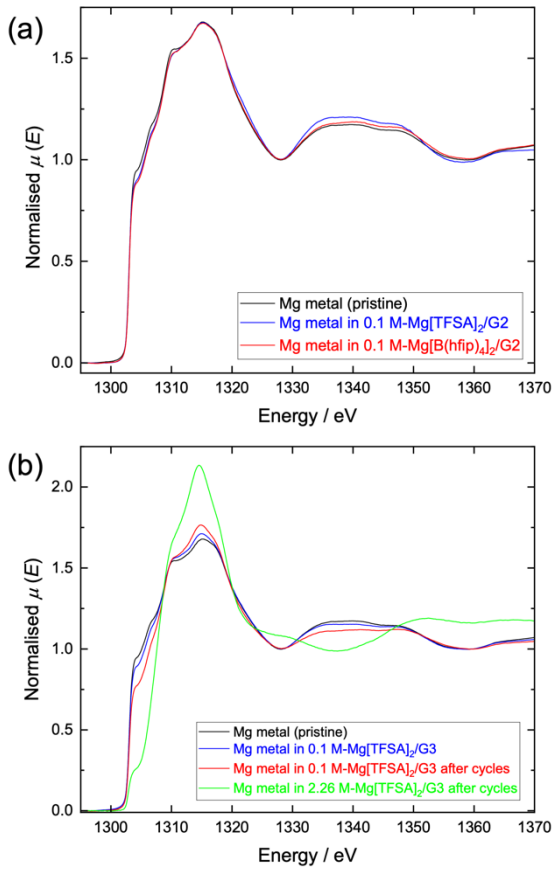

Fig. 1 Mg K-edge XANES spectra of metallic Mg treated in different conditions: (a) soaked in G2 glyme solvent with different electrolytes, (b) soaked in G3 glyme solvent with $Mg[TFSA]_2$ before- and after charge/discharge cycles.

the chemical state of Mg metal surface. However, when Mg metal is electrochemically treated (i.e. the charge/discharge cycles), the surface condition is chemically changed, which is evidenced by XANES spectral change (Fig. 1-(b)). The collected spectra are currently analysed to obtain more detailed information about the chemical states of Mg species formed by the electrochemical treatment. This work was supported by GteX Program of Japan Science and Technology Agency (Grant No. JPMJGX23S1).

References

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