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Enhanced Reliability of Aluminium-Sulfur Batteries with Cost-effective Ionic Liquid Electrolyte and Sulfur/Graphite Cathode

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Table S1: Comparison of recent Al-S battery performance in terms of cathode material and electrolyte

Reference	Cathode composition	Electrolyte	Sulfur Content (% wt)	Sulfur Loading (mg cm-2)	Cycle	Specific Current (mAg-1)	Initial to final Discharge capacity (mAhg-1)	Discharge Voltage (V)
2015[1]	Mixture of S.and ketien black,PVDF(50:30:20) on stainless steel (non-rechargeable)	EMIMCl-AlCl3 (1:1.5)	50	1.1	1	30	1400	1.2
2018[2]	Spreading the mixture of S and ionic liquid electrolyte onto activated CNF paper (S:CNF=1:2)	EMIMCl-AlCl3 (1:1.3)	33	1.0	50	30 (C/50)	1000–600	1.05
2020[3]	S on activated carbon cloth and Co catalyst	EMIMCl-AlCl3 (1:1.3)	n/a	0.8-1.0	100	1000	1320–500	0.65
2017[4]	Spreading the mixture of S and ionic liquid electrolyte onto activated CNF paper (S:CNF=1:2)	0.5M $LiCF_3SO_3$ in EMIMCl-AlCl3 (1:1.25)	33	1.0	1	30 (C/50)	1250	0.76
H.Yang et. Al,2018[5]	S, CMK-3,Ketjer black,PTFE (40:4010:10)	NBMP/ EMIMBr-AlCl3 (1:1.3)	40	n/a	20	251	1500–400	0.5
Y.Bian et. al, 2018[6]	S, MWCNT,Polyacrylic latex (10:80:10) on Ni foil	Urea-AlCl3 (1:1.4)	10	0.42	100	1000	740–500	1.7

W. Wang et. al, 2018[7]	Sulfurized Polyacrylonitrile (SPAN) and PTFE (80:10:10) on carbon paper.	EMIMCl-AlCl3 (1:1.5)	10	0.12	22	25	320–200	0.3
W. Chu et. al, 2019[8]	S,CMK-3 1:1, with 10 % PTFE and 10 % Super C on Mo foil	Acetamide-AlCl3 (1:13)	40	0.25	60	100	1500–500	0.55
K. Zhang et. al, 2019[9]	BN/S/C (6:1:2) with 10 % PVDF coated on Pt coated OHP organic	EMIMCl-AlCl3 (1:1.3)	10	0.3	100	100	532–100	1.15
Johan Lampkin et. al, 2020[10]	S,CNT with PEO and PVP coated on Mo foil (58.8:29.4:9:3.9	EMIMCl-AlCl3 (1:1.5)	58.8	0.4-3.5		50	1404	0.31
Johan Lampkin et. al, 2020[10]	S,CNT with PEO and PVP coated on Mo foil (58.8:29.4:9:3.9	Acetamide-AlCl3 (1:13)	58.8	0.4-3.5		50	2129	0.42
Johan Lampkin et. al, 2020[10]	S,CNT with PEO and PVP coated on Mo foil (58.8:29.4:9:3.9	Urea-AlCl3 (1:1.4)	58.8	0.4-3.5		50	2359	0.41
This work	**Sulfur-graphite active material and Super-p and PVDF (80:10:10) coated on SS Mesh**	**EMIMCl-AlCl3 (1:1.3)**	**70**	**0.8-1.0**	**2 50**	**200 300**	**1147–1281 947–600**	**1.8**

Characterization of cathode material pre and post electrochemical analysis:

TGA:

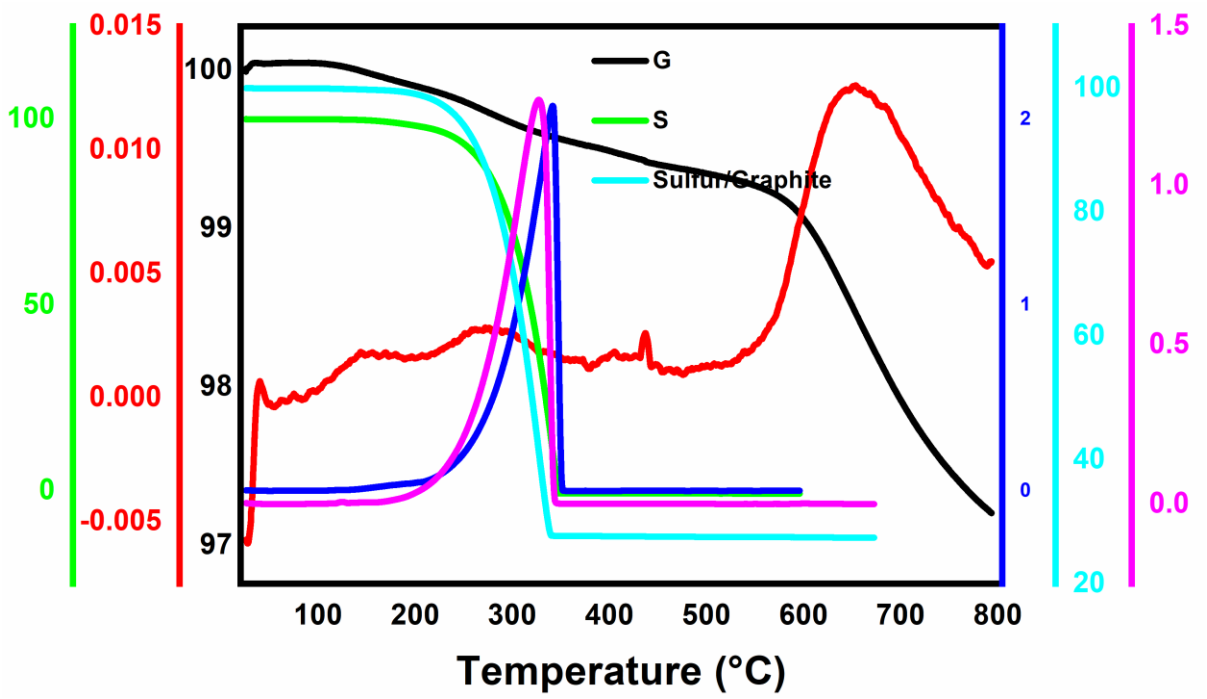

Fig. S1: TGA of sulfur, commercially procured graphite and composite S@Gf

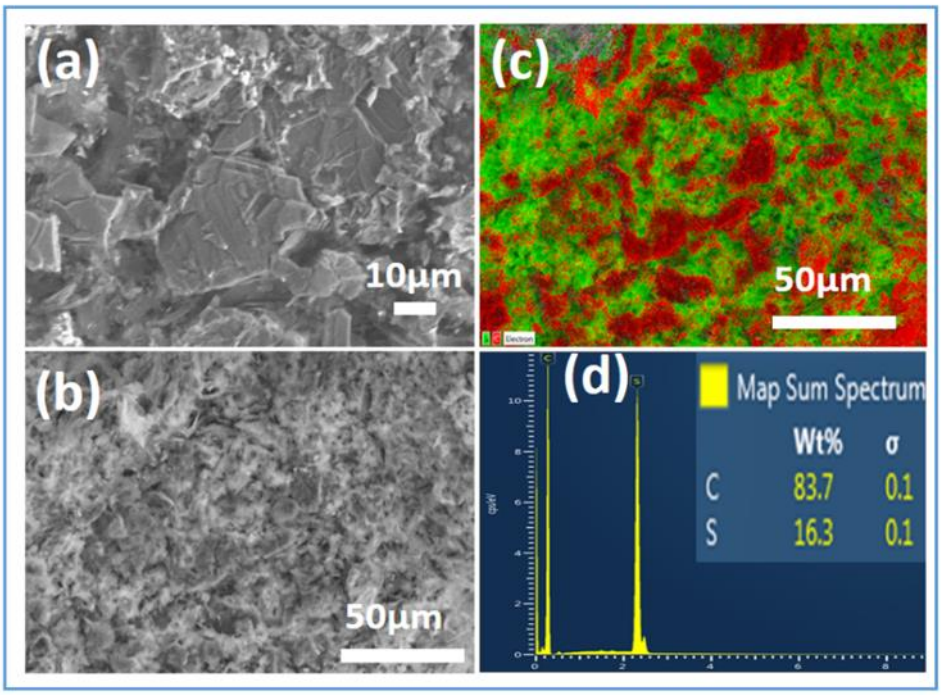

Fig. S2: Composite S@Gf SEM and EDAX and EDAX Mapping.

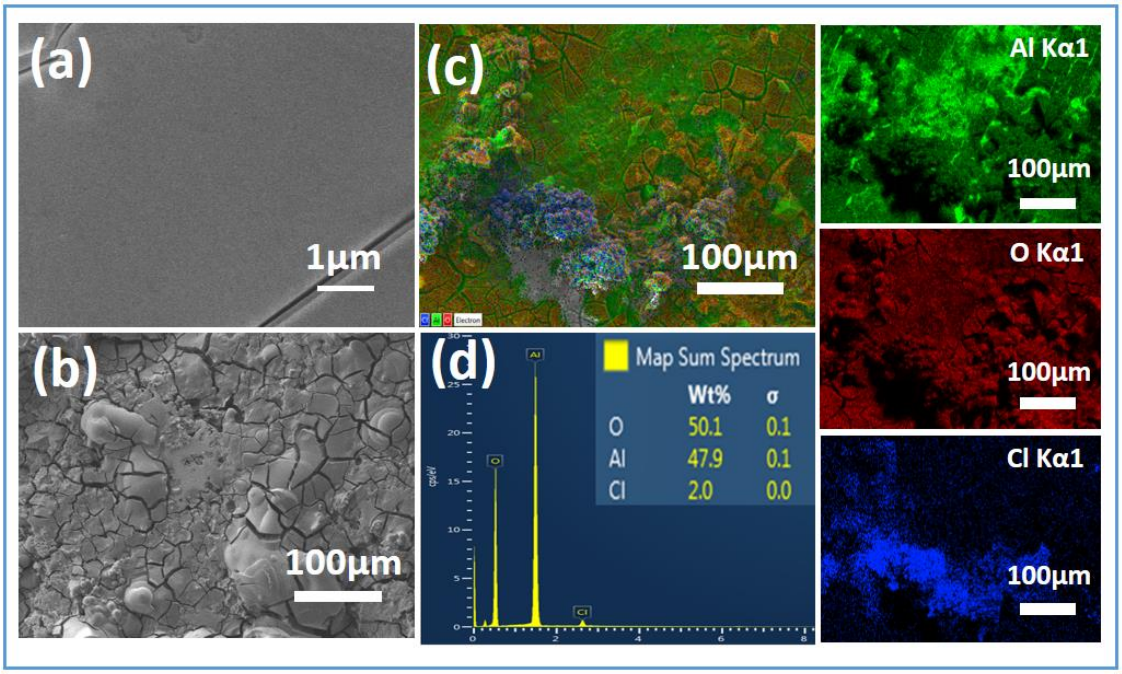

Fig. S3: (a-b) FE-SEM imgaes of charge state aluminium anode at 2.0 V, **(c-d)** EDAX and EDAX mapping

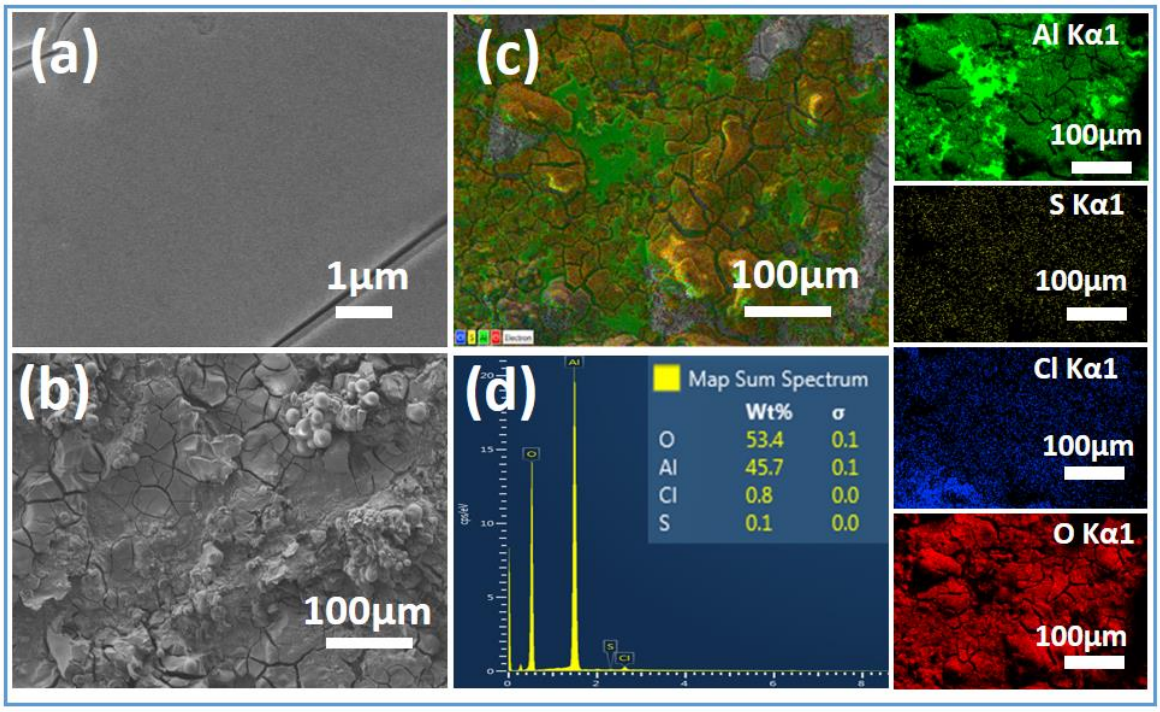

Fig. S4: (a-b) FE-SEM low magnification and high magnification and **(c-d)** EDAX and EDAX mapping at discharge state anode (Al) 0.1 V state

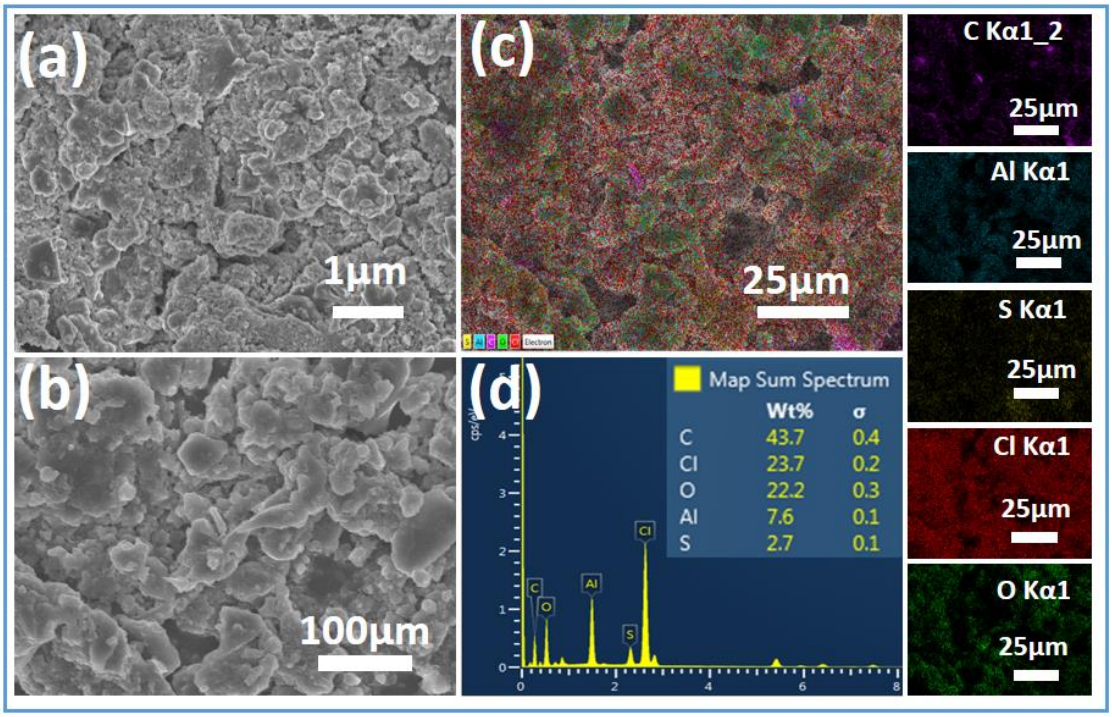

Fig. S5: (a-b)) EDAX and (**c-d)** mapping of Charge state cathode at 2.0 V FE-SEM low magnification and high magnification of S@Gf cathode material.

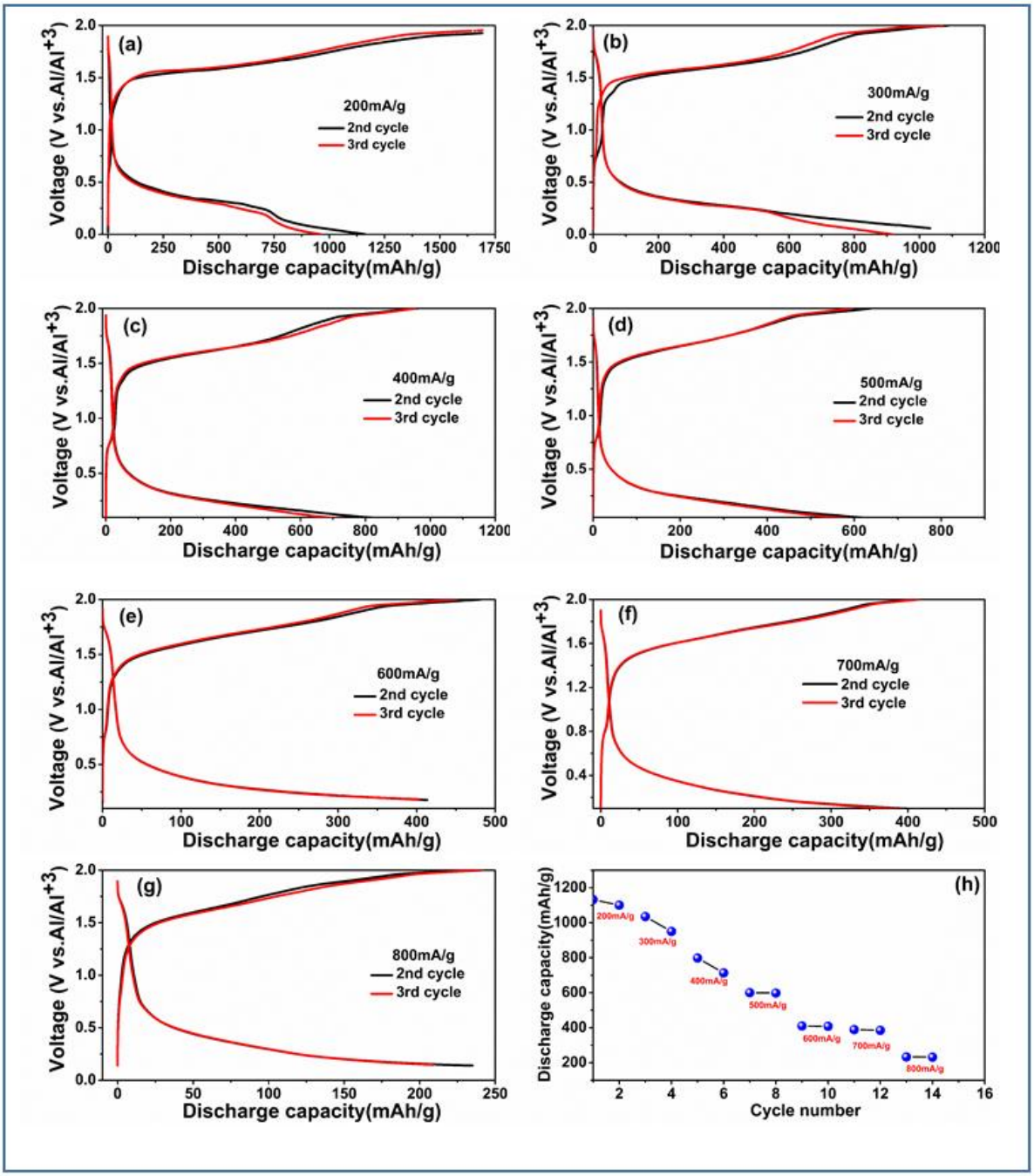

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Fig. S6 Charge discharge performance at current rate **a)** 200, **b)** 300, **c)** 400, **d)** 500, **e)** 600, **f)** 700, **g)** 800 mA/g and **h)** Discharge capacity vs. Cycle number**.**

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