Support information

CO$_2$-tolerant oxygen permeation membranes containing transition metals as sintering aids with high oxygen permeability

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**Table S1** the relative density of CPM-PSFA (M = Fe, Co, Ni, Cu) composite membranes after sintering at 1275 °C.

|        | Theoretical density (g/cm³) | Volume density (g/cm³) | Relative density | Porosity |
|--------|-----------------------------|------------------------|------------------|----------|
| M = Ni | 6.22                        | 5.48                   | 0.88             | 0.12     |
| M = Co | 6.22                        | 6.15                   | 0.99             | 0.01     |
| M = Cu | 6.23                        | 5.08                   | 0.82             | 0.18     |
| M = Fe | 6.22                        | 5.35                   | 0.86             | 0.14     |

**Table S2** the average grain size of CPM-PSFA (M = Fe, Co, Ni, Cu) composite membranes after sintering at 1275 °C for 5 h.

|        | CPFe-PSFA | CPCo-PSFA | CPNi-PSFA | CPCu-PSFA |
|--------|-----------|-----------|-----------|-----------|
| CPM    | 1.01 μm   | 1.11 μm   | 0.94 μm   | 3.90 μm   |
| PSFA   | 1.01 μm   | 1.22 μm   | 1.04 μm   | 3.45 μm   |
Figure S1. XRD patterns of CPM-PSFA (M = Fe, Co, Ni, Cu) membranes after sintering at 1275 °C for 5 h.
Figure S2. XRD patterns of CPM-PSFA (M = Fe, Co, Ni, Cu) membranes after sintering at 1350 °C for 5 h.
Figure S3. XRD patterns of CPM-PSFA (M = Fe, Co, Ni, Cu) membranes after sintering at 1400 °C for 5 h.
Figure S4 Schematic diagram of oxygen permeability test device.
Figure S5 (a) The temperature dependence of resistivity of the CPM-PSFA (M = Fe, Co, Ni, Cu) in the 275K-350K. (b) temperature dependence of conductivity of CPM-PSFA (M = Fe, Co, Ni, Cu) in the 275 K-350 K.