Claims

1. An activated metal-organic framework of formula I:

$$X_{1-x}Y_x(Z)_3 \qquad I$$

where:
X is a metal in the +3 oxidation state;
Y is one or more metals in the +3 oxidation state, provided that each of the metals that represent X are different to each of the one or metals that represent Y;
x is from 0 to 0.9999, wherein
Z is $HCOO^-$; and
the metal-organic framework has a BET surface area of from 250 to 1,000 m^2/g as obtained from a 298 K CO_2 sorption isotherm.

2. The metal-organic framework of formula I according to Claim 1, wherein the BET surface area is from 500 to 600 m^2/g, such as from 514 to 599 m^2/g, such as from 582 to 599 m^2/g.

3. The metal-organic framework of formula I according to Claim 1 or Claim 2, wherein the metal-organic framework has a set of unit-cell parameters where a = b = c = from 11.303 to 11.894 Å, α = β = γ = 90°, Volume = from 1562 to 1600 $Å^3$, space group: I m-3.

4. The metal-organic framework of formula I according to any one of the preceding claims, wherein x is from 0 to 0.99, such as from 0.25 to 0.85.

5. The metal-organic framework of formula I according to any one of the preceding claims, wherein X is selected from Al, Fe, Mn, Y, Sc, Ga, In, Ti, Fe, Mn, V, Cr, Co, Tl, Bi, Ru, Os, Re, Ir, Rh, Ce, La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu.

6. The metal-organic framework of formula I according to Claim 5, wherein X is Al.

7. The metal-organic framework of formula I according to any one of the preceding claims, wherein Y, when present, is selected from one or more of the group consisting of Al, Fe, Mn, Y, Sc, Ga, In, Ti, Fe, Mn, V, Cr, Co, Tl, Bi, Ru, Os, Re, Ir, Rh, Ce, La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu, optionally wherein:

(a) Y, when present, is selected from one or more of the group consisting of Al, Tl, Fe, Ga, In, Mn, V and Cr;
(b) Y, when present, is selected from one or more of the group consisting of Fe, Ga, In, Mn, V and Cr;
(c) Y, when present, is selected from the group consisting of Al, Tl, Fe, Ga, In, Mn, V and Cr; or
(d) Y, when present, is selected from the group consisting of Fe, Ga, In, Mn, V and Cr.

8. The metal-organic framework of formula I according to Claim 7, wherein Y, when present, is Fe.

9. The metal-organic framework of formula I according to any one of the preceding claims, wherein the metal-organic framework displays a CO_2 adsorption value of from 3 to 6 (e.g. from about 4 to about 5) mmol/g at 298 K and under 1 atmosphere of CO_2.

10. The metal-organic framework of formula I according to any one of the preceding claims, wherein the metal-organic framework displays a CO_2 adsorption value of from 2 to 3 (e.g. about 2.3) mmol/g and from 90 to 150 (e.g. about 100) selectivity over N_2 at 298 K and under 1 atmosphere of total pressure provided by a gas stream of 15% CO_2 and 85% N_2 vol:vol.

11. The metal-organic framework of formula I according to any one of the preceding claims, wherein the metal-organic framework displays an O_2 adsorption value of from 0.5 to 4 (e.g. from about 1 to about 3) mmol/g at 298 K and under 1 atmosphere of O_2.

12. The metal-organic framework of formula I according to any one of the preceding claims, wherein it is selected from:
(a) $Al(HCOO)_3$;
(b) $Al_{0.75}Fe_{0.25}(HCOO)_3$;
(c) $Al_{0.5}Fe_{0.5}(HCOO)_3$;
(d) $Al_{0.25}Fe_{0.75}(HCOO)_3$; and
(e) $Al_{0.15}Fe_{0.85}(HCOO)_3$.
(f) $V(HCOO)_3$; and
(g) $V_{0.3}Al_{0.7}(HCOO)_3$.

13. The metal-organic framework of formula I according to any one of the preceding claims, wherein the metal-organic framework of formula I is:
(a) incorporated into a polymeric matrix material; or

(b) coated onto a substrate, such as a polymer, a ceramic, or a metal, optionally wherein the substrate is a polymer.

14. A method of adsorbing CO_2 and/or O_2 from a gas, comprising subjecting a metal-organic framework of formula I according to any one of Claims 1 to 13 to a flow of a gas comprising one or both of CO_2 and O_2.

15. The method according to Claim 14, wherein the gas further comprises nitrogen and water vapour.

16. The method according to Claim 14 or Claim 15, wherein the gas has a relative humidity of from less than or equal to 25% to 90%.

17. The method according to Claim 16, wherein the gas has a relative humidity of less than or equal to 25%.

18. A method of releasing CO_2 and/or O_2 from a metal-organic framework of formula I according to any one of Claims 1 to 13 to which CO_2 and/or O_2 has been adsorbed, the process comprising:

(a) providing a metal-organic framework of formula I to which CO_2 and/or O_2 has been adsorbed; and

(b) activating it by subjecting it to:

(i) a temperature of from 90 to 160 °C (e.g. from 100 to 150 °C, such as 120 °C) under reduced pressure for a period of time (e.g. from 1 to 2 hours); or

(ii) a temperature of from 170 to 250 °C (e.g. from 175 to 185 °C, such as about 180 °C) under 1 atmosphere pressure for a period of time (e.g. from 1 to 2 hours).

19. A method of obtaining an activated metal-organic framework of formula I according to any one of Claims 1 to 13, the method comprising the steps of:

(a) providing an unactivated metal-organic framework of formula I; and

(b) activating it by subjecting it to:

(i) a temperature of from 90 to 160 °C (e.g. from 100 to 150 °C, such as 120 °C) under reduced pressure for a period of time (e.g. from 1 to 2 hours); or

(ii) a temperature of from 170 to 250 °C (e.g. from 175 to 185 °C, such as about 180 °C) under 1 atmosphere pressure for a period of time (e.g. from 1 to 2 hours).

for a period of time, whereby the BET surface area of the metal-organic framework of formula I is increased to a value of from 500 to 600 m^2/g as obtained from a 298 K CO_2 sorption isotherm following step (b).