Supplementary Information for

Temperature-Induced Structural Reorganization of W-doped $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ Composite Membranes for Air Separation

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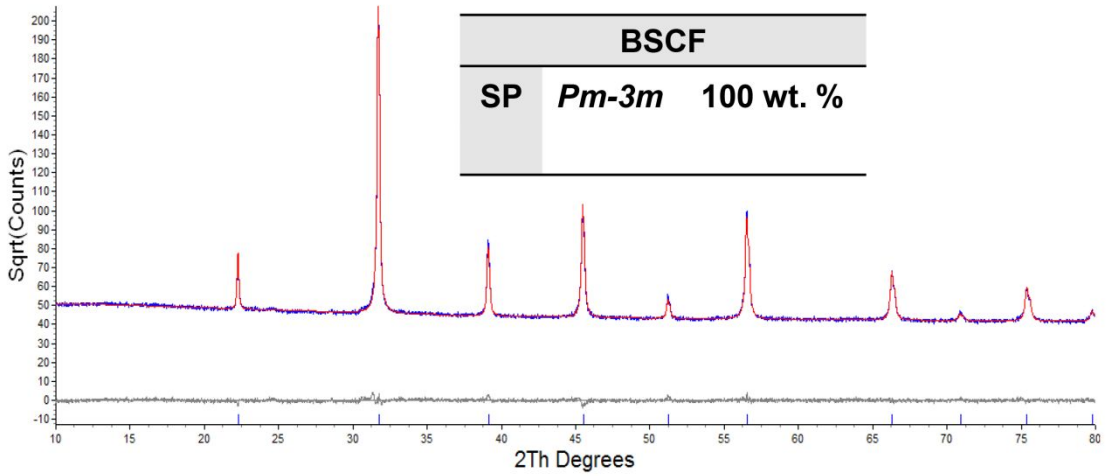
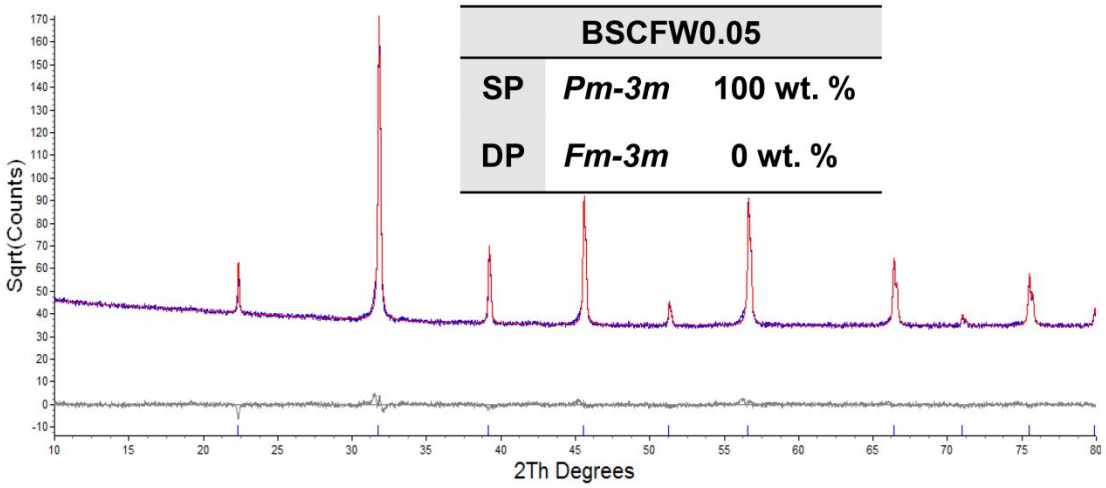

BSCF
SP Pm-3m 100 wt. %
Sqrt(Counts)
2Th Degrees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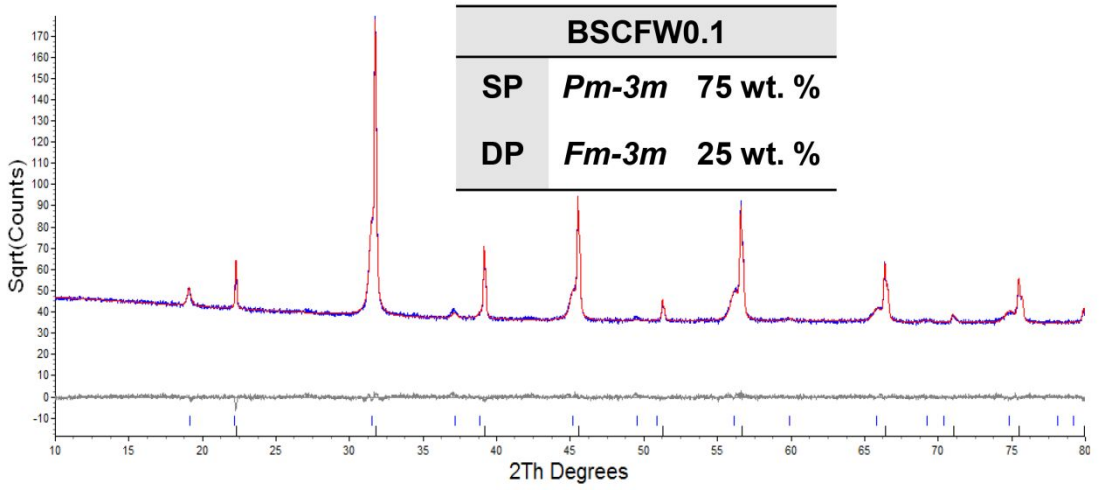
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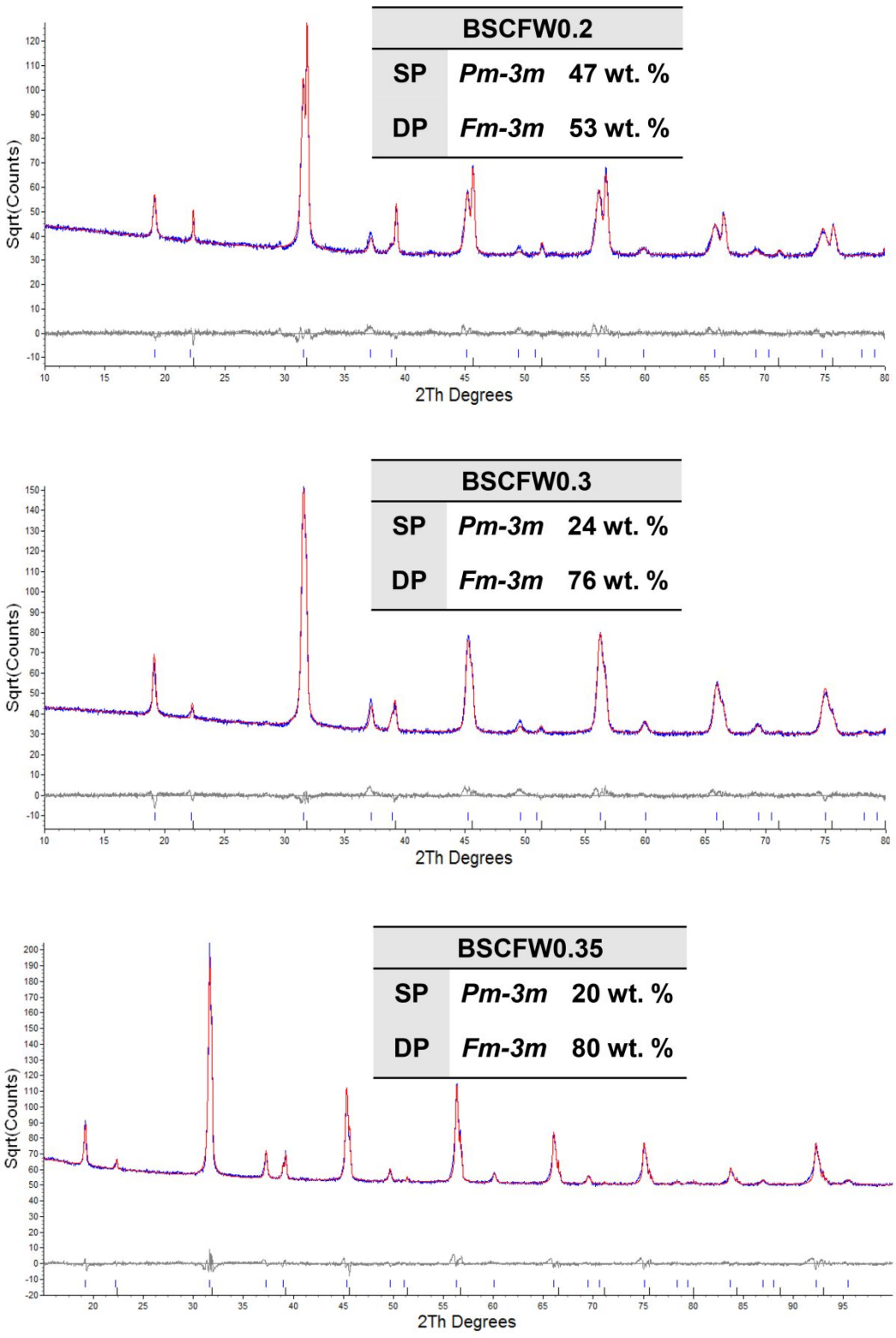

Figure S1. The original XRD results of quantitative Rietveld analysis made with commercial TOPAS software for BSCF-W series

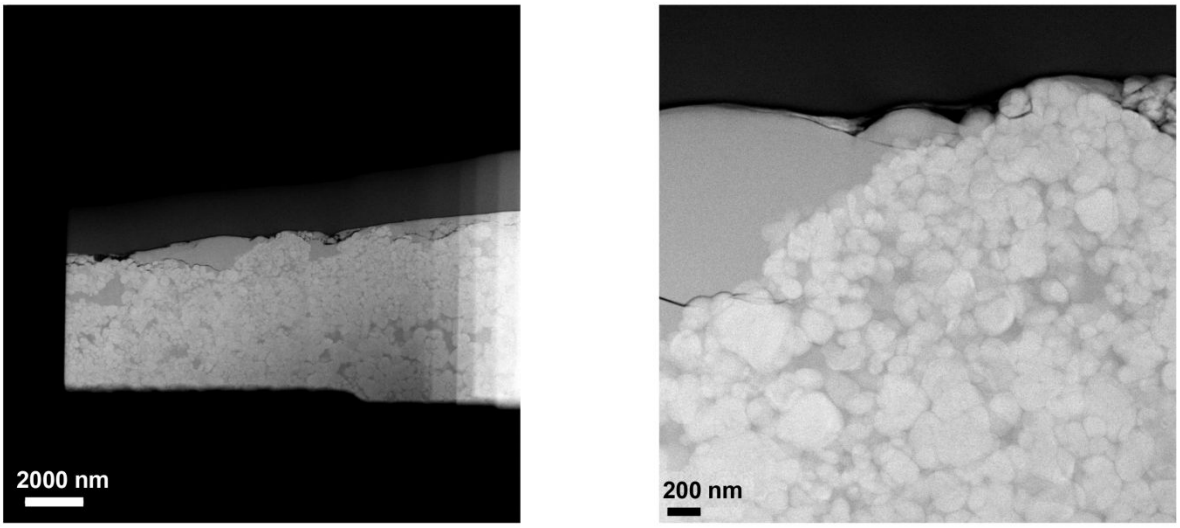

Figure S2: Low magnification HAADF-STEM images of BSFCW0.35

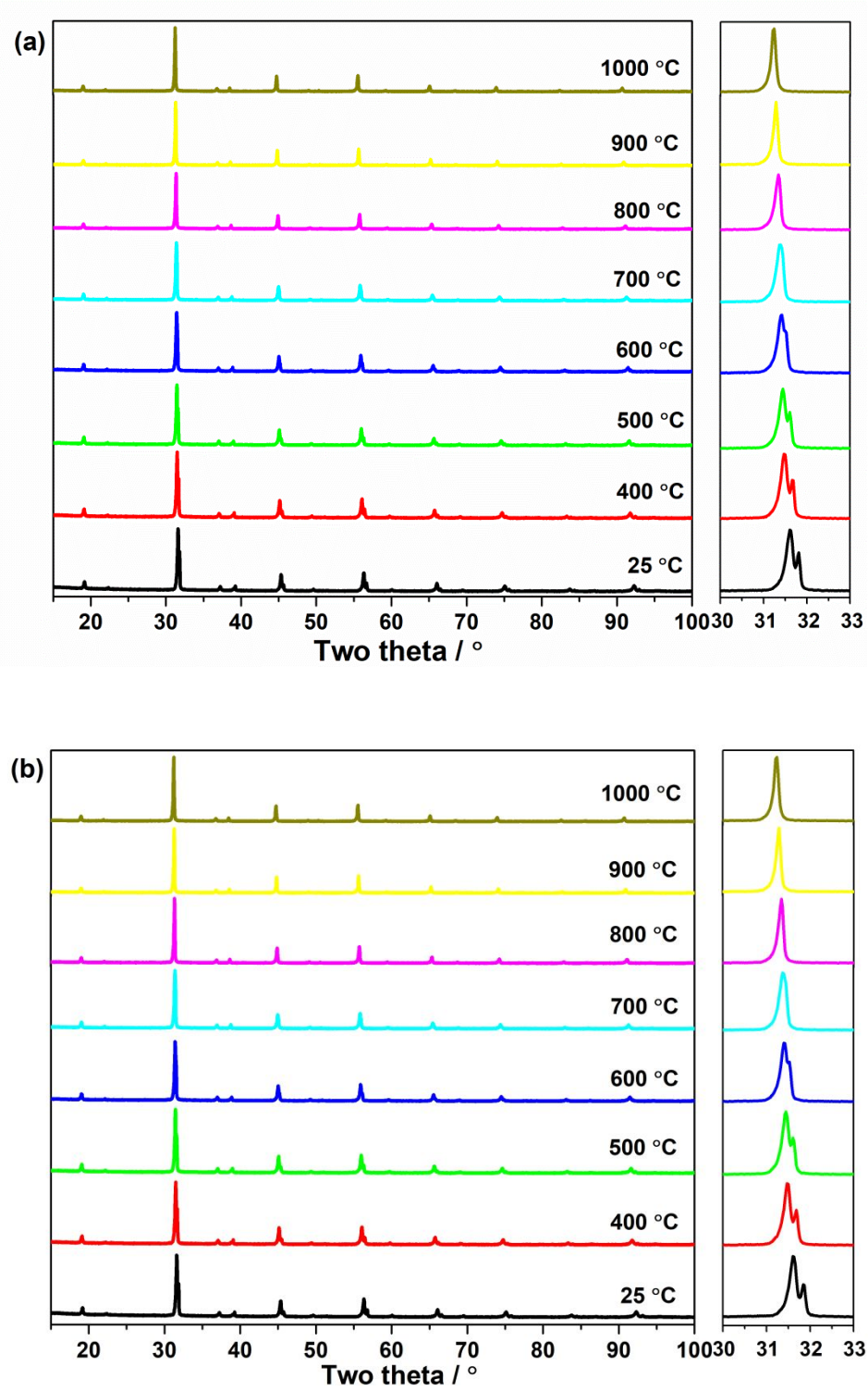

Figure S3: In-situ X-ray diffraction patterns of BSCFW0.35 membrane heated from 400 to 1000 °C (a) and cooled again (b) in steps of 100 °C with an equilibration time of about 40 min at each temperature in air

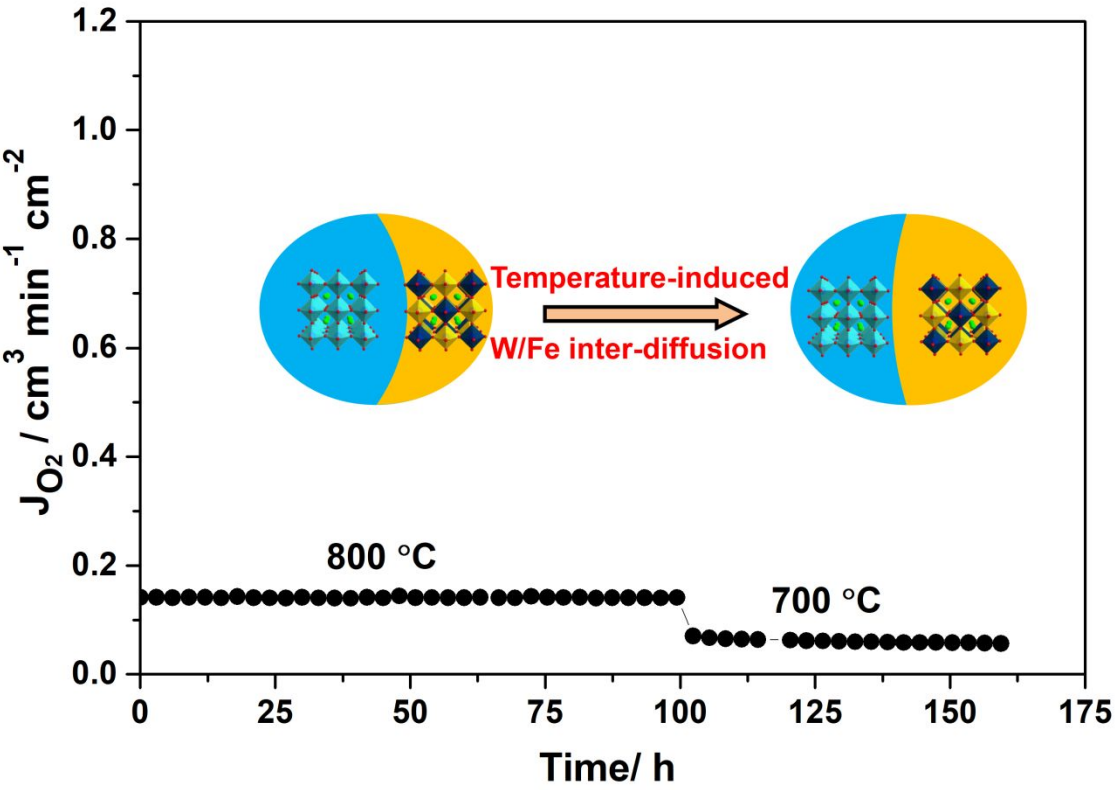

Figure S4 Oxygen permeation fluxes of BSCFW0.35 membrane as a function of time at 800 and 700 ºC. Feed side: F_{air} = 150 cm^3 min^{-1}; Permeate side: F_{Ar} = 50 cm^3 min^{-1}, membrane thickness: 1 mm.

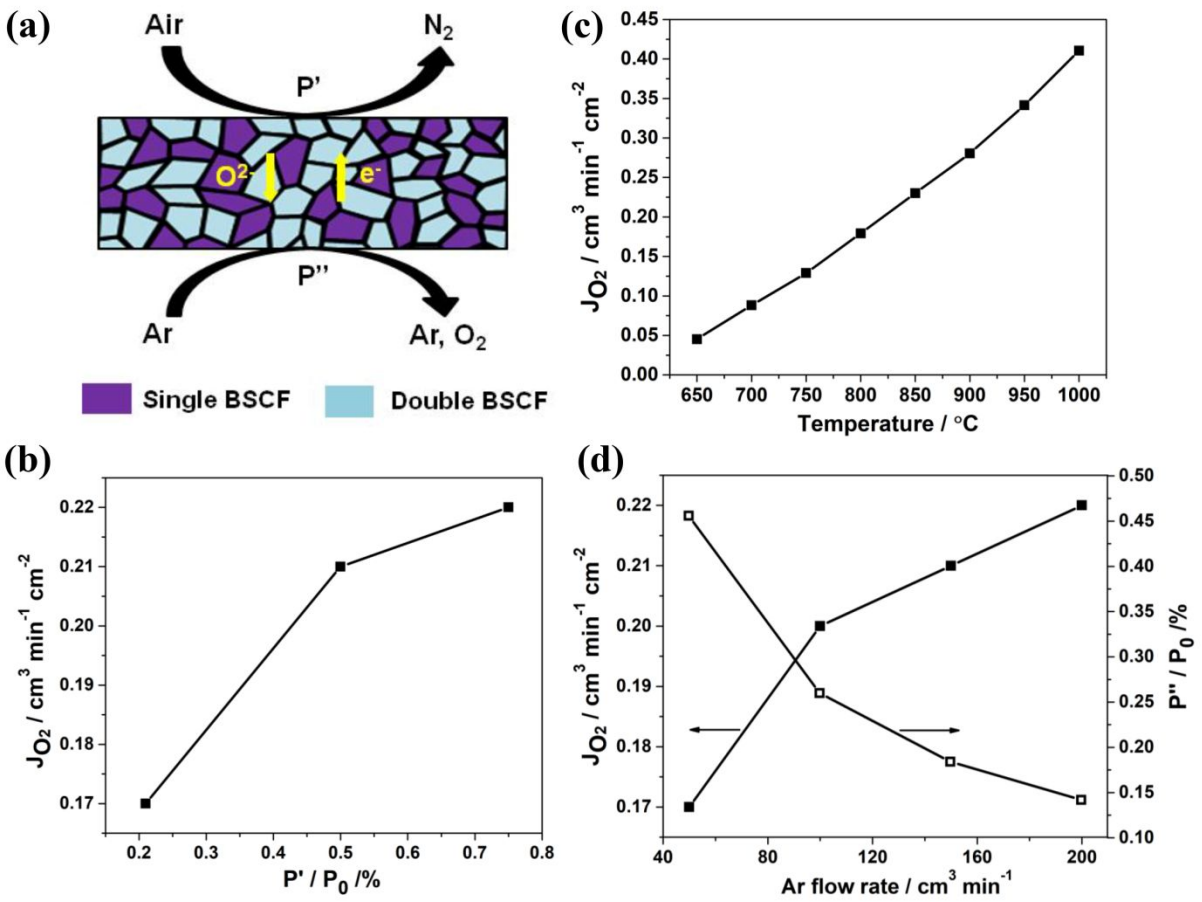

Figure S5: The effects of operating temperature and oxygen partial pressure on oxygen permeation flux of BSCFW0.35 membrane.

Table S1: Elemental analysis data of the DP and SP phases in BSCFW0.35

DP phase

Element	AN	series	Net	[wt.%]	[norm. wt.%]	[norm. at.%]	Error in wt.% (1 Sigma)
Iron	26	K-series	5153	22.63657	4.21016	8.406024	0.726063
Cobalt	27	K-series	15247	67.63462	12.57932	23.80066	1.887639
Strontium	38	K-series	7518	84.523	15.72037	20.0056	2.177101
Barium	56	L-series	27164	179.4024	33.36692	27.0921	5.508082
Tungsten	74	L-series	28783	183.4687	34.12322	20.69562	4.619752
			Sum:	537.6653	100	100	

SP phase

Element	AN	series	Net	[wt.%]	[norm. wt.%]	[norm. at.%]	Error in wt.% (1 Sigma)
Iron	26	K-series	55489	66.14518	14.41344	23.04117	1.813727
Cobalt	27	K-series	68193	84.54745	18.42341	27.90915	2.250758
Strontium	38	K-series	32753	88.04043	19.18455	19.54722	2.060828
Barium	56	L-series	107857	173.0928	37.71799	24.51996	5.199337
Tungsten	74	L-series	27458	47.08728	10.26061	4.982486	1.206135
			Sum:	458.9132	100	100	

Table S2 Comparison of oxygen permeation flux of several typical oxygen transport membranes with BSCFW0.2 membrane for air separation

Membrane materials	Thickness / mm	Temp. / ℃	$J(O_2)$ under Air/He /cm³ min⁻¹ cm⁻²	Ref.
$Ba_{0.5}Sr_{0.5}Fe_{0.8}Zn_{0.2}O_{3-\delta}$	1.15	750	0.36	1
$BaFe_{0.8}Ce_{0.2}O_{3-\delta}$	1.0	800	0.16	2
$GdBaCo_2O_{5+\delta}$	0.8	800	0.03	3
40wt.% Fe_2O_3 – 60wt.% $Ce_{0.9}Gd_{0.1}O_{2-\delta}$	0.5	950	0.10	4
60wt.% $Ce_{0.9}Gd_{0.1}O_{2-\delta}$ – 40wt.% $NiFe_2O_4$	0.5	900	0.11	5
75wt.% $Sm_{0.15}Ce_{0.85}O_{2-\delta}$ – 25wt.% $Sm_{0.6}Sr_{0.4}FeO_{3-\delta}$	0.5	800	0.18	6
80 wt.% $Ce_{0.84}Gd_{0.16}O_{2-\delta}$ – 20 wt% $SrFeO_{3-\delta}$	0.5	800	0.14	7
BSCFW0.2 SP/DP composite	1.0	800	0.72	This work

Reference

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