Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Performance study of magnesium-sulfur battery using graphene based sulfur composite as cathode electrode and a non-nucleophilic Mg electrolyte

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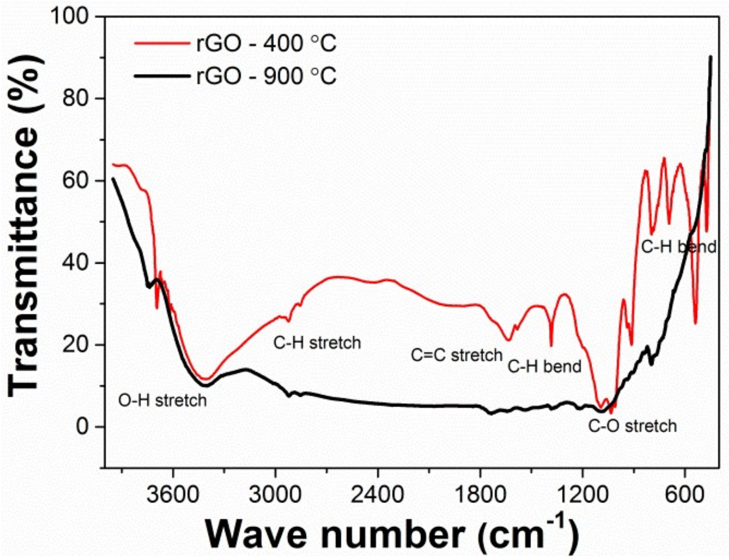

Fig.S1: FTIR spectra of rGO exfoliated at 400 °C and further heated to 900 °C under vacuum for 1 h.

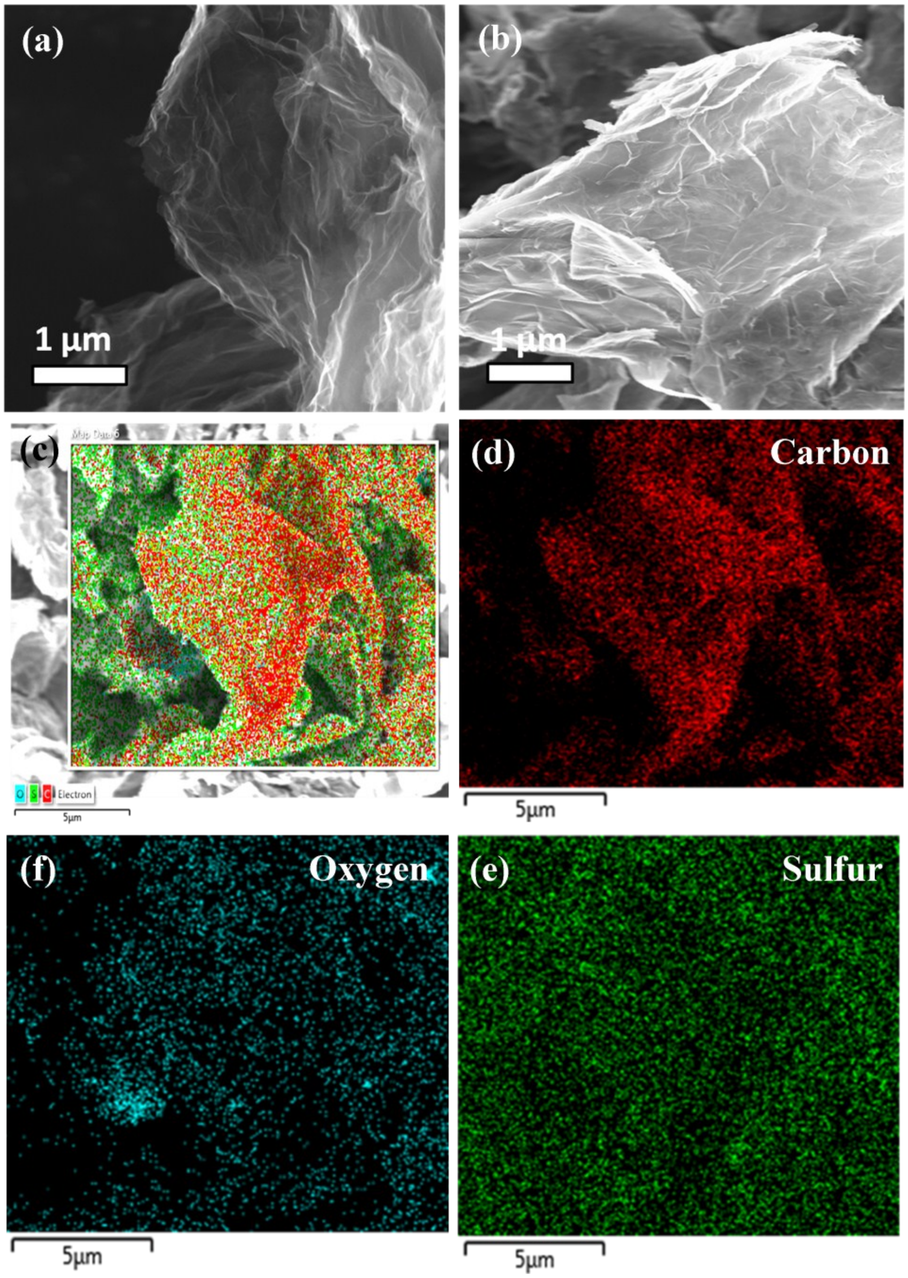

Fig. S2: Scanning electron micrographs of *rGO* (a), and S-*rGO* (b) nanocomposite. Elemental distribution within the samples was studied by energy dispersive X-ray spectroscopy (EDS), using SEM equipped with Silicon Drift Detector (OXFORD Instruments). Elemental mapping of S-*rGO* nanocomposite (c-f) illustrating the uniform distribution of C, O and S.

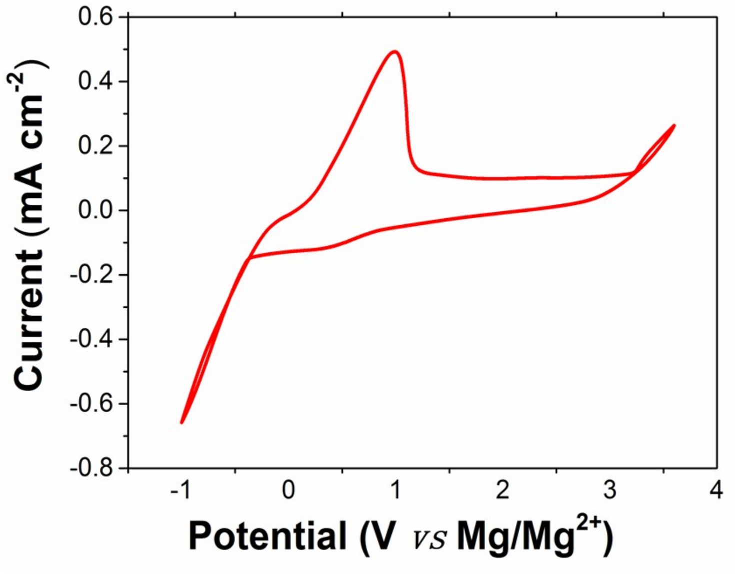

Fig.S3: Cyclic voltammetry of the non-nucleophilic Mg electrolyte using Inconel disc as the working electrode and a Mg foil as reference/counter electrode at a scan rate of 25 mV s^{-1}. The measurements were carried out with a two-electrode cell using Biologic VMP-3 potentiostat.

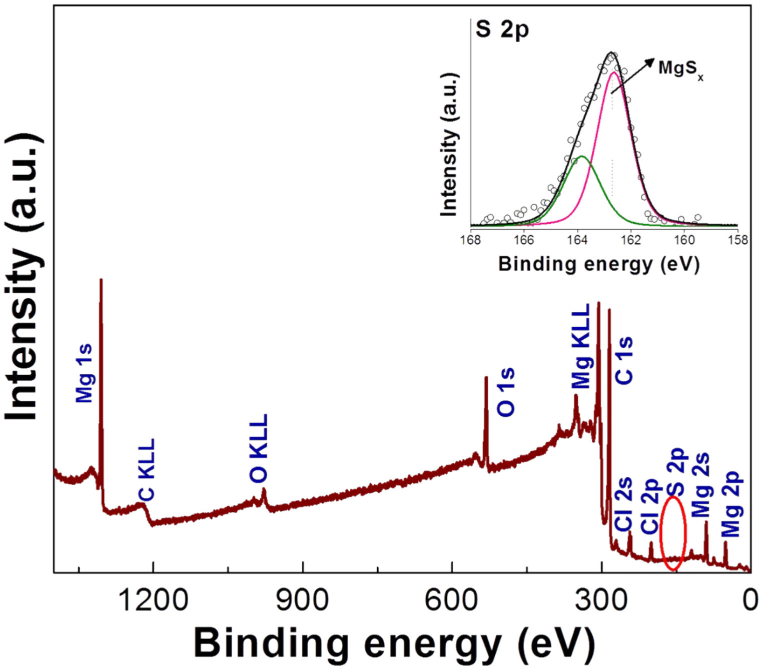

Fig. S4: XPS survey spectrum of a Mg/C anode after 50 battery cycles. Inset shows a high resolution S2p XP spectrum.

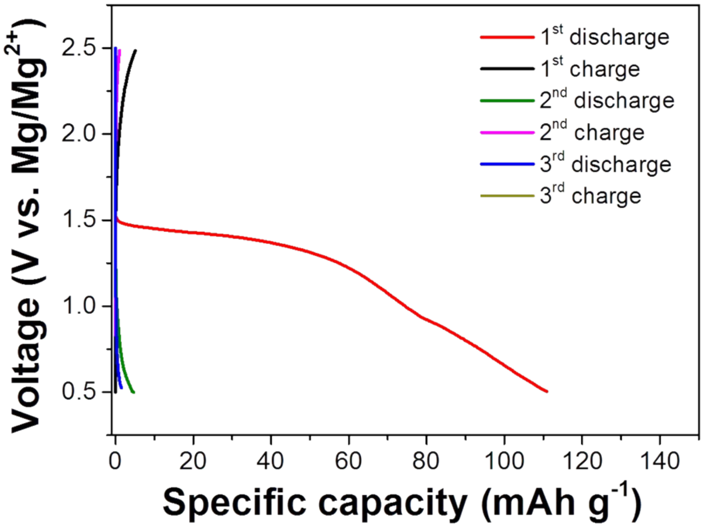

Fig.S5: Electrochemical battery performance of a sulfur cathode without rGO in Mg/S battery at the current density of 20 mAg^{-1}.

The cathode electrodes were made by mechanical mixing of 75 wt. % of sublimed sulfur (99.5 %, Alfa Aesar), 10 wt. % polyvinylidenefluoride (PVDF, Kynar) binder and 15 wt. % Super P carbon, using N-methyl-2-pyrrolidinone (NMP, Sigma-Aldrich) solvent. The slurry was uniformly coated over an Inconel 625 current collector disk (10 mm diameter) and dried at 60 °C for 24 h to remove the solvent. A Swagelok type cell was used with Mg-carbon composite pellets (10 mm) as anode electrode, Celgard 2500 as the separator, and a non-nucleophilic Mg electrolyte. The sulfur loading within the cathode electrode (1.5 mg cm^{-2}) and the amount of electrolyte (80 µL) were restricted to the same amount used in the previous cell with S-rGO as cathode electrode.

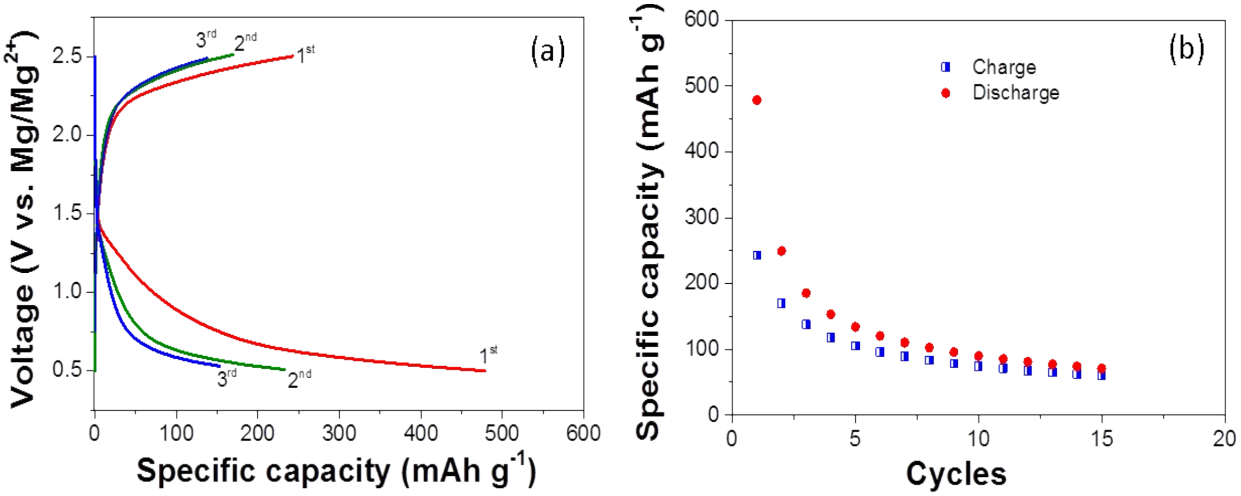

Fig.S6: Electrochemical Mg/S battery performance of a (Sulfur/high temperature treated rGO) composite cathode electrode at a current density of 20 mAg^{-1}. (a) Initial cycles, (b) Cyclic stability.

To understand the influence of the oxygen functional groups over rGO towards electrochemical Mg/S battery performance, we have carried out the following procedure. The rGO was heated to a high temperature of 900 °C under vacuum atmosphere for 1 hr to remove the oxygen functional groups. This sample was labelled as rGO (900 °C). The removal of oxygen functional groups from the sample were verified by FTIR (Fig. S1). Sulfur/rGO (900 °C) composite was prepared by mechanical mixing using a ball mill (200 rpm, 4hr). The sulfur loading within the composite was the same as that of S-rGO (52 wt. %). The cathode electrodes were made by mixing of 75 wt. % of sulfur/rGO (900 °C), 10 wt. % polyvinylidenefluoride (PVDF, Kynar) binder and 15 wt. % Super P carbon, using N-methyl-2-pyrrolidinone (NMP, Sigma-Aldrich) solvent. The slurry was uniformly coated over an Inconel 625 current collector disk (10 mm diameter) and dried at 60 °C for 24 h to remove the solvent. A Swagelok type cell was used with Mg-carbon composite pellets (10 mm) as anode electrode, Celgard 2500 as the separator, and a non-nucleophilic Mg electrolyte. The sulfur loading within the cathode electrode (1.5 mg cm^{-2}) and the amount of electrolyte (80 μL) was the same like that of the cell using S-rGO as cathode electrode.