CLAIMS

What is claimed is:

1. A composition comprising:

a covalent organic framework comprising one or more functional groups, the one or more functional groups comprising imine, a framework structure of the covalent organic framework comprising the one or more functional groups; and

one or more metal ions and at least one counterion having a stoichiometry within the composition of MX_Y, where M is the one or more metal ions, X is the at least one counterion, and Y is a) between 2.9 and 3.1, b) between 1.9 and 2.1, c) between 3.9 and 4.1, or d) between 0.9 and 1.1, the one or more metal ions comprising metal ions of Mg, Ca, Y, La, Al, Ga, In, Co, Cr, Fe, Ti, Zr, Sc, V, Mn, or a combination thereof,

the composition comprising i) a molar ratio of the one or more metal ions to nitrogen of 0.005 to 0.5, ii) 1.0 wt% to 15 wt% of the one or more metal ions relative to a weight of the composition, or iii) a combination of i) and ii),

wherein the one or more metal ions form a bonding complex with imine from the one or more functional groups.

2. The composition of claim 1, wherein Y is between 2.9 and 3.1 and wherein the one or more metal ions comprise metal ions of Al, Ga, In, Co, Cr, Fe, or a combination thereof.

3. The composition of claim 1 or 2, wherein the at least one counterion comprises chloride, bromide, nitrate, nitrite, phosphate, perchlorate, or a combination thereof.

4. The composition of any one of claims 1 to 3, wherein the composition further comprises waters of hydration.

5. The composition of any one of claims 1 to 4, wherein the covalent organic framework comprises Py-1P, Py-TT, or Py-Py.

6. The composition of any one of claims 1 to 5, wherein the composition comprises a surface area of 300 cm^2/g or more.

7. The composition of any one of claims 1 to 6, wherein the framework structure further comprises a functional group comprising sulfide, thieno, thienyl, or a combination thereof.

8. The composition of any one of claims 1 to 7, wherein the covalent organic framework comprises a layered crystalline structure.

9. A composition comprising:

a covalent organic framework comprising imine functional groups, a framework structure of the covalent organic framework comprising the imine functional groups;

one or more metal ions and at least one counterion having a stoichiometry within the composition of MX_Y, where M is the one or more metal ions, X is the at least one counterion, and Y is between 2.9 and 3.1, the composition comprising i) a molar ratio of the one or more metal ions to nitrogen of 0.005 to 0.5, ii) 1.0 wt% to 15 wt% of the one or more metal ions relative to a weight of the composition, or iii) a combination of i) and ii); and

CO_2,

the composition comprising a molar ratio of CO_2 to the one or more metal ions between 0.01 and 1.0, the composition further comprising a peak in an FTIR spectrum between 1635 cm^{-1} and 1660 cm^{-1}, and a peak in the FTIR spectrum between 1615 cm^{-1} and 1630 cm^{-1}.

10. The composition of claim 9, wherein the one or more metal ions comprise metal ions of Al, Ga, In, Co, Cr, Fe, or a combination thereof.

11. The composition of claim 9 or 10, wherein the covalent organic framework comprises Py-1P.

12. A method for forming a composition, comprising:

providing a covalent organic framework comprising one or more functional groups, the one or more functional groups comprising imine, a framework structure of the covalent organic framework comprising the one or more functional groups;

adding one or more metal ions and at least one counterion to the composition to form a metal ion-doped composition, the metal ion-doped composition having a stoichiometry within the composition of MX_Y, where M is the one or more metal ions, X is the at least one counterion, and Y is a) between 2.9 and 3.1, b) between 1.9 and 2.1, c) between 3.9 and 4.1, or d) between 0.9 and 1.1, the one or more metal ions comprising metal ions of Mg, Ca, Y, La, Al, Ga, In, Co, Cr, Fe, Ti, Zr, Sc, V, Mn, or a combination thereof;

washing the metal ion-doped composition to remove at least a portion of the one or more metal ions and at least a portion of the at least one counterion to form a washed composition; and adding one or more additional metal ions and at least one additional counterion to the composition to form a washed metal ion-doped composition, the washed metal ion-doped composition having a stoichiometry within the composition of $M^*X^*_{Y^*}$,

where M* comprises the one or more additional metal ions, X* comprises the at least one additional counterion, and Y* is a) between 2.9 and 3.1, b) between 1.9 and 2.1, c) between 3.9 and 4.1, or d) between 0.9 and 1.1,

the one or more additional metal ions comprising metal ions of Mg, Ca, Y, La, Al, Ga, In, Co, Cr, Fe, Ti, Zr, Sc, V, Mn, or a combination thereof;

wherein i) the washed metal ion-doped composition comprises a molar ratio of the metal ions comprising M* to nitrogen of 0.005 to 0.5, ii) the washed metal ion-doped composition comprises 1.0 wt% to 15 wt% of the metal ions comprising M*, relative to a weight of the composition, or iii) a combination of i) and ii), and

wherein the one or more metal ions form a bonding complex with imine from the one or more functional groups.

13. The method of claim 12, the metal ions comprising M* further comprises a remaining portion of the one or more metal ions.

14. The method of claim 12 or 13, wherein X* further comprises a remaining portion of the at least one counterion.

15. The method of any one of claims 12 to 14, wherein at least one of the one or more additional metal ions is different from the one or more metal ions, or wherein the at least one additional counterion is different from the at least one counterion, or a combination thereof.

16. The method of claim 12, i) wherein Y is between 2.9 and 3.1 and wherein the one or more metal ions comprise metal ions of Al, Ga, In, Co, Cr, Fe, or a combination thereof; ii) wherein Y* is between 2.9 and 3.1 and wherein the one or more additional metal ions comprise metal ions of Al, Ga, In, Co, Cr, Fe, or a combination thereof; or iii) a combination of i) and ii).

17. A method for sorbing CO_2 from a fluid, comprising:

exposing a fluid comprising CO_2 to a sorbent material, the sorbent material comprising:

a covalent organic framework comprising one or more functional groups, the one or more functional groups comprising imine, a framework structure of the covalent organic framework comprising the one or more functional groups; and

one or more metal ions and at least one counterion having a stoichiometry within the composition of MX_Y, where M is the one or more metal ions, X is the at least one counterion, and Y is a) between 2.9 and 3.1, b) between 1.9 and 2.1, c) between 3.9 and 4.1, or d) between 0.9 and 1.1,

the one or more metal ions comprising metal ions of Mg, Ca, Y, La, Al, Ga, In, Co, Cr, Fe, Ti, Zr, Sc, V, Mn, or a combination thereof,

the composition comprising i) a molar ratio of the one or more metal ions to nitrogen of 0.005 to 0.5, ii) 1.0 wt% to 15 wt% of the one or more metal ions relative to a weight of the composition, or iii) a combination of i) and ii),

wherein the one or more metal ions form a bonding complex with imine from the one or more functional groups.

18. The method of claim 17, wherein the sorbent material comprises one or more of a membrane structure; a hollow fiber sorbent structure; a structured monolith comprising a thin-film deposited on the structured monolith, the deposited thin-film comprising the covalent organic framework; or a combination thereof.