CLAIMS

1. A structure comprising a substrate comprising an activated adsorbent material and a metal species deposited thereon, wherein the metal species comprises a metal, a metal oxide, a metal oxide phosphate, a multi-metal oxide, a perovskite, a metal sulfide, a metal nitride, a metal phosphide, an organometallic compound, or a combination thereof.

2. The structure of claim 1, wherein the metal species deposited thereon is a film, layer, or coating.

3. The structure of claim 1 or 2, wherein other than activation, the activated adsorbent material is not additionally modified.

4. The structure of any of claims 1-3, wherein the activated adsorbent material comprises activated carbon, carbon charcoal, nanostructured carbon, expanded graphite, graphene, zeolites, clays, porous polymers, porous alumina, porous silica, molecular sieves, kaolin, titania, ceria, or a combination thereof.

5. The structure of any of claims 1-4, wherein the activated adsorbent material comprises an activated carbon in a powder, granular, pellet, monolith, or honeycomb form.

6. The structure of claim 5, wherein the activated carbon is derived from at least one of wood, wood dust, wood flour, cotton linters, peat, coal, coconut, lignite, carbohydrates, petroleum pitch, petroleum coke, coal tar pitch, fruit pits, fruit stones, nut shells, nut pits, sawdust, palm, vegetables, a synthetic polymer, natural polymer, lignocellulosic material, or a combination thereof.

7. The structure of claim 5 or 6, wherein the activated carbon is activated using an activating comprising at least one of phosphoric acid, sulfuric acid, boric acid, nitric acid, oxygenated acids, steam, air, peroxides, alkali hydroxides, metal chlorides, ammonia, carbon dioxide, or a combination thereof.

8. The structure of any of claims 1-7, wherein the activated adsorbent material is characterized by a mesoporous pore size.

9. The structure of any of claims 1-8, wherein the activated adsorbent material is characterized by a nitrogen B.E.T. surface area from about 600 to about 2500 square meters per gram.

10. The structure of any of claims 5-7, wherein the activated carbon has a bulk oxygen to carbon ratio of less than or equal to about 0.25 at a depth less than 5 nm.

11. The structure of any of claims 5-7 or 10, wherein the activated carbon has a bulk phosphorous to carbon ratio of less than or equal to about 0.10 at a depth less than 5 nm.

12. The structure of any of claims 5-7 10 or 11, wherein the activated carbon has a bulk nitrogen to carbon ratio at a depth less than 5 nm of less than or equal to about 0.15.

13. The structure of any of claims 5-7 or 10-12, wherein the activated carbon has a surface oxygen to carbon ratio of less than or equal to about 1, based on the total number of surface carbons.

14. The structure of any of claims 5-7 or 10-13, wherein the activated carbon has at least one of (i) surface phosphorous to carbon ratio of less than or equal to about 0.33, based on the total number of surface carbons, (ii) surface nitrogen to carbon ratio of less than or equal to about 0.5, based on the total number of surface carbons or (iii) surface oxygen of oxidized phosphorous to phosphorous ratio of less than or equal to about 1.0, based on the total number of surface phosphorous atoms.

15. The structure of any of claims 1-14, wherein the metal species comprises titanium oxide.

16. The structure of any of claims 1-14 and 15, wherein the metal species comprises palladium.

17. The structure of any of claims 1-14, 15 and 16, wherein the structure comprises from about 0.5 to about 50 wt% of the metal species, based on the total weight of the structure.

18. A method for preparing a structure comprising:

a. providing an activated carbon powder in a reactor;

b. administering at least one atomic layer deposition cycle to deposit a metal species comprising metal precursor, wherein the administering at least one atomic layer deposition cycle comprises:

i. introducing metal precursor gas into the reactor to provide metal precursor deposited on a surface of the activated carbon powder;

ii. introducing water vapor or ambient air into the reactor to provide the metal oxide deposited on the surface of the activated carbon powder.

19. The method of claim 14, wherein the activated carbon is derived from at least one of wood, wood dust, wood flour, cotton linters, peat, coal, coconut, lignite, carbohydrates, petroleum pitch, petroleum coke, coal tar pitch, fruit pits, fruit stones, nut shells, nut pits, sawdust, palm, vegetables, a synthetic polymer, natural polymer, lignocellulosic material, or a combination thereof.

20. The method of claim 14 or 15, wherein the activated carbon is activated using an activating comprising at least one of phosphoric acid, sulfuric acid, boric acid, nitric acid, oxygenated acids, steam, air, peroxides, alkali hydroxides, metal chlorides, ammonia, carbon dioxide, or a combination thereof.

21. The method of any of claims 14-16, wherein the activated carbon is characterized by a mesoporous pore size, macroporous pore size, or a combination thereof.

22. The method of any of claims 14-17, wherein the activated carbon is characterized by a nitrogen B.E.T. surface area from about 600 to about 2500 square meters per gram.

23. The method of any of claims 14-18, wherein the activated carbon has a bulk oxygen to carbon ratio of less than or equal to about 0.25 at a depth less than 5 nm.

24. The method of any of claims 14-19, wherein the activated carbon has a bulk phosphorous to carbon ratio of less than or equal to about 0.10 at a depth less than 5 nm.