Supplementary Information

Hydrous Amorphous RuO_2 nanoparticles Supported on Reduced Graphene Oxide for Non-aqueous Li-O_2 Batteries

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Experimental details

Preparation of rGO/hydrous amorphous RuO_2 composite

Graphene oxide (GO) aqueous solution was prepared by the modified Hummers method, which was then freeze-dried to obtain solid GO powders. GO powders were then instantly exposed to a high temperature of 850°C for a duration of 10 minutes in a pre-heated furnace to reduce oxide groups on the GO surface to obtain rGO powders.

The rGO/hydrous amorphous RuO_2 composite was synthesized by a simple sol-gel method using ruthenium chloride hydrate ($RuCl_3 \cdot xH_2O$, Sigma-Aldrich) and sodium hydroxide (NaOH, Samchun Pure Chemical). The $RuCl_3 \cdot xH_2O$ was dissolved in D.I water to make an aqueous solution (38 mM). Then, the solution was added dropwise to rGO (5 mg) followed by sonication for 10 min and was dried under 90°C in a vacuum oven to remove water. After drying, 1M NaOH was added dropwise into the above powder, and was kept at 60°C for 30 min for reaction. The resulting product was washed and dried.[9]

Measurements

The crystal structure of as-synthesized samples were observed with X-ray powder diffractometer (XRD, (Rigaku Ultima IV Diffractometer) with a graphite-monochromator equipped with Cu Kα radiation; operating at 40 kV and 40 mA.

The particle size and morphology were observed using field-emission scanning electron microscopy (FE-SEM, Tescan Mira 3 LMU FEG, 20kV) and transmission electron microscopy (TEM, Tecnai G2 T-20S, FEI) equipped with energy-dispersive X-ray spectroscopy (EDS).

X-ray photoelectron spectroscopy (XPS) was carried out with an AXIS-NOVA (Kratos Inc., UK) system using Al-Kα (150W) radiation.

The cathode was formulated by mixing the as-synthesized powder and PTFE at a weight ratio of 8:2, dispersed in isopropanol and deionized water (1:1 v/v). The obtained slurry was spread on SUS (steel use stainless) mesh as a gas diffusion layer as well as a current collector, followed by vacuum drying at 120^{o}C for 12 h. The electrolyte was 1 M LiTFSI dissolved in a TEGDME. Li foil was used as an anode, and coin cells (CR2032 type) were assembled in an argon-filled glove box.

Electrochemical measurements were carried out using a galvanostatic cycling method with a WBCS-3000 battery cycler (WonAtech) with the applied current density of 100 mA/g.

Results

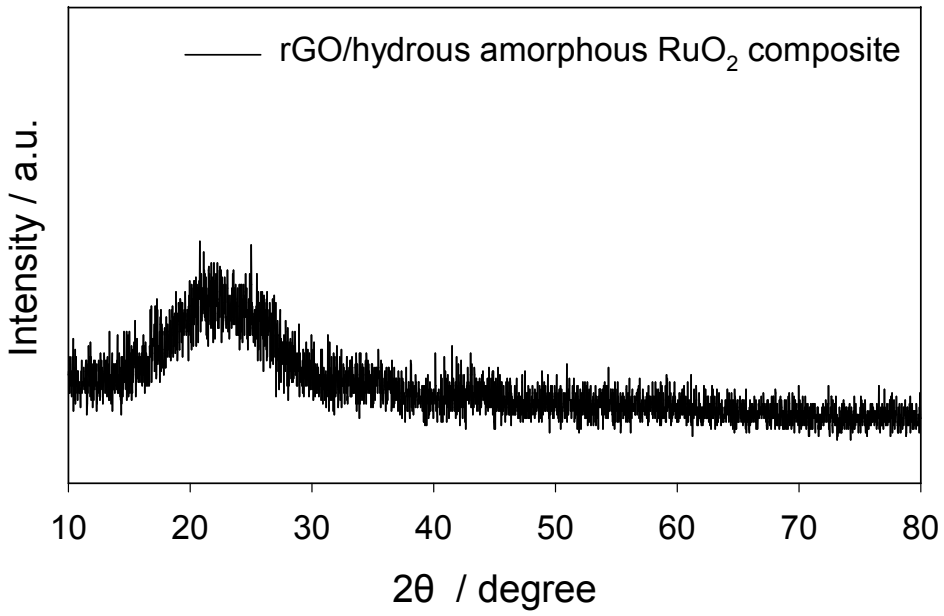

Fig. S1 XRD patterns of rGO and rGO/hydrous amorphous RuO_2 composite

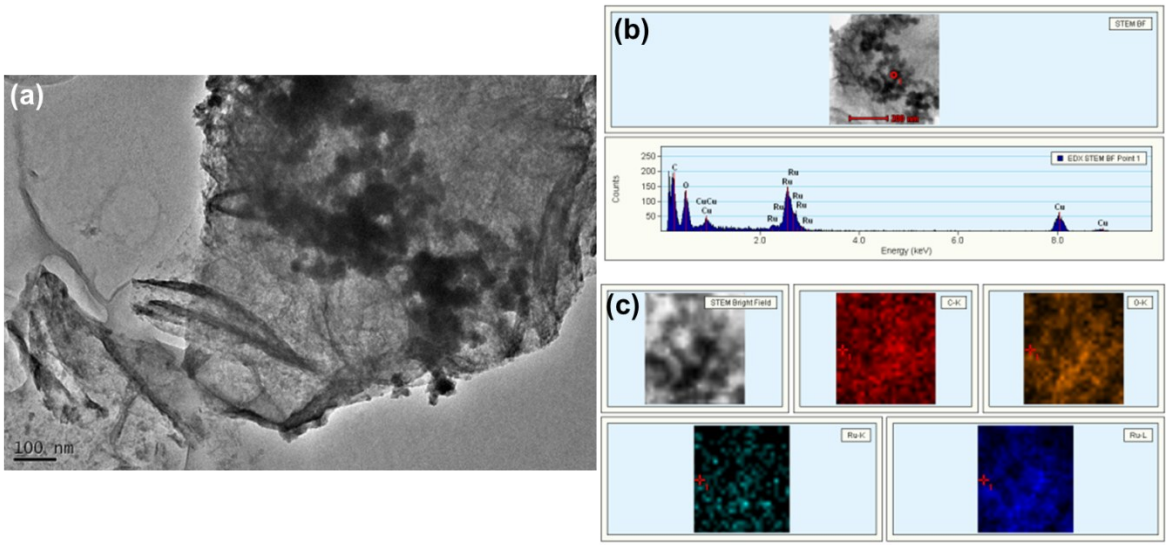

Fig. S2 TEM-EDS analysis of rGO/hydrous amorphous RuO_2 composite: (a) TEM image (b) EDS obtained from nanoparticle region (c) mapping images

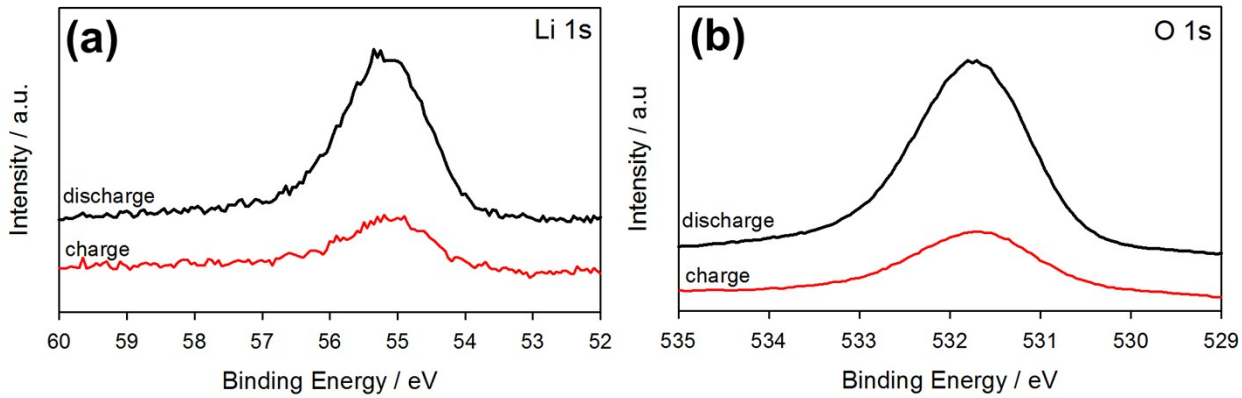

Fig. S3 XPS analysis of rGO/hydrous amorphous RuO_2 composite (a) Li 1s spectra and (b) O 1s spectra after the first discharge and charge

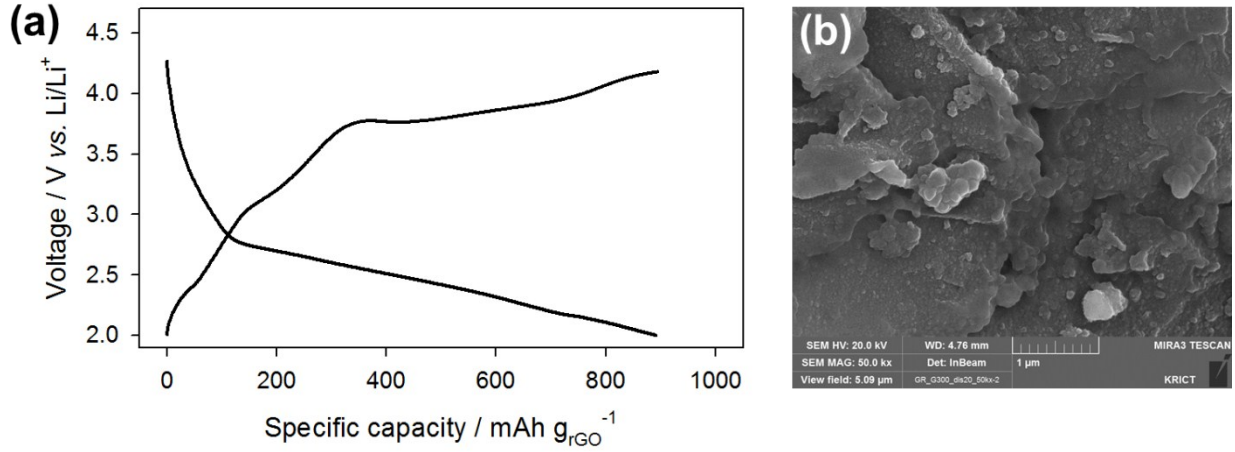

Fig. S4 rGO/dehydrated amorphous RuO_2 composite (a) voltage profile (b) FE-SEM image after first discharge