Summary

One embodiment of the present disclosure~~invention~~ is a unique fuel cell system. Another embodiment is a unique desulfurization system. Yet another embodiment is a method of operating a fuel cell system. Other embodiments include apparatuses, systems, devices, hardware, methods, and combinations for fuel cell systems and desulfurization systems. Further embodiments, forms, features, aspects, benefits, and advantages of the present application will become apparent from the description and figures provided herewith.

In one aspect of the invention, there is provided a fuel cell system, comprising:

a fuel cell;

a catalytic reactor having a high combustion activity (high oxidation activity) sulfur oxidation catalyst having platinum, and having iron configured in concentration to improve the effectiveness and durability of the sulfur oxidation catalyst in comparison to a sulfur oxidation catalyst having platinum but not having iron; wherein the catalytic reactor is configured to contact a sulfur-containing hydrocarbon fuel and an oxidant with the sulfur oxidation catalyst; wherein the sulfur oxidation catalyst is configured to oxidize organic and inorganic sulfur-containing compounds, including mercaptans, sulfides, thiophenes, hydrogen sulfide, carbonyl sulfide and carbonyl disulfide, to form sulfur oxides in the form of sulfur dioxides, sulfur trioxides and mixtures thereof; and wherein the platinum concentration in the sulfur oxidation catalyst is in the range of 0.01% to 20% by weight and the iron concentration in the catalyst is in the range of 0.5% to 40% by weight; and

an adsorbent fluidly disposed between the catalytic reactor and the fuel cell, wherein the adsorbent is configured to adsorb the sulfur oxides SO_2 and SO_3,

wherein the catalytic reactor and the adsorbent are operative to remove sulfur-containing compounds from the sulfur-containing hydrocarbon fuel prior to supplying the hydrocarbon fuel to the fuel cell; and wherein the catalytic reactor and the adsorbent are configured to desulfurize hydrocarbon fuel with an O_2/S ratio of at least 10.

In another aspect, there is provided a desulfurization system, comprising:

a catalytic reactor operative to oxidize sulfur-containing compounds in a feed stream having a sulfur-containing hydrocarbon fuel and an oxidant, wherein the catalytic reactor includes a high combustion activity (high oxidation activity) sulfur oxidation catalyst having platinum, and having iron configured in concentration to improve the effectiveness and durability of the sulfur oxidation catalyst in comparison to a sulfur oxidation catalyst having platinum but not having iron; wherein the platinum concentration in the sulfur oxidation catalyst in the range of 0.01% to 20% by weight, and the iron concentration in the sulfur oxidation catalyst is in the range of 0.5% to 40% by weight; and wherein the sulfur oxidation catalyst is configured to oxidize organic and inorganic sulfur-containing compounds, including mercaptans, sulfides, thiophenes, hydrogen sulfide, carbonyl sulfide and carbonyl disulfide, to form sulfur oxides in the form of sulfur dioxides, sulfur trioxides and mixtures thereof; and

a sulfur oxide trap in fluid communication with and disposed downstream of the catalytic reactor, wherein the sulfur oxide trap is configured to capture sulfur oxides SO_2 and SO_3 from the feed stream; wherein the desulfurization system is configured to desulfurize a feed stream having an O_2/S ratio of at least 10.

In another aspect, there is provided a desulfurization system, comprising:

a catalytic reactor operative to oxidize sulfur-containing compounds in a feed stream having a sulfur-containing hydrocarbon fuel and an oxidant, wherein the catalytic reactor includes a sulfur oxidation catalyst having platinum, and having iron configured in concentration to improve the effectiveness and durability of the sulfur oxidation catalyst in comparison to a sulfur oxidation catalyst having platinum but not having iron; and wherein the sulfur oxidation catalyst is configured to oxidize organic and inorganic sulfur-containing compounds, including mercaptans, sulfides, thiophenes, hydrogen sulfide, carbonyl sulfide and carbonyl disulfide, to form sulfur oxides in the form of sulfur dioxides, sulfur trioxides and mixtures thereof; and

a sulfur oxide trap in fluid communication with and disposed downstream of the catalytic reactor, wherein the sulfur oxide trap is configured to capture the sulfur dioxides and the sulfur trioxides from the feed stream,

wherein the platinum concentration in the sulfur oxidation catalyst is in the range from 0.01% to 20% by weight, and the iron concentration in the sulfur oxidation catalyst is selected to provide greater desulfurization of the sulfur-containing hydrocarbon fuel than that provided by catalysts having platinum as the only active metal and that provided by catalysts having platinum and other base metals as the active metals and is in the range from 0.5% to 40% by weight; and wherein the catalytic reactor and the adsorbent are configured to desulfurize hydrocarbon fuel having an O_2/S ratio of at least 10.