Supporting information

Fabrication of Mesoporous $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ Perovskite as a Low-Cost and Efficient Catalyst for Oxygen Reduction

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Tables

Table S1. Elements quantification of samples by EDX.

Sample	Element	Wt. %	At. %	Sample	Element	Wt. %	At. %
m-BSCF	Ba	41.70	20.51	CS-BSCF	Ba	40.58	20.74
	Sr	22.59	17.42		Sr	24.55	19.67
	Co	23.23	26.62		Co	23.98	28.56
	Fe	5.72	6.92		Fe	5.37	6.75
	O	6.76	28.53		O	5.54	24.29
	Total	100.00	100.00		Total	100.00	100.00

Table S2. Elements quantification of samples by ICP-OES.

Sample	Element	Wt. %	At. %	Sample	Element	Wt. %	At. %
m-BSCF	Ba	45.5	0.33	CS-BSCF	Ba	42.3	0.31
	Sr	27.8	0.32		Sr	26.7	0.31
	Co	28.4	0.48		Co	23.8	0.40
	Fe	7.29	0.13		Fe	6.89	0.12

Table S3. Pore structural parameters and the electron-transfer number of prepared composites

Sample	S_{BET}[a] /m^2g^{-1}	D_{BJH}[b] /nm	V_{BJH}[c] /cm^3g^{-1}	$ECSA$[d] /$m^2\ g_{cat.}^{-1}$	$BET_{cur.}$ [e] /mA $m_{cat.}^{-2}$
CS	560	-	-	-	-
KIT-6	916	7.8	1.2	-	
CS-BSCF	13	-	-	7.5	390
m-BSCF	81	11.7	0.37	24	98.9
SG-BSCF	2.5	-	-	6.7	1470
20wt%Pt/C	185			-	

[a] BET surface area

[b] BJH desorption average pore diameter

[c] BJH desorption cumulative pore volume.

[d] electrochemically active surface area (ECSA), which is calculated by formula:

$$\mathrm{ECSA} = \frac{S_H/V}{0.21(mC.cm^{-2}) \cdot M_{\mathrm{catal}}}$$

S_H: ORR peak area; V: scan rate; $mC.cm^{-2}$: Milli Cullen.per square centimeter; M_{catal}: quality of catalyst with the unit of gram.

[e] ORR peak current versus BET surface area, which is calculated by formula:

$$\mathrm{BET_{cur.}} = \frac{I_{ORR}}{S_{BET} \times 0.0686}$$

I_{ORR}: ORR peak current (mA); S_{BET}: BET surface area of catalyst ($m^2\ g^{-1}$); 0.0686: the quality of catalyst transferred to the working electrode (mg).

Table S4. Electrochemical parameters of ORR performance for the prepared samples.

Sample	V_O[a] /V	J_L[b]/ $mAcm_{disk}^{-2}$	J_K[c]/ $mAcm_{disk}^{-2}$	*I*s[d] /$\mu A\ cm^{-2}_{cat.}$	*I*m[e] /$A\ g^{-1}_{cat.}$	n[f]
CS-BSCF	-0.25	4.6	4.2	246.7	32.1	2.7-3.2
m-BSCF	-0.05	5.2	5.0	44.4	35.7	3.6-3.8
SG-BSCF	-0.28	3.6	3.9	446.4	24.3	2.9-3.3
20wt%Pt/C	0.05	4.8	5.3	17.9	36.4	3.8-3.9

[a] onset potential vs Ag/AgCl

[b] limited current density

[c] kinetic current density extrapolated from the intercept of the linearly fitted K-L plots at -0.55 V (versus Ag/AgCl)

[d] Specific ORR activity (*I*s)

[e] Mass ORR activity (*I*m)

[f] Electron transfer number.

Table S5. Comparison of ORR performance for BSCF catalysts in alkaline medium.

Catalyst	Loading $mg_{cat\cdot}\ cm_{disk}^{-2}$	Electrolyte	E_{onset} vs. RHE/V	Limited Current / $mAcm_{disk}^{-2}$	n	Ref.
m-BSCF	0.15	0.1 M KOH	0.925	5.2	3.5-3.8	This work
BSCF	0.64	0.1 M KOH	0.75	5.0	3.5-3.6	[1]
O_2-BSCF	0.64	0.1 M KOH	0.75	6.0	3.7-3.8	[1]
BSCF-NC	0.40	0.1 M KOH	0.93	5.2	3.9	[2]
BSCF/AB	0.26	0.1 M KOH	0.80	4.0	3.5-3.7	[3]

Reference:

[1] Jae-Il Jung, Hu Young Jeong, Min Gyu Kim, Gyutae Nam, Joohyuk Park, and Jaephil Cho, Fabrication of $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ Catalysts with Enhanced Electrochemical Performance by Removing an Inherent Heterogeneous Surface Film Layer, *Adv. Mater.*, **2015**, *27*, 266–271.

[2] Jian Wang, Hong Zhao, Yang Gao, Dengjie Chen, Chi Chen, Mattia Saccoccio, Francesco Ciucci, $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ on N-doped mesoporous carbon derived from organic waste as a bi-functional oxygen catalyst. *Int. J. Hydrogen Energy*, **2016**, 41, 10744-10754.

[3] Emiliana Fabbri, Rhiyaad Mohamed, Pieter Levecque, Olaf Conrad, Rudiger Kotz, Thomas J. Schmidt, Composite Electrode Boosts the Activity of $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ Perovskite and Carbon toward Oxygen Reduction in Alkaline Media. *ACS Catal.*, **2014**, 4, 1061−1070.

Figures

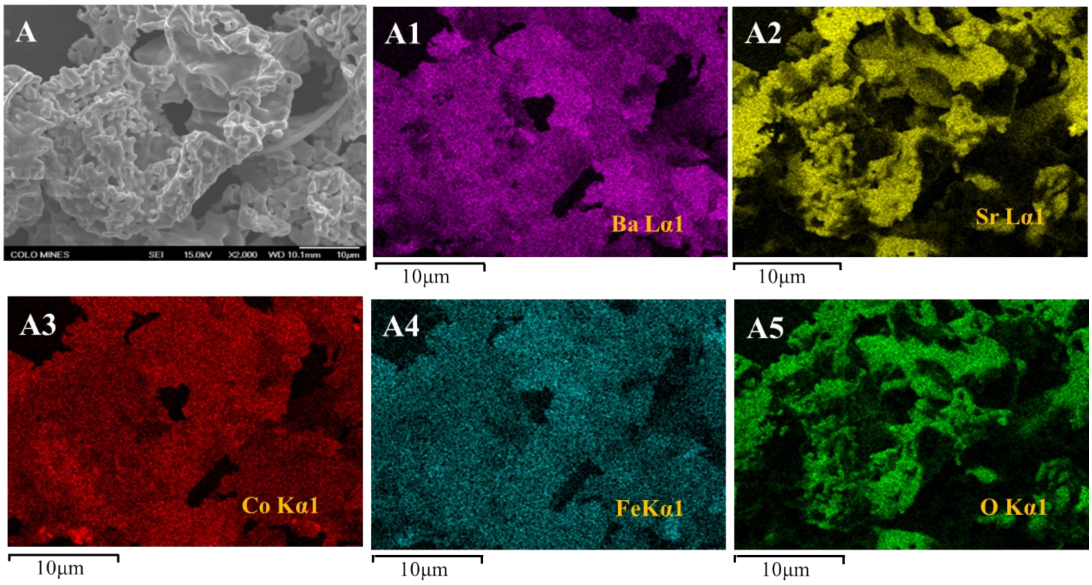

Fig. S1 SEM image of the sample CS-BSCF (A) and the corresponding element mappings (A1-A5).

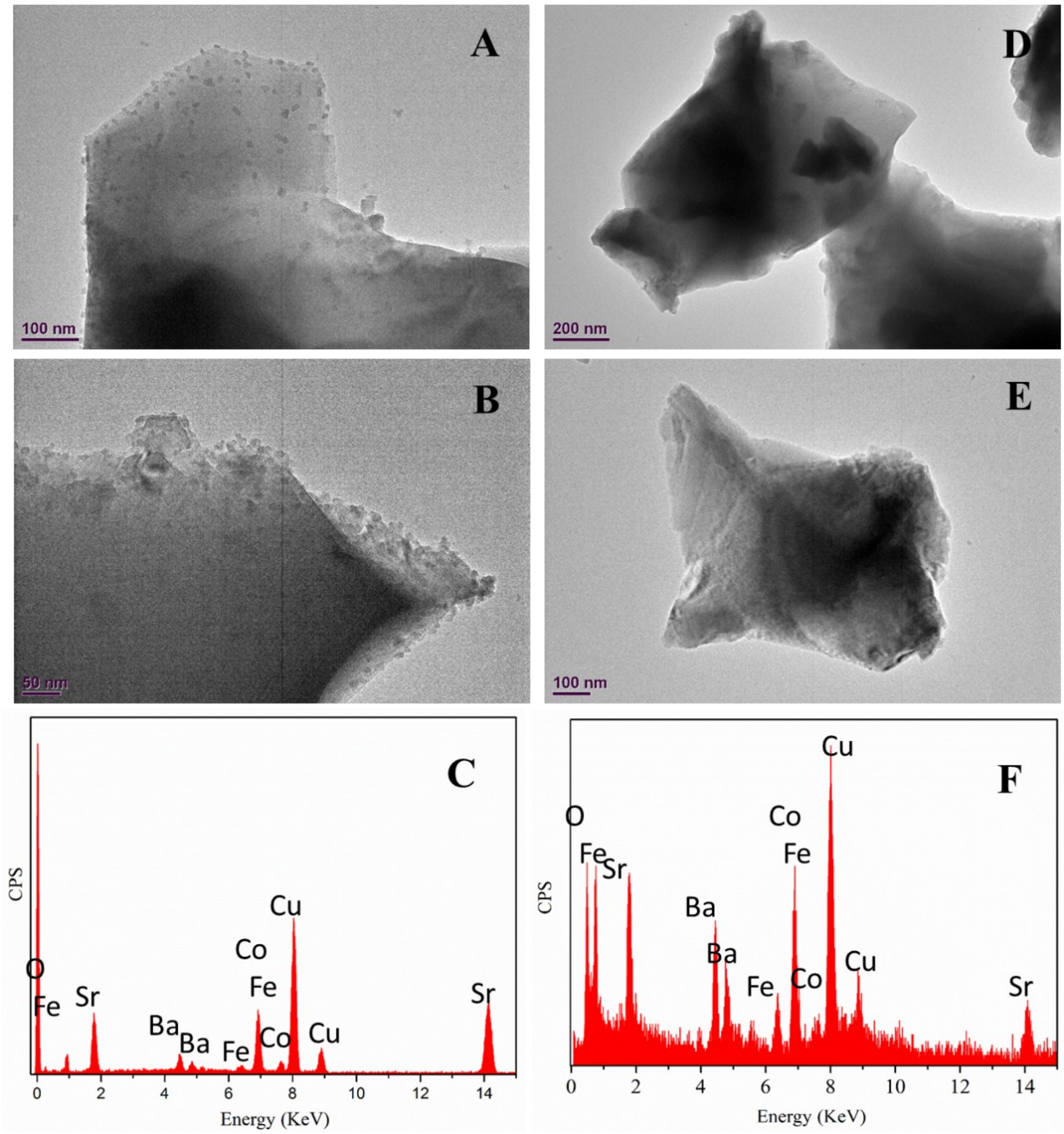

Fig. S2 TEM images of sample CS-BSCF (A, B) and SG-BSCF (D, E); (C) and (F) are the corresponding EDX spectra of CS-BSCF and SG-BSCF, respectively.

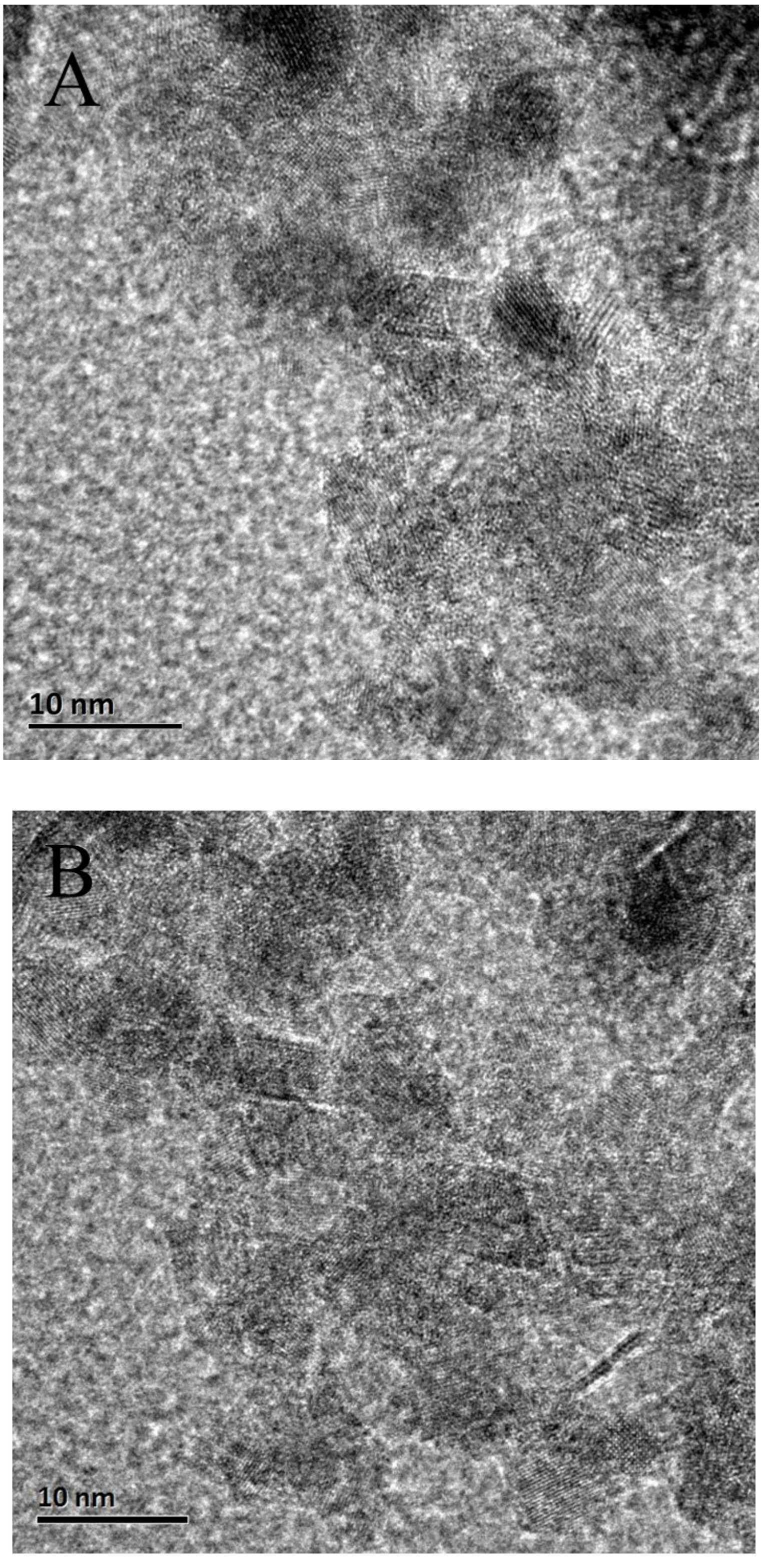

Fig. S3 HR-TEM images of m-BSCF, (A) as prepared sample, (B) after cycled for 100th in oxygen saturated 0.1 M KOH.

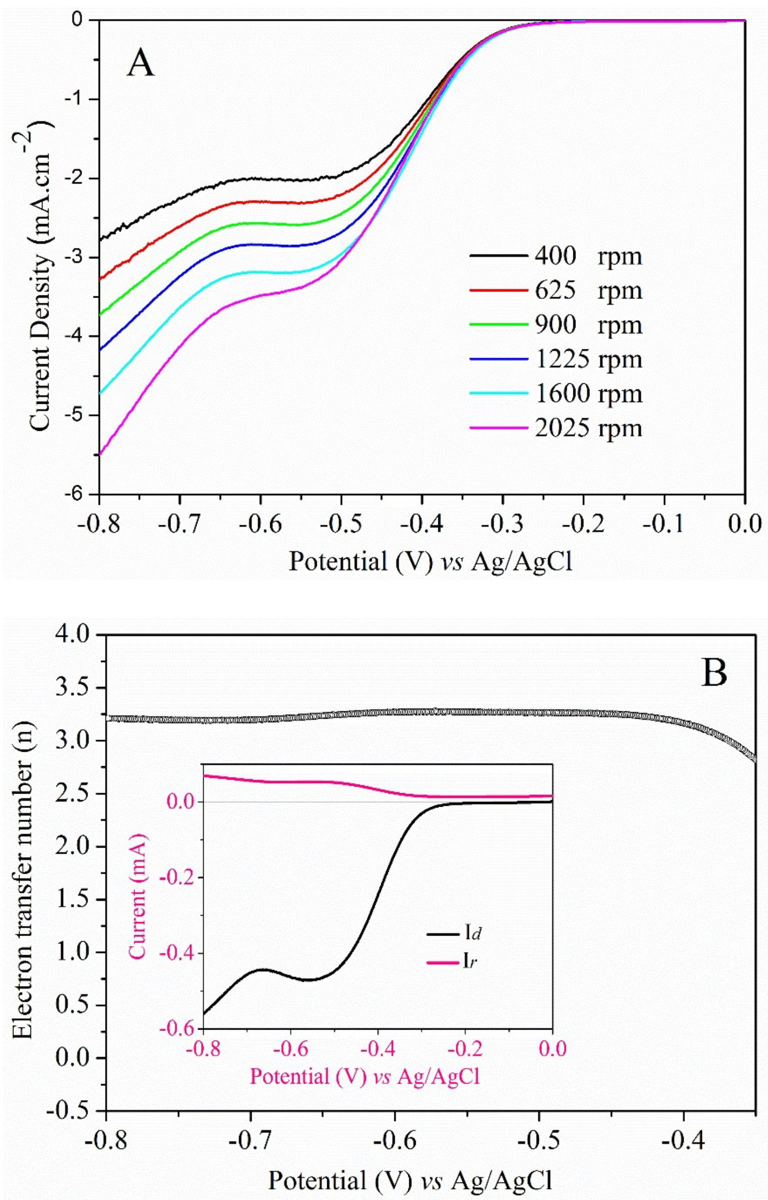

Fig. S4 (A) LSV curves of sample CS-BSCF in oxygen saturated 0.1 M KOH, (B) Electron transfer number of CS-BSCF during the oxygen reduction process in the same electrolyte and the corresponding I*d* and I*r* curves in the inset.

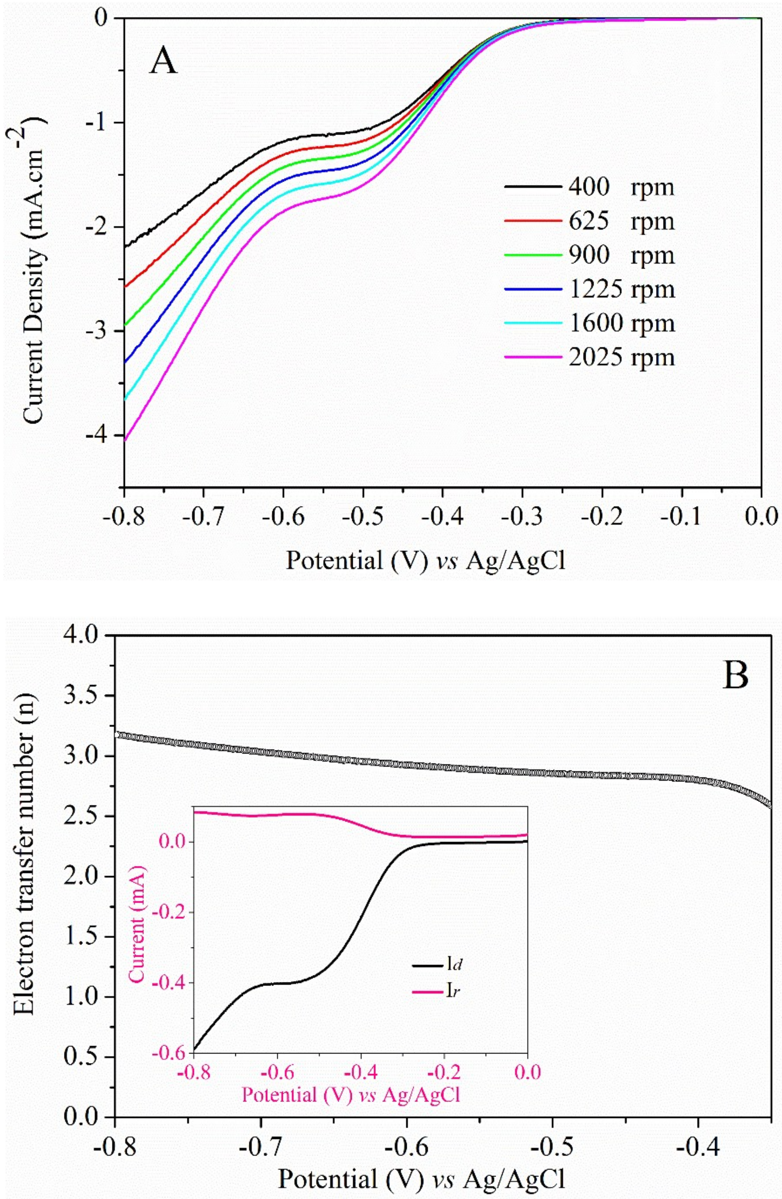

Fig. S5 (A) LSV curves of sample SG-BSCF in oxygen saturated 0.1 M KOH, (B) Electron transfer number of CS-BSCF during the oxygen reduction process in the same electrolyte and the corresponding I*d* and I*r* curves in the inset.

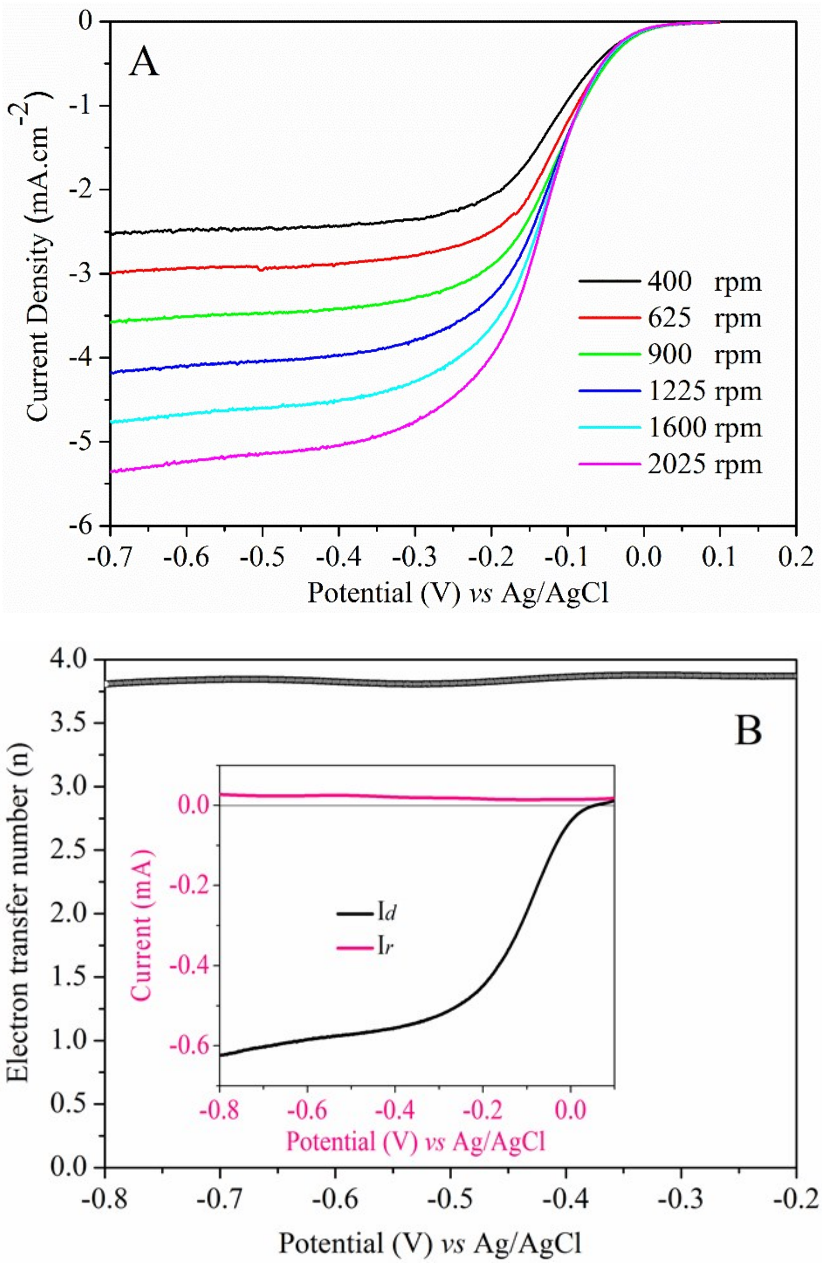

Fig. S6 (A) LSV curves of reference sample 20wt%Pt/C in oxygen saturated 0.1 M KOH, (B) Electron transfer number of 20wt%Pt/C during the oxygen reduction process in the same electrolyte and the corresponding I*d* and I*r* curves in the inset.

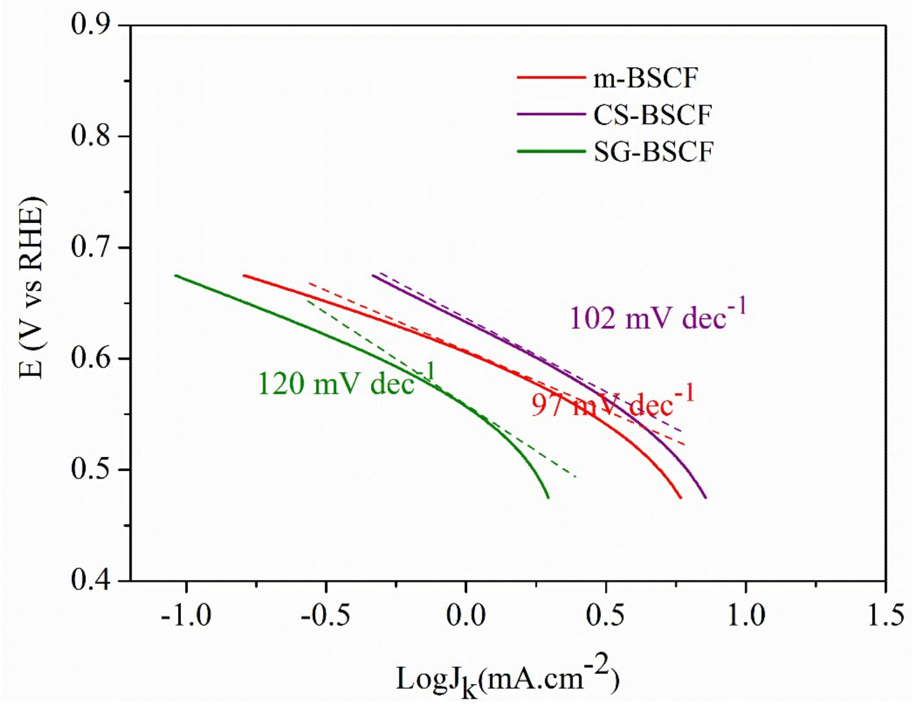

Fig. S7 Tafel plots of the prepared samples.

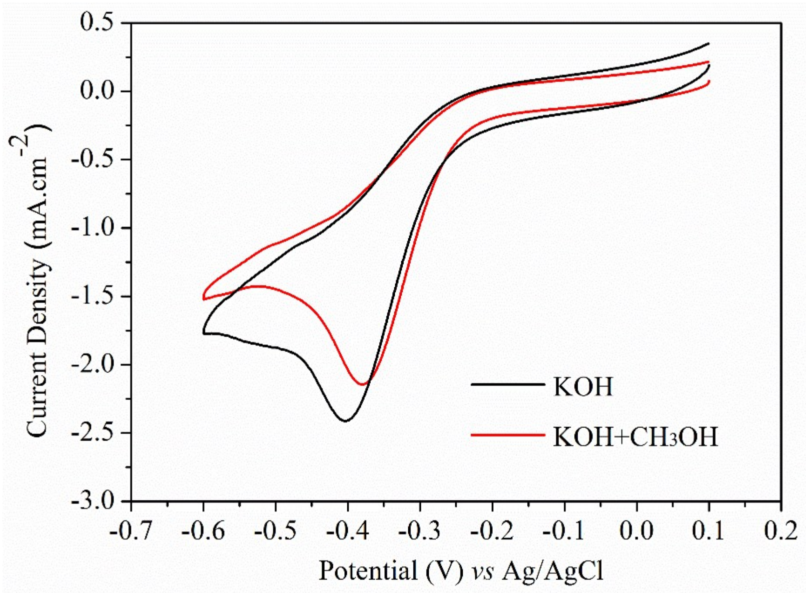

Fig. S8 Methanol tolerance property of CS-BSCF in electrolyte of 0.1M KOH and 3M CH_3OH.

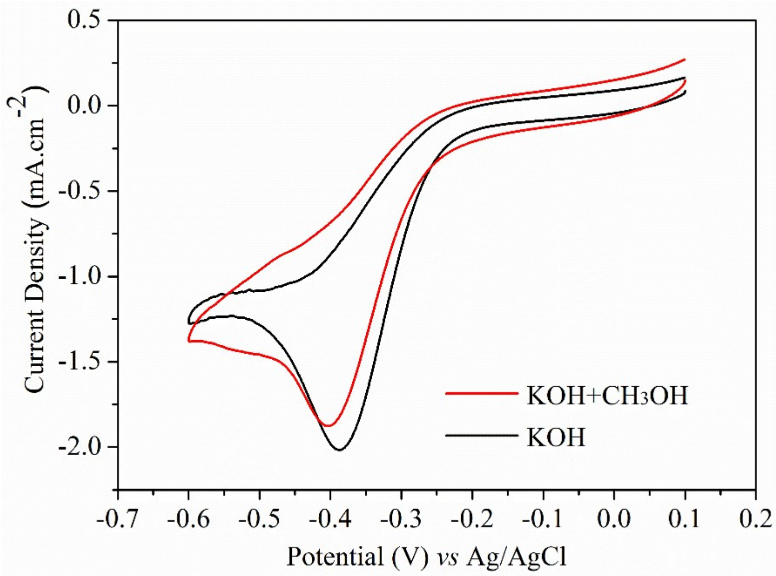

Fig. S9 Methanol tolerance property of SG-BSCF in electrolyte of 0.1M KOH and 3M CH_3OH.