CLAIMS

1. A structure comprising a substrate comprising a wood-based activated carbon adsorbent material having a Brunauer-Emmet-Teller (BET) surface area of from 1400 to 2500 m^2/g, a surface oxygen to surface carbon ratio of less than or equal to 1 based on the total number of surface oxygen and surface carbons as determined by X-ray photoelectron spectroscopy (XPS), and a metal species deposited thereon via atomic layer deposition, 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 wood-based activated carbon adsorbent material is not additionally modified prior to having a metal species deposited thereon.

4. The structure of any of claims 1-3, wherein the wood-based activated carbon adsorbent material comprises carbon charcoal, nanostructured carbon, graphite, graphene or a combination thereof.

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

6. The structure of claim 5, wherein the wood-based activated carbon adsorbent material is derived from at least one of wood, sawdust, wood flour, or a combination thereof.

7. The structure of claim 5 or 6, wherein the wood-based activated carbon adsorbent material 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 wood-based activated carbon adsorbent material is characterized by a mesoporous pore size, .

9. The structure of any of claims 5-7, wherein the wood-based activated carbon adsorbent material has a surface oxygen to surface carbon ratio of less than or equal to 0.25 at a depth less than 5 nm as determined by XPS.

10. The structure of any of claims 5-7 or 9, wherein the wood-based activated carbon adsorbent material has a bulk phosphorous to carbon ratio of less than or equal to 0.10 at a depth less than 5 nm as determined by XPS.

11. The structure of any of claims 5-7, 9 or 10, wherein the wood-based activated carbon adsorbent material has a bulk nitrogen to carbon ratio at a depth less than 5 nm of less than or equal to 0.15 as determined by XPS.

12. The structure of any of claims 5-7 or 9-11, wherein the wood-based activated carbon adsorbent material has at least one of (i) surface phosphorous to carbon ratio of less than or equal to 0.33, based on the total number of surface carbons, (ii) surface nitrogen to carbon ratio of less than or equal to 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 1.0, based on the total number of surface phosphorous atoms as determined by XPS.

13. The structure of any of claims 1-12, wherein the metal species comprises titanium oxide.

14. The structure of any of claims 1-13, wherein the metal species comprises palladium.

15. The structure of any of claims 1-14, wherein the structure comprises from 0.5 to 50 wt% of the metal species, based on the total weight of the structure as determined by XPS.

16. A method for preparing a structure comprising:

a. providing a wood-based activated carbon adsorbent 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 wood-based activated carbon adsorbent powder;

ii. introducing water vapor or ambient air into the reactor to provide the metal precursor deposited on the surface of the wood-based activated carbon adsorbent powder.

17. The method of claim 16, wherein the wood-based activated carbon adsorbent material is derived from at least one of wood, sawdust, wood flour, or a combination thereof.

18. The method of claim 16, wherein the wood-based activated carbon adsorbent material 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.

19. The method of any of claims 16-18, wherein the wood-based activated carbon adsorbent material is characterized by a mesoporous pore size.

20. The method of any of claims 16-19, wherein the wood-based activated carbon adsorbent material is characterized by a BET surface area from 1400 to 2500 m^2/g.

21. The method of any of claims 16-20, wherein the wood-based activated carbon adsorbent material has a surface oxygen to surface carbon ratio of less than or equal to 0.25 at a depth less than 5 nm as determined by XPS.

22. The method of any of claims 16-21, wherein the wood-based activated carbon adsorbent material has a bulk phosphorous to carbon ratio of less than or equal to 0.10 at a depth less than 5 nm as determined by XPS.