Ammonia (NH3);

maintaining a $NO_x$ removal efficiency of the at least one filter medium in an amount of at least 70% of an initial $NO_x$ efficiency by:

providing an $NO_2$ concentration, measured from the upstream side of the filter medium, in a range from 2% to 99% of a total concentration of the $NO_x$ compounds, wherein providing the $NO_2$ concentration, measured from the upstream side of the filter medium, in a range from 2% to 99% of a total concentration of the $NO_x$ compounds comprises introducing at least one oxidizing agent into the flue gas stream; and

controlling $NO_2$ concentration, measured from the downstream side of the filter medium, to a range of from 0.0001% to 0.5% of the concentration of the flue gas stream;

wherein the method cleans the flue gas stream.

**SUMMARY**

**[10a]** In one aspect, the present disclosure refers to a method comprising:

providing at least one filter medium;

wherein the at least one filter medium comprises:

a porous catalytic fluoropolymer film including at least one catalyst material, the porous catalytic fluoropolymer film comprising a plurality of perforations, each of the plurality of perforations being a straight passageway from an upstream side surface to a downstream side surface of the porous catalytic fluoropolymer film; and

ammonium bisulfate (ABS) deposits, ammonium sulfate (AS) deposits, or any combination thereof;

flowing a flue gas stream transverse to a cross-section of the at least one filter medium, such that the flue gas stream passes through the cross section of the at least one filter medium,

wherein the flue gas stream comprises:

$NO_x$ compounds comprising:

Nitric Oxide (NO), and

Nitrogen Dioxide ($NO_2$); and

increasing $NO_x$ removal efficiency of the at least one filter medium;

wherein the increasing of the $NO_x$ removal efficiency of the at least one filter medium comprises increasing an upstream $NO_2$ concentration to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds, wherein increasing the upstream $NO_2$ concentration to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds comprises introducing at least one oxidizing agent into the flue gas stream;

wherein the method regenerates the at least one filter medium.

**[10b]** In yet another aspect, the present disclosure refers to a system comprising:

at least one filter medium,

wherein the at least one filter medium comprises:

an upstream side;

a downstream side;

a porous catalytic fluoropolymer film including at least one catalyst material, the porous catalytic fluoropolymer film comprising a plurality of

perforations, each of the plurality of perforations being a straight passageway from an upstream side surface to a downstream side surface of the porous catalytic fluoropolymer film; and

ammonium bisulfate (ABS) deposits, ammonium sulfate (AS) deposits, or any combination thereof;

at least one filter bag,

wherein the at least one filter medium is disposed within the at least one filter bag; and

at least one filter bag housing,

wherein the at least one filter bag is disposed within the at least one filter bag housing;

wherein the at least one filter bag housing is configured to receive a flow of a flue gas stream transverse to a cross-section of the at least one filter medium, such that the flue gas stream passes through the cross section of the at least one filter medium from the upstream side of the at least one filter medium to the downstream side of the at least one filter medium,

wherein the flue gas stream comprises:

$NO_x$ compounds comprising:

Nitric Oxide (NO), and

Nitrogen Dioxide ($NO_2$); and

wherein the system is configured to increase an $NO_x$ removal efficiency of the at least one filter medium when an upstream $NO_2$ concentration is increased to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds, and wherein the upstream $NO_2$ concentration is

increased to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds by introducing at least one oxidizing agent into the flue gas stream.

## DRAWINGS

**[11]** Some embodiments of the disclosure are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the embodiments shown are by way of example and for purposes of illustrative discussion of embodiments of the disclosure. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the disclosure may be practiced.

**[12]** Figures 1A-1D depict embodiments of an exemplary filter medium and according to the present disclosure.

## CLAIMS

1. A method comprising:

providing at least one filter medium;

wherein the at least one filter medium comprises:

a porous catalytic fluoropolymer film including at least one catalyst material, the porous catalytic fluoropolymer film comprising a plurality of perforations, each of the plurality of perforations being a straight passageway from an upstream side surface to a downstream side surface of the porous catalytic fluoropolymer film; and

ammonium bisulfate (ABS) deposits, ammonium sulfate (AS) deposits, or any combination thereof;

flowing a flue gas stream transverse to a cross-section of the at least one filter medium, such that the flue gas stream passes through the cross section of the at least one filter medium,

wherein the flue gas stream comprises:

$NO_x$ compounds comprising:

Nitric Oxide (NO), and

Nitrogen Dioxide ($NO_2$); and

increasing $NO_x$ removal efficiency of the at least one filter medium;

wherein the increasing of the $NO_x$ removal efficiency of the at least one filter medium comprises increasing an upstream $NO_2$ concentration to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds, wherein increasing the upstream $NO_2$ concentration to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds comprises introducing at least one oxidizing agent into the flue gas stream;

wherein the method regenerates the at least one filter medium.

2. The method of claim 1, wherein a temperature of the flue gas stream ranges from 160 °C to 280 °C during the flowing step.

3. The method of claim 1 or claim 2, wherein the flue gas stream further comprises Oxygen ($O_2$), Water ($H_2O$), Nitrogen ($N_2$), Carbon Monoxide (CO), Sulfur Dioxide ($SO_2$), Sulfur Trioxide ($SO_3$), one or more hydrocarbons, or any combination thereof.

4. The method of any of claims 1 to 3, wherein flowing the flue gas stream transverse to the cross-section of the at least one filter medium comprises flowing the flue gas stream perpendicular to the cross-section of the at least one filter medium.

5. The method of any of claims 1 to 4, wherein the at least one filter medium is disposed within at least one filter bag, wherein the at least one filter bag is housed within at least one filter bag housing, and wherein the at least one catalyst material is in the form of catalyst particles.

6. The method of claim 5, wherein the at least one filter medium comprises:

    a porous protective layer; and

    a porous catalytic layer comprising the porous catalytic fluoropolymer film, wherein the porous catalytic layer comprises the catalyst particles.

7. The method of claim 6, wherein the porous protective layer of the at least one filter medium comprises a microporous layer, wherein the microporous layer comprises an expanded polytetrafluoroethylene (ePTFE) membrane.

8. The method of claim 6 or claim 7, wherein the porous catalytic layer of the at least one filter medium comprises at least one polymeric substrate.

9. The method of any of claims 6 to 8, wherein the porous catalytic layer comprises at least one ceramic substrate.

10. The method of any of claims 6 to 8, wherein the porous catalytic layer comprises polytetrafluorethylene (PTFE), poly(ethylene-co-tetrafluoroethylene) (ETFE), ultra-high molecular weight polyethylene (UHMWPE), polyparaxylylene (PPX), polylactic acid,

polyimide, polyamide, polyaramid, polyphenylene sulfide, fiberglass, or any combination thereof.

11. The method of any of claims 6 to 10, wherein the catalyst particles are enmeshed within the porous catalytic layer.

12. The method of any of claims 6 to 11, wherein the porous catalytic layer is in the form of a layered assembly comprising:

the porous catalytic fluoropolymer film; and

at least one felt batt, wherein the at least one felt batt is positioned on at least one side of the porous catalytic fluoropolymer film.

13. The method of claim 12, wherein the porous catalytic film comprises an expanded polytetrafluoroethylene (ePTFE) membrane.

14. The method of claim 12, wherein the at least one felt batt comprises: a polytetrafluoroethylene (PTFE) felt, a PTFE fleece, an expanded polytetrafluoroethylene (ePTFE) felt, an ePTFE fleece, a woven fluoropolymer staple fiber, a nonwoven fluoropolymer staple fiber, or any combination thereof.

15. The method of any of claims 1 to 12, wherein the at least one catalyst material comprises at least one of: Vanadium Monoxide (VO), Vanadium Trioxide ($V_2O_3$), Vanadium Dioxide ($VO_2$), Vanadium Pentoxide ($V_2O_5$), Tungsten Trioxide ($WO_3$), Molybdenum Trioxide ($MoO_3$), Titanium Dioxide ($TiO_2$), Silicon Dioxide ($SiO_2$), Aluminum Trioxide ($Al_2O_3$), Manganese Oxide ($MnO_2$), zeolites, or any combination thereof.

16. The method of any of claims 1 to 12, wherein ABS deposits are disposed on the catalyst material of the at least one filter medium in a concentration ranging from 0.01% to 99% by mass of the at least one filter medium during the providing step.

17. The method of any of claims 1 to 12, wherein, after increasing the upstream $NO_2$ concentration to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds, ABS deposits are disposed on the catalyst material of the at least one filter medium in a concentration ranging from 0.01% to 98% by mass of the at least one filter medium.

18. The method of any of claims 1 to 12, wherein the at least one oxidizing agent is chosen from: hydrogen peroxide ($H_2O_2$), ozone ($O_3$), hydroxyl radical, or any combination thereof.

19. The method of any of claims 1 to 12, wherein the increasing of the $NO_x$ removal efficiency further comprises removing at least some of the ABS deposits, the AS deposits, or any combination thereof, from the at least one filter medium.

20. The method of any of claims 1 to 19, further comprising adding ammonia ($NH_3$) to the flue gas stream.

21. A system comprising:

at least one filter medium,

wherein the at least one filter medium comprises:

an upstream side;

a downstream side;

a porous catalytic fluoropolymer film including at least one catalyst material, the porous catalytic fluoropolymer film comprising a plurality of perforations, each of the plurality of perforations being a straight passageway from an upstream side surface to a downstream side surface of the porous catalytic fluoropolymer film; and

ammonium bisulfate (ABS) deposits, ammonium sulfate (AS) deposits, or any combination thereof;

at least one filter bag,

wherein the at least one filter medium is disposed within the at least one filter bag; and

at least one filter bag housing,

wherein the at least one filter bag is disposed within the at least one filter bag housing;

wherein the at least one filter bag housing is configured to receive a flow of a flue gas stream transverse to a cross-section of the at least one filter medium, such that the flue gas stream passes through the cross section of the at least one filter medium from the upstream side of the at least one filter medium to the downstream side of the at least one filter medium,

wherein the flue gas stream comprises:

$NO_x$ compounds comprising:

Nitric Oxide (NO), and

Nitrogen Dioxide ($NO_2$); and

wherein the system is configured to increase an $NO_x$ removal efficiency of the at least one filter medium when an upstream $NO_2$ concentration is increased to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds, and wherein the upstream $NO_2$ concentration is increased to a range from 2% to 99% of a total concentration of the upstream $NO_x$ compounds by introducing at least one oxidizing agent into the flue gas stream.