CLAIMS

WHAT IS CLAIMED IS:

1. A method comprising:

extracting, using a computer system, training data comprising one or more parameters from each catalyst of a plurality of catalysts, wherein each parameter is collected from a respective catalyst of the plurality of catalyst;

classifying the training data in accordance with at least one catalyst feature at least one of the contaminations of the catalyst and the aging time of the catalyst;

determining a feature vector from the classified training data based on the one or more parameters extracted from catalyst of the plurality of catalysts, wherein the feature vector is indicative of whether the catalyst performs normally or abnormally from a performance perspective and a contaminant perspective;

generating, using the computer system, a machine learning model, wherein the machine learning model is trained based on the feature vector, to predict the function and performance of a catalyst;

generating, using the computer system, a performance baseline curve from the training data in accordance with the destruction removal efficiency (DRE) of a gas; and providing, by the computer system based on the trained machine learning model, a maintenance recommendation for the catalyst.

2. The method of claim 1, wherein providing, by the computer system based on the trained machine learning model, a maintenance recommendation for the catalyst comprises providing at least one of:

a recommendation on whether to maintain the catalyst;

a recommendation on whether to replace the catalyst at the present time; and

a recommendation on whether to replace the catalyst at a future date.

3. The method of claim 1, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

4. The method of claim 1, wherein the DRE comprises a percentage of conversion of a gas at a given temperature of the inlet.

5. The method of claim 4, wherein the feature vector indicates a level of conversion of a gas at a temperature chosen between 325 °F and 800 °F.

6. The method of claim 4, wherein the feature vector indicates a level of conversion of a gas at a space velocity between 100000 h^{-1} and 500000 h^{-1}.

7. The method of claim 1, wherein the determining of the feature vector comprises:

detecting, using the computer system, two or more probability distribution functions of the performance and contamination of the catalyst;

determining an optimal one of the two or more probability distribution functions of the performance and contamination of the catalyst.

8. The method of claim 7, wherein probability distribution function is chosen from a Normal distribution, Weibull distribution, Johnson SU distribution, Cauchy distribution, Logistic distribution, Log Logistic distribution, Log Gamma distribution, Levy distribution, Maxwell-Boltzmann distribution, Gumbel distribution, Generalized Pareto distribution, Noncentral T distribution, Pareto-Levy Stable distribution, and Gamma distribution.

9. The method of claim 7, wherein probability distribution function is chosen from Normal, Logistic, Weibull, Johnson SU and Pareto-Levy Stable distribution.

10. The method of claim 1, wherein the gas is chosen from carbon monoxide (CO), a volatile organic chemical (VOC), and ozone (O_3).

11. The method of claim 1, wherein the contaminants are chosen from Fe, Ni, Sn, Cr, Pb, Ti, Mn, Sb, P, Zn, Ca, Mg, Ba, Mo, Si, Na, K, S, and As.

12. The method of claim 11, wherein the contaminants are determined by X-ray Photoelectron Spectroscopy or inductively coupled plasma mass spectrometry.

13. The method of claim 1, wherein the catalyst is a heterogenous catalyst.

14. The method of claim 1, wherein the catalyst is a solid supported catalyst.

15. The method of claim 1, wherein the catalyst comprises platinum group metals.

16. The method of claim 15, wherein the platinum group metals are chosen from ruthenium, rhodium, palladium, osmium, iridium, and platinum.

17. The method of claim 1, wherein classifying the training data in accordance with at least one of the contamination of the catalyst and the aging time of the catalyst comprises classifying the performance baseline curve from the training data in accordance with at least one catalyst feature, the contamination of the catalyst and the aging time of the catalyst.

18. The method of claim 17, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

19. The method of claim 1, wherein generating, using the computer system, the performance baseline curve from the training data in accordance with the DRE of a gas comprises generating the performance baseline curve using pattern recognition techniques.

20. A system comprising:

at least one system configured to:

extract training data comprising one or more parameters from each catalyst of a plurality of catalysts, wherein each parameter is collected from a respective catalyst of the plurality of catalyst;

classify the training data in accordance with at least one catalyst feature at least one of the contaminations of the catalyst and the aging time of the catalyst;

determine a feature vector from the classified training data based on the one or more parameters extracted from catalyst of the plurality of catalysts, wherein the feature vector is indicative of whether the catalyst performs normally or abnormally from a performance perspective and a contaminant perspective;

generate a machine learning model, wherein the machine learning model is trained based on the feature vector, to predict the function and performance of a catalyst;

generate a performance baseline curve from the training data in accordance with the destruction or removal efficiency (DRE) of a gas; and

provide based on the trained machine learning model a maintenance recommendation for the catalyst.

21. The system of claim 20, wherein the system provides a maintenance recommendation for the catalyst comprising at least one of:

a recommendation on whether to maintain the catalyst;

a recommendation on whether to replace the catalyst at the present time; and

a recommendation on whether to replace the catalyst at a future date.

22. The system of claim 20, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

23. The system of claim 20, wherein the DRE comprises a percentage of conversion of a gas at a given temperature of the inlet.

24. The system of claim 23, wherein the feature vector indicates a level of conversion of a gas at a temperature chosen between 325 °F and 800 °F.

25. The system of claim 23, wherein the feature vector indicates a level of conversion of a gas at a space velocity between 100000 h^{-1} and 500000 h^{-1}.

26. The system of claim 20, wherein the system determines the feature vector comprising:

detecting two or more probability distribution functions of the performance and contamination of the catalyst;

determining an optimal one of the two or more probability distribution functions of the performance and contamination of the catalyst.

27. The system of claim 26, wherein probability distribution function is chosen from a Normal distribution, Weibull distribution, Johnson SU distribution, Cauchy distribution, Logistic distribution, Log Logistic distribution,

Log Gamma distribution, Levy distribution, Maxwell-Boltzmann distribution, Gumbel distribution, Generalized Pareto distribution, Noncentral T distribution, Pareto-Levy Stable distribution, and Gamma distribution.

28. The system of claim 26, wherein probability distribution function is chosen from Normal, Logistic, Weibull, Johnson SU and Pareto-Levy Stable distribution.

29. The system of claim 20, wherein the gas is chosen from carbon monoxide (CO), a volatile organic chemical (VOC), and ozone (O_3).

30. The system of claim 20, wherein the contaminants are chosen from Fe, Ni, Sn, Cr, Pb, Ti, Mn, Sb, P, Zn, Ca, Mg, Ba, Mo, Si, Na, K, S, and As.

31. The system of claim 30, wherein the contaminants are determined by X-ray Photoelectron Spectroscopy or inductively coupled plasma mass spectrometry.

32. The system of claim 20, wherein the catalyst is a heterogenous catalyst.

33. The system of claim 20, wherein the catalyst is a solid supported catalyst.

34. The system of claim 20, wherein the catalyst comprises platinum group metals.

35. The system of claim 34, wherein the platinum group metals are chosen from ruthenium, rhodium, palladium, osmium, iridium, and platinum.

36. The system of claim 20, wherein classifying the training data in accordance with at least one of the contamination of the catalyst and the aging time of the catalyst comprises classifying the performance baseline curve from the training data in accordance with at least one catalyst feature, the contamination of the catalyst and the aging time of the catalyst.

37. The system of claim 36, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

38. The system of claim 20, wherein generating, using the computer system, the performance baseline curve from the training data in accordance with the DRE of a gas comprises generating the performance baseline curve using pattern recognition techniques.

39. A non-transitory computer readable medium storing instructions that, when executed by a processor, cause the processor to:

extract training data comprising one or more parameters from each catalyst of a plurality of catalysts, wherein each parameter is collected from a respective catalyst of the plurality of catalyst;

classify the training data in accordance with at least one catalyst feature at least one of the contaminations of the catalyst and the aging time of the catalyst;

determine a feature vector from the classified training data based on the one or more parameters extracted from catalyst of the plurality of catalysts, wherein the feature vector is indicative of whether the catalyst performs normally or abnormally from a performance perspective and a contaminant perspective;

generate a machine learning model, wherein the machine learning model is trained based on the feature vector, to predict the function and performance of a catalyst;

generate a performance baseline curve from the training data in accordance with the destruction or removal efficiency (DRE) of a gas; and

provide based on the trained machine learning model a maintenance recommendation for the catalyst.

40. The non-transitory computer readable medium of claim 39, wherein the processor is further configured, to generate system provides a maintenance recommendation for the catalyst:

provide a recommendation on whether to maintain the catalyst;

provide a recommendation on whether to replace the catalyst at the present time; and

provide a recommendation on whether to replace the catalyst at a future date.

41. The non-transitory computer readable medium of claim 39, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

42. The non-transitory computer readable medium of claim 39, wherein the DRE comprises a percentage of conversion of a gas at a given temperature of the inlet.

43. The non-transitory computer readable medium of claim 39, wherein the feature vector indicates a level of conversion of a gas at a temperature chosen between 325 ºF and 800 °F.

44. The non-transitory computer readable medium of claim 43, wherein the feature vector indicates a level of conversion of a gas at a space velocity between 100000 h^{-1} and 500000 h^{-1}.

45. The non-transitory computer readable medium of claim 39, wherein the processor is further configured to, to determine the feature vector:

detect two or more probability distribution functions of the performance and contamination of the catalyst;

detect an optimal one of the two or more probability distribution functions of the performance and contamination of the catalyst.

46. The non-transitory computer readable medium of claim 45, wherein probability distribution function is chosen from a Normal distribution, Weibull

distribution, Johnson SU distribution, Cauchy distribution, Logistic distribution, Log Logistic distribution, Log Gamma distribution, Levy distribution, Maxwell-Boltzmann distribution, Gumbel distribution, Generalized Pareto distribution, Noncentral T distribution, Pareto-Levy Stable distribution, and Gamma distribution.

47. The non-transitory computer readable medium of claim 45, wherein probability distribution function is chosen from Normal, Logistic, Weibull, Johnson SU and Pareto-Levy Stable distribution.

48. The non-transitory computer readable medium of claim 39, wherein the gas is chosen from carbon monoxide (CO), a volatile organic chemical (VOC), and ozone (O_3).

49. The non-transitory computer readable medium of claim 39, wherein the contaminants are chosen from Fe, Ni, Sn, Cr, Pb, Ti, Mn, Sb, P, Zn, Ca, Mg, Ba, Mo, Si, Na, K, S, and As.

50. The non-transitory computer readable medium of claim 49, wherein the contaminants are determined by X-ray Photoelectron Spectroscopy or inductively coupled plasma mass spectrometry.

51. The non-transitory computer readable medium of claim 39, wherein the catalyst is a heterogenous catalyst.

52. The non-transitory computer readable medium of claim 39, wherein the catalyst is a solid supported catalyst.

53. The non-transitory computer readable medium of claim 39, wherein the catalyst comprises platinum group metals.

54. The non-transitory computer readable medium of claim 53, wherein the platinum group metals are chosen from ruthenium, rhodium, palladium, osmium, iridium, and platinum.

55. The non-transitory computer readable medium of claim 54, wherein to classify the performance baseline curve from the training data in accordance with at least one of the contamination of the catalyst and the aging time of the catalyst, the processor is further configured to:

classify the training data in accordance with at least one catalyst feature, the contamination of the catalyst and the aging time of the catalyst.

56. The non-transitory computer readable medium of claim 55, wherein the at least one catalyst feature comprises the loading of platinum group metals, ratio among platinum group metals and cell density.

57. The non-transitory computer readable medium of claim 39, wherein generating, using the computer system, the performance baseline curve from the training data in accordance with the DRE of a gas comprises generating the performance baseline curve using pattern recognition techniques.