MOF-derived carbon materials mounted with highly dispersed Ru and MoO_3 for rechargeable Li-O_2 cathode yield enhanced cyclability

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List of contents:

Total number of Pages(12)

Supplementary Figures(7)

Supplementary Tables(3)

Table S1 The experimental results of MOF applied to Li-O_2 cells

Year	Catalyst	Capacity (Current density)	Discharge voltage (V)	Charge voltage(V)	Cycle number(limited capacity or voltage, current density)
2014	N-Fe-MOF[1]	5300 mAh $g_{cat.}^{-1}$ (50 mA $g_{cat.}^{-1}$)	～2.8 V	～3.8 V	50 (2.5-4.1 V, 400 mAh g_{cat}^{-1})
2014	Mn-MOF-74-SP(4:4)[2]	9420mAh $g_{Super\ P}^{-1}$ (50 mA g^{-1}）	～2.7 V	～4.2 V	30 (1000 mAhg^{-1}, 250 mA g^{-1})
2014	FOC-SP[3] (1:5)	5970 mAh $g_{carbon+catalyst}^{-1}$ （0.1 mA cm^{-2}）	～2.7 V	～3.75 V	30 (600 mAh g^{-1}, 0.1 mA cm^{-2})
2015	Co-Mn-O nanocubes[4] -XC-72(4:5)	7653mAh g^{-1} （0.04 mA cm^{-2}）	～2.75 V	～4.1 V	100 (500 mAh g^{-1}, 0.16 mA cm^{-2})
2015	ZZFC Nanocages-SP(8:1)[5]	11000 mAhg^{-1} （300 mA g^{-1}）	2.7 V	4.26 V	15 (5000 mAh g^{-1}, 300 mA g^{-1})
2015	Ni-MOF-XC-72(3:6)[6]	9000 mA h g^{-1} （0.12 mA cm^{-2}）	2.8 V	3.5 V	170 (600 mAh g^{-1}, 0.6 mA cm^{-2})
2017	NPC/rGO-KB(6:3)[7]	7500 mAh g^{-1} （200 mA g^{-1}）	2.7 V	～4.2 V	125 (1000 mAh g^{-1}, 200 mA g^{-1})
2017	Co-MOF-74-SP(4:4)[8]	11350 mA h g^{-1} （100 mA g^{-1}）	2.74 V	～3.6 V	8 (1000 mAh g^{-1}, 250 mA g^{-1})
2018	MnCo-MOF-74-KB(4:4)[9]	11150 mAh g^{-1} （200 mA g^{-1}）	～2.7 V	～4.2 V	44 (1000 mAh g^{-1}, 200 mA g^{-1})
2018	Co/CoO/C@Ni[10]	8000 mAh g^{-1} （0.1 mA cm^{-2}）	～2.8 V	～3.5 V	70 (600 mAh g^{-1}, 0.1 mA cm^{-2})
2018	Co_9S_8@CPNs-SP(6:3)[11]	6000 mAh g^{-1} (100 mA g^{-1})	2.65 V	～４.２ V	110 (500 mAh g^{-1}, 100 mA g^{-1})

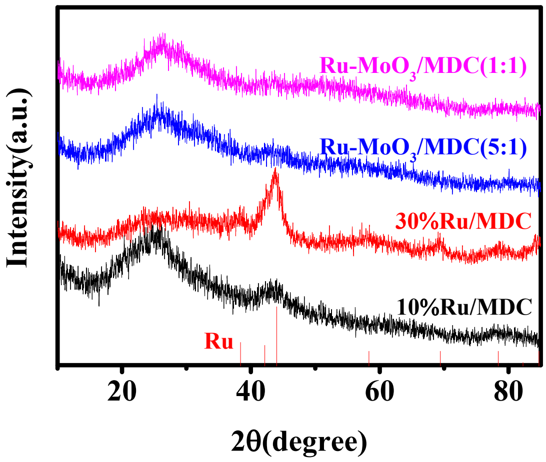

Fig. S1 XRD patterns of 10%Ru/MDC, 30%Ru/MDC, Ru-MoO_3/MDC(5:1), Ru-MoO_3/MDC(1:1) catalysts.

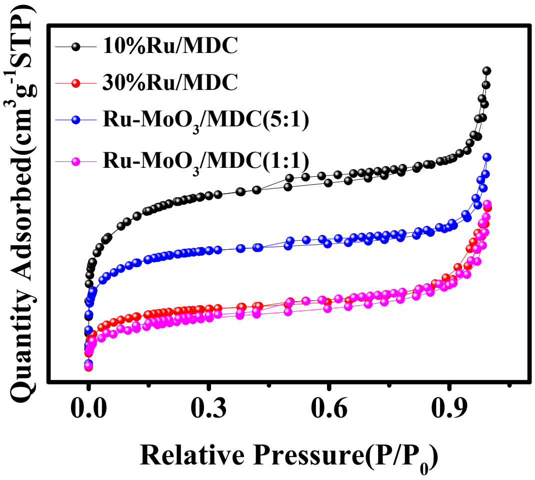

Fig.S2 N_2 adsorption–desorption isotherms of 10%Ru/MDC, 30%Ru/MDC; (b) Ru-MoO_3/MDC(5:1), Ru-MoO_3/MDC(1:1) catalysts.

Table S2 The details of the catalysts about specific surface area

Sample	BET Surface Area	Pore Volume
MDC	1170.8 m^2 g^{-1}	0.79 m^3 g^{-1}
10%Ru/MDC	786.6 m^2 g^{-1}	0.60 m^3 g^{-1}
20%Ru/MDC	565.0 m^2 g^{-1}	0.40 m^3 g^{-1}
30%Ru/MDC	306.5 m^2 g^{-1}	0.35 m^3 g^{-1}
MoO_3/MDC	703.4 m^2 g^{-1}	0.36 m^3 g^{-1}
Ru-MoO_3/MDC(5:1)	553.7 m^2 g^{-1}	0.42 m^3 g^{-1}
Ru-MoO_3/MDC(3:1)	496.1 m^2 g^{-1}	0.38 m^3 g^{-1}
Ru-MoO_3/MDC(1:1)	265.2 m^2 g^{-1}	0.37 m^3 g^{-1}

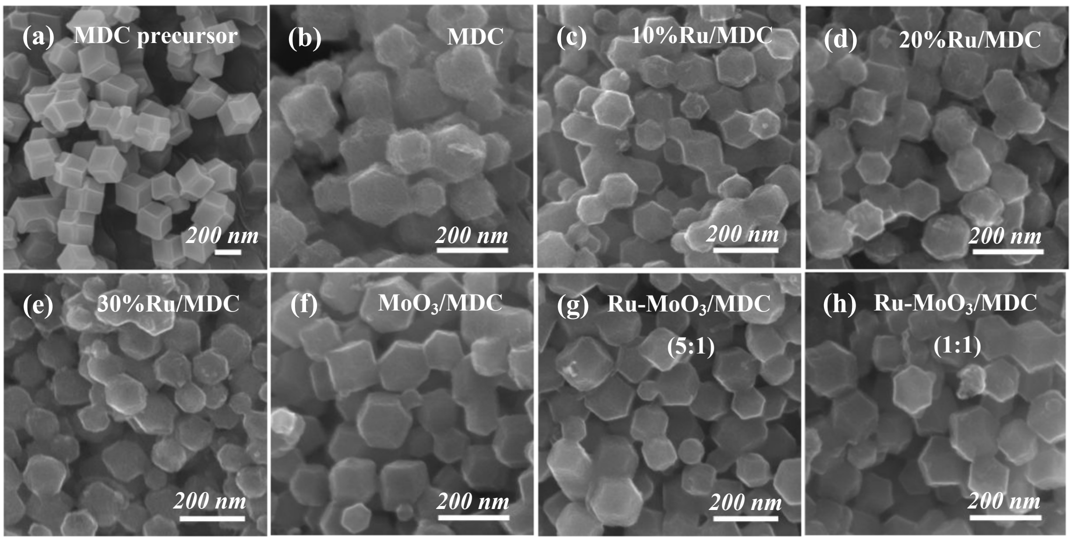

Fig.S3 SEM images of (a) MDC precursor; (b) MDC; (c) 10%Ru/MDC; (d) 20%Ru/MDC; (e) 30%Ru/MDC; (f) MoO_3/MDC; (g) Ru-MoO_3/MDC(5:1); (h) Ru-MoO_3/MDC(1:1)catalysts.

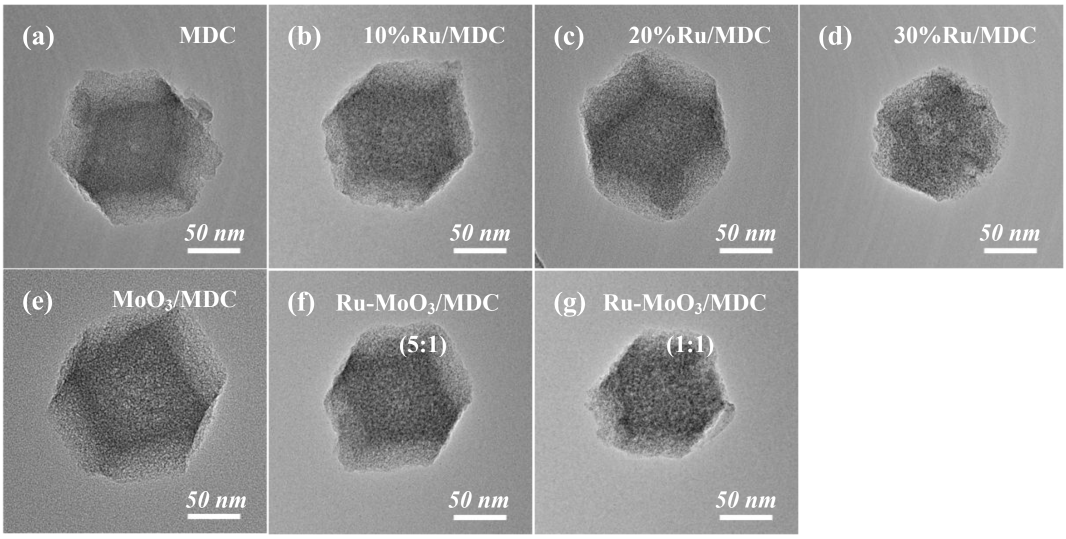

Fig.S4 TEM images of (a) MDC; (b) 10%Ru/MDC; (c) 20%Ru/MDC; (d) 30%Ru/MDC (e) MoO_3/MDC; (f) Ru-MoO_3/MDC(5:1); (g) Ru-MoO_3/MDC(1:1)catalysts.

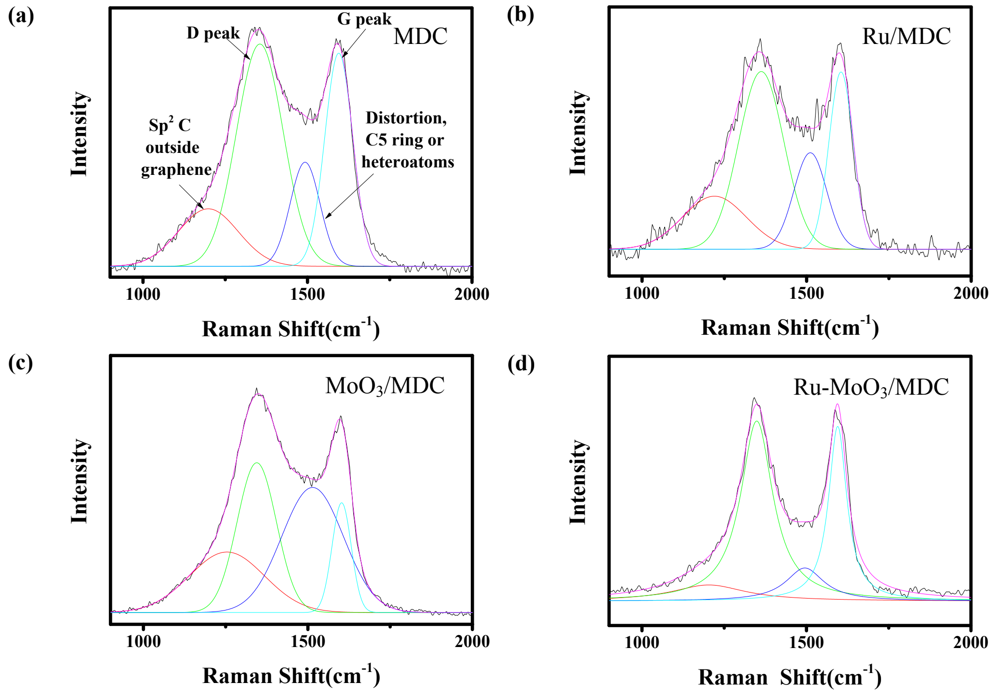

Fig.S5 Raman fitting curves of (a) MDC; (b) Ru/MDC; (c) MoO_3/MDC; (d) Ru-MoO_3/MDC

Table S3. Raman fitting results of various catalysts.

Sample	Sp2 C-outside graphene %	D peak %	Distortion, C5 ring or heteroatoms %	G peak %
MDC	15.02%	45.35%	13.53%	26.1%
Ru/MDC	17.89%	42.56%	16.8%	22.75%
MoO_3/MDC	22.42%	29.02%	38.16%	10.39%
Ru-MoO_3/MDC	10.44%	50.69%	10.99%	27.88%

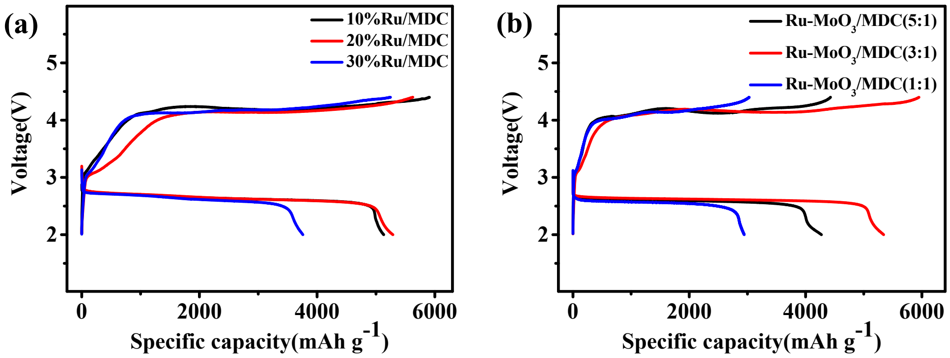

Fig.S6 First discharge-charge curves of (a) 10%Ru/MDC, 20%Ru/MDC, 30%Ru/MDC; (b) Ru-MoO_3/MDC(5:1), Ru-MoO_3/MDC(3:1), Ru-MoO_3/MDC(1:1) catalysts.

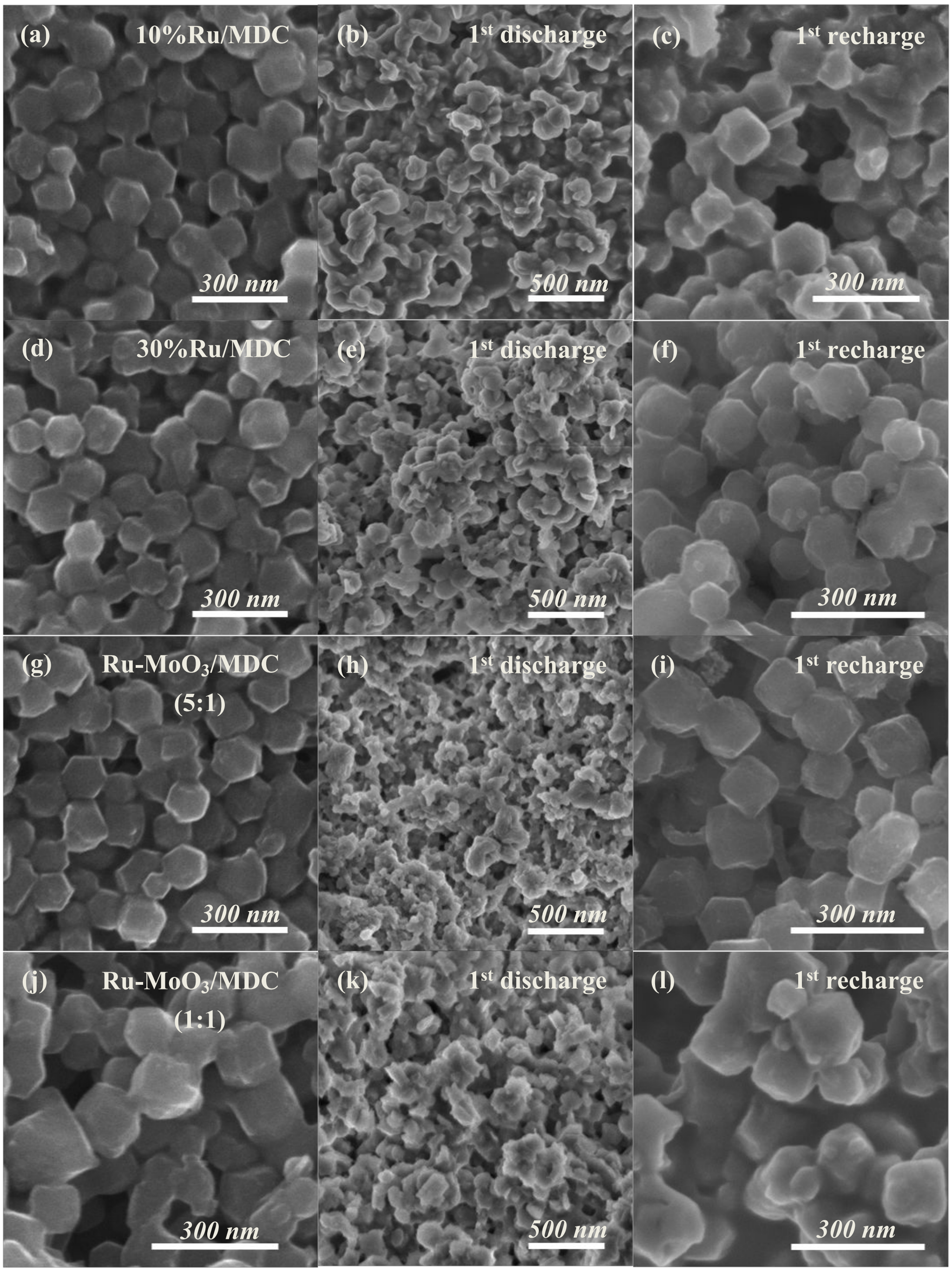

Fig.S7 SEM images of Li-O_2 batteries based on 10%Ru/MDC, 30%Ru/MDC, Ru-MoO_3/MDC(5:1), Ru-MoO_3/MDC(1:1) as oxygen cathodes before discharge(a,d,g,j), after first discharge (b,e,h,k) and recharged (c,f,i,l).

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