

Supplemental Information

Mitigation of Iron and Aluminum Powder Deflagrations via Active Explosion Suppression in a 1 m³ Sphere Vessel

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Supplemental Figures and Tables:

Figure A-1. Thermogravimetric profiles of iron powder mixed with sodium bicarbonate (SBC) inert material (1:1 ratio by weight). Temperature range from 50 °C to 1100 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure A-2. Thermogravimetric profiles of iron powder mixed with monoammonium phosphate (MAP) inert material (1:1 ratio by weight). Temperature range from 50 °C to 1100 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure A-3. Thermogravimetric profiles of iron powder mixed with sodium chloride (Met-L-X) inert material (1:1 ratio by weight). Temperature range from 50 °C to 1100 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-1. Thermogravimetric profile for sodium bicarbonate inert material. Temperature range from room temperature to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-2. Thermogravimetric profile for monoammonium phosphate inert material. Temperature range from room temperature to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-3. Thermogravimetric profile for Met-L-X inert material. Temperature range from room temperature to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-4. Differential scanning calorimetry profile for sodium bicarbonate inert material. Temperature range from 50 °C to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-5. Differential scanning calorimetry profile for monoammonium phosphate inert material. Temperature range from 50 °C to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure B-6. Differential scanning calorimetry profile for Met-L-X inert material. Temperature range from 50 °C to 1300 °C, with a constant heating ramp rate of 10 °C/min (in air).

Figure C-1. Particle size distribution for iron powder [Fe-101].

Figure C-2. Particle size distribution for aluminum powder [Al-100].

Figure C-3. Post-grinding particle size distribution for sodium bicarbonate [SBC].

Figure C-4. Post-grinding particle size distribution for monoammonium phosphate [MAP].

Figure C-5. Post-grinding particle size distribution for sodium chloride [Met-L-X].

Table C-6. Particle size statistical data for all fuel powders [iron, aluminum].

Table C-7. Particle size statistical data for all suppressant powders [SBC, MAP, Met-L-X].

Figure D-1. TGA and MS ion-current curves for mass numbers 12, 17, 18, and 44 in SBC sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-2. TGA and MS ion-current curves for mass numbers 12, 17, 18, and 44 in Met-L-X sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-3. TGA and MS ion-current curves for mass numbers 35, 36, 37, and 38 in Met-L-X sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-4. TGA and MS ion-current curves for mass numbers 70, 72, and 74 in Met-L-X sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-5. TGA and MS ion-current curves for mass numbers 15, 17, 18, and 19 in MAP sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-6. TGA and MS ion-current curves for mass numbers 30 and 44 in MAP sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Figure D-7. TGA and MS ion-current curves for mass numbers 35, 36, 48, and 64 in MAP sample, heated from 40 °C to 1400 °C at 10 °C/min (in air).

Table E-1. Measured packed densities for all three suppressant agents, and agent fill weights during open-air dispersion testing.

Table E-2. Average inverse velocity measurements for open-air dispersion testing, reported exclusively along the central plume axis (Track Point 2) with respect to previous frame (instantaneous) and custom origin (bulk) reference states.

Mass Loss Profiles for 1:1 Iron/Agent Mixtures

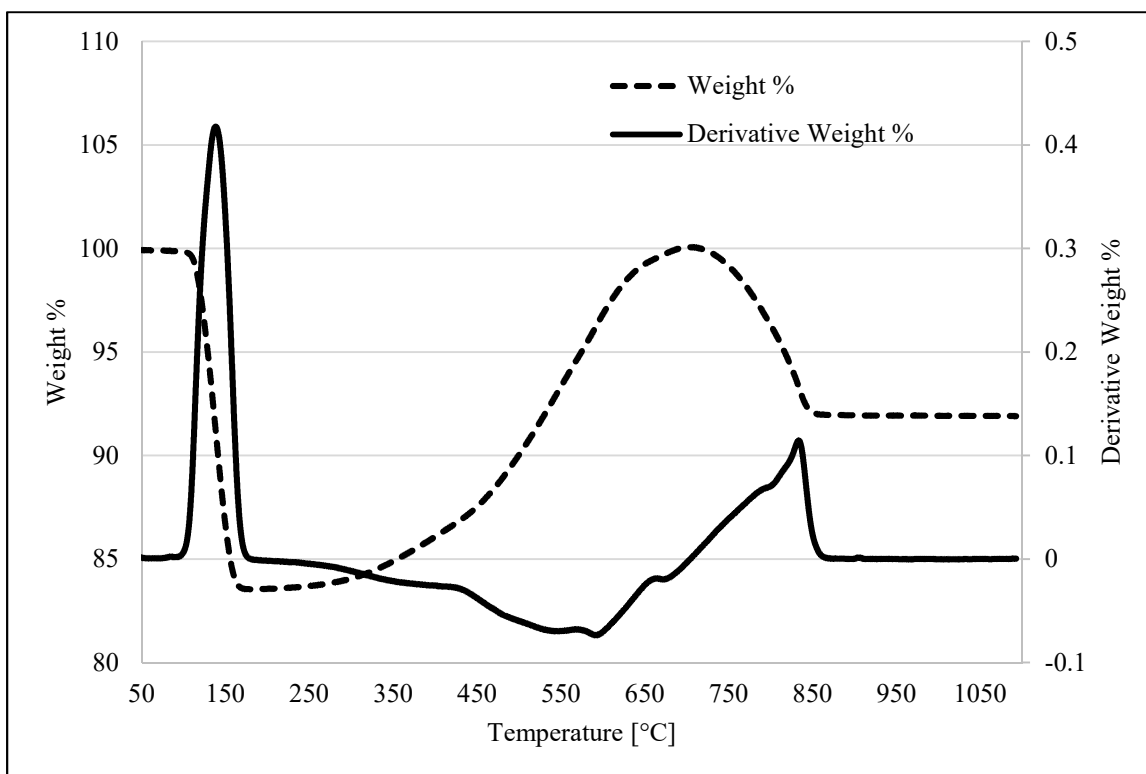


Fig. A-1 (Fe + SBC)

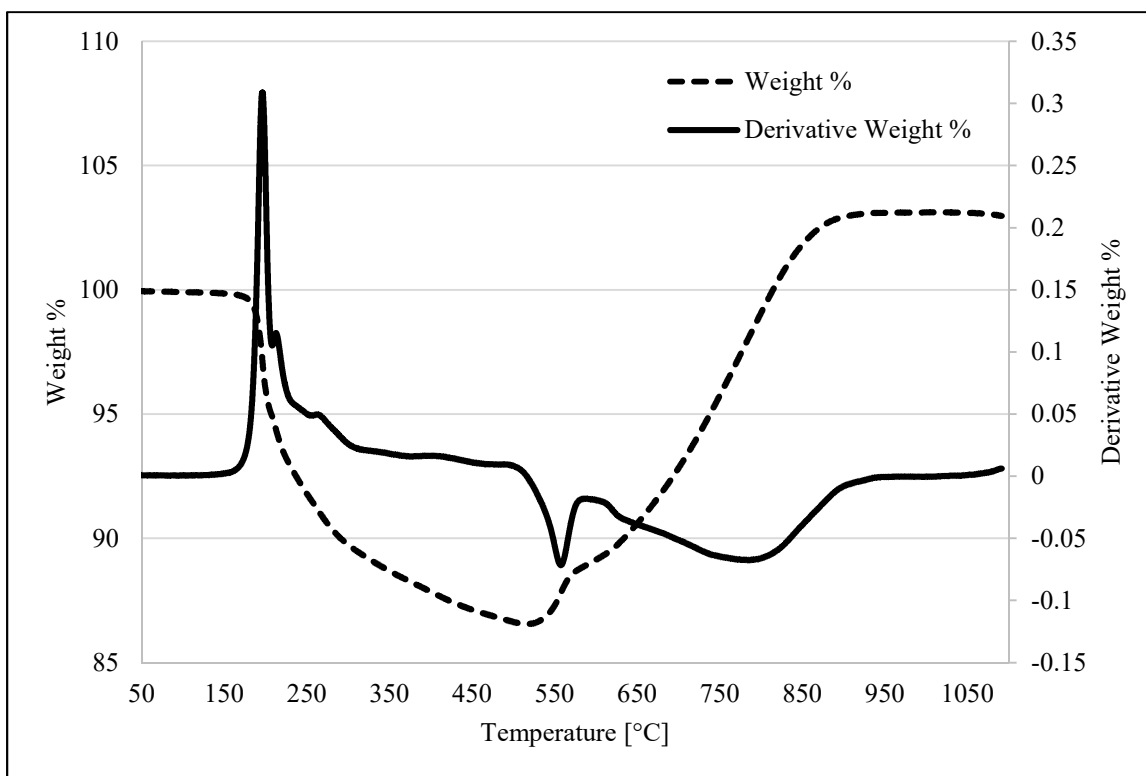


Fig. A-2 (Fe + MAP)

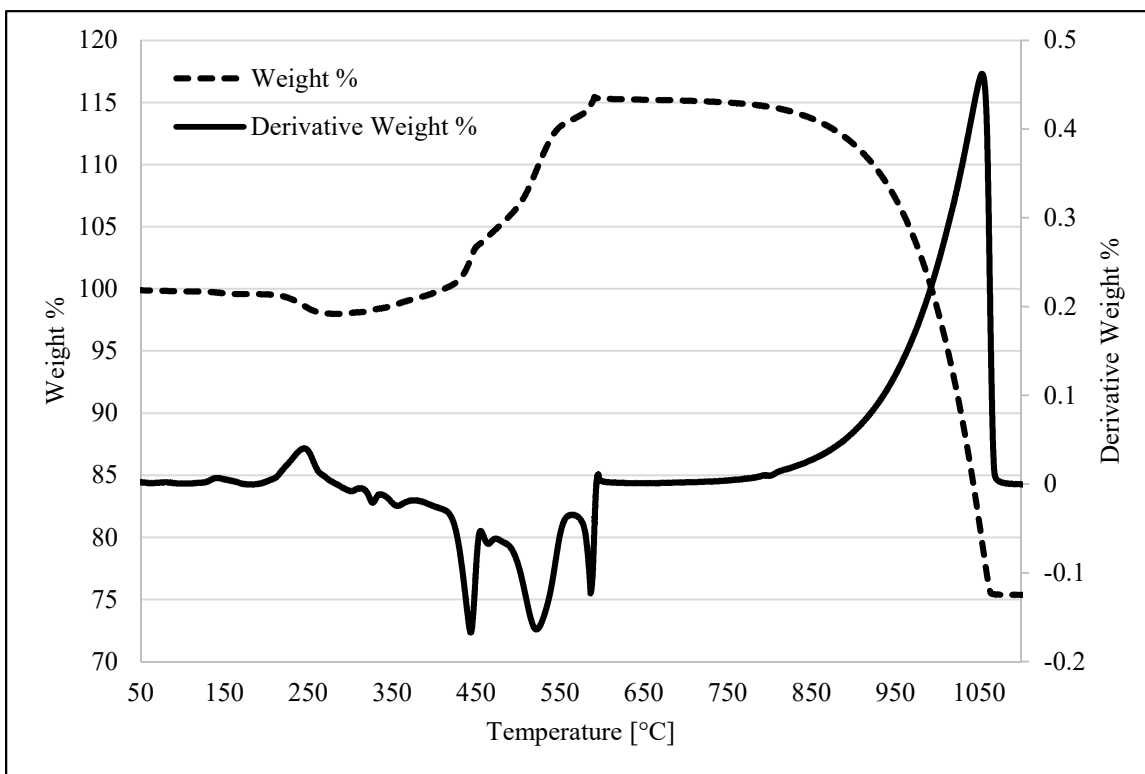


Fig. A-3 (Fe + Met-L-X)

TGA & DSC Profiles for Inert Materials

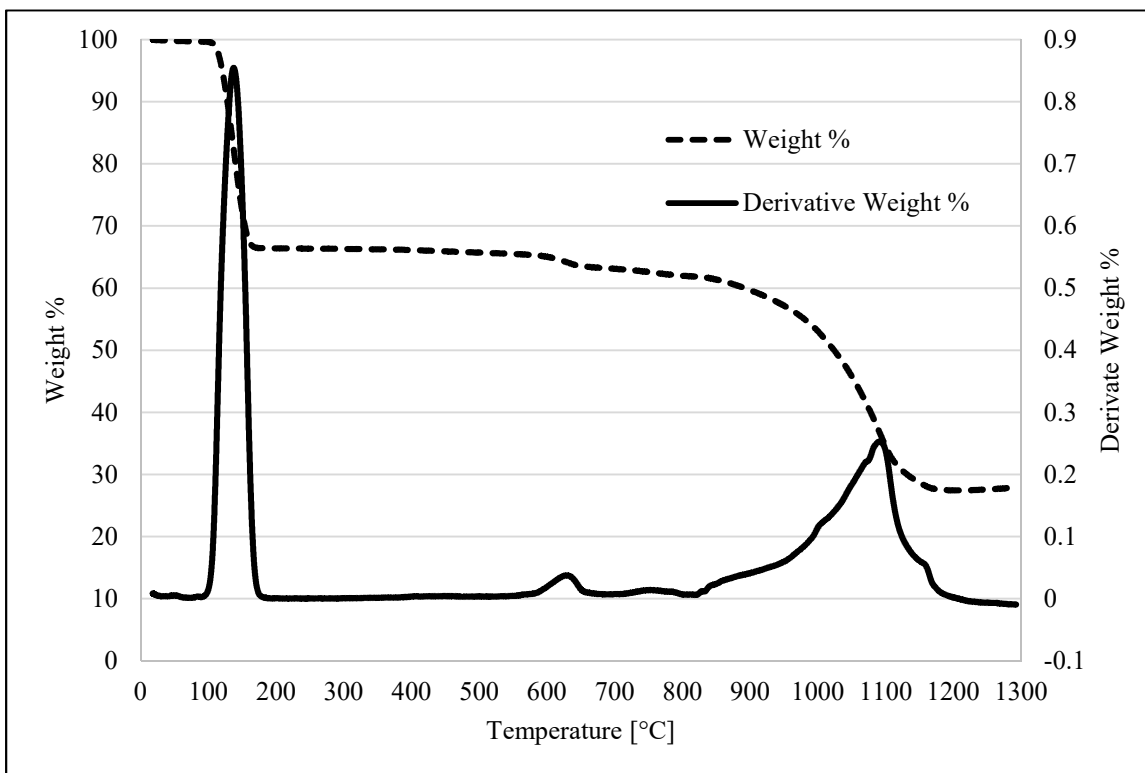


Fig. B-1 (Mass Loss - SBC)

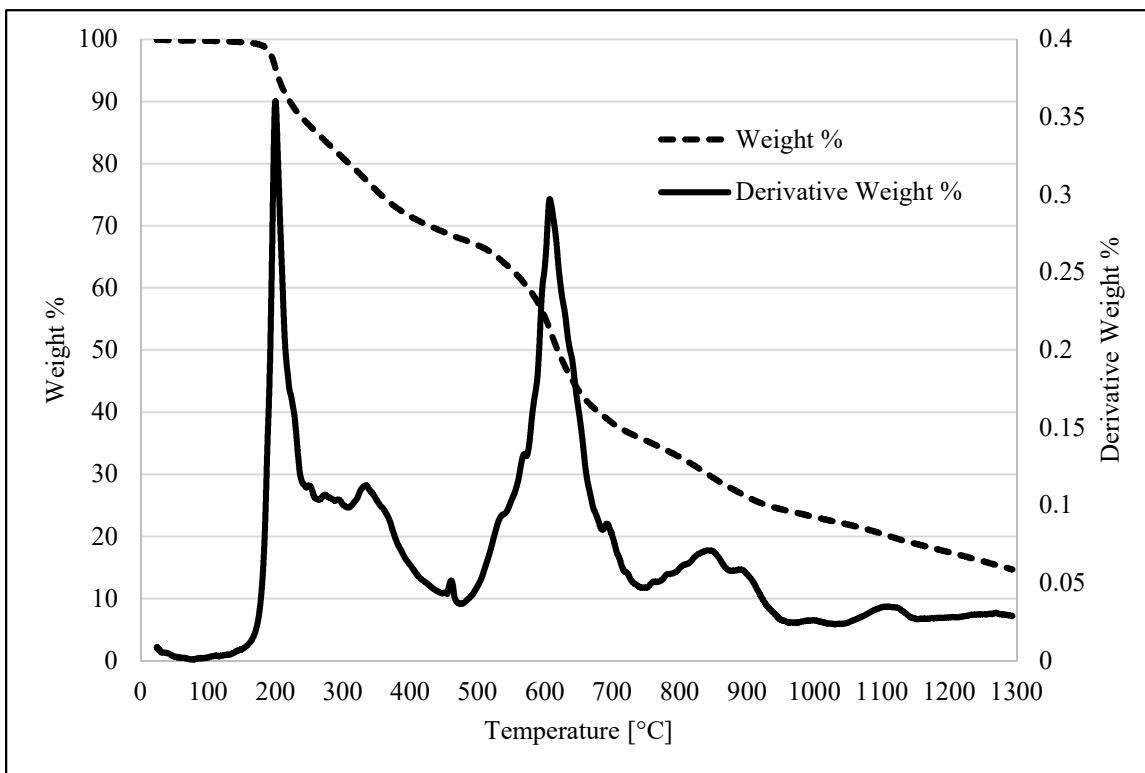


Fig. B-2 (Mass Loss - MAP)

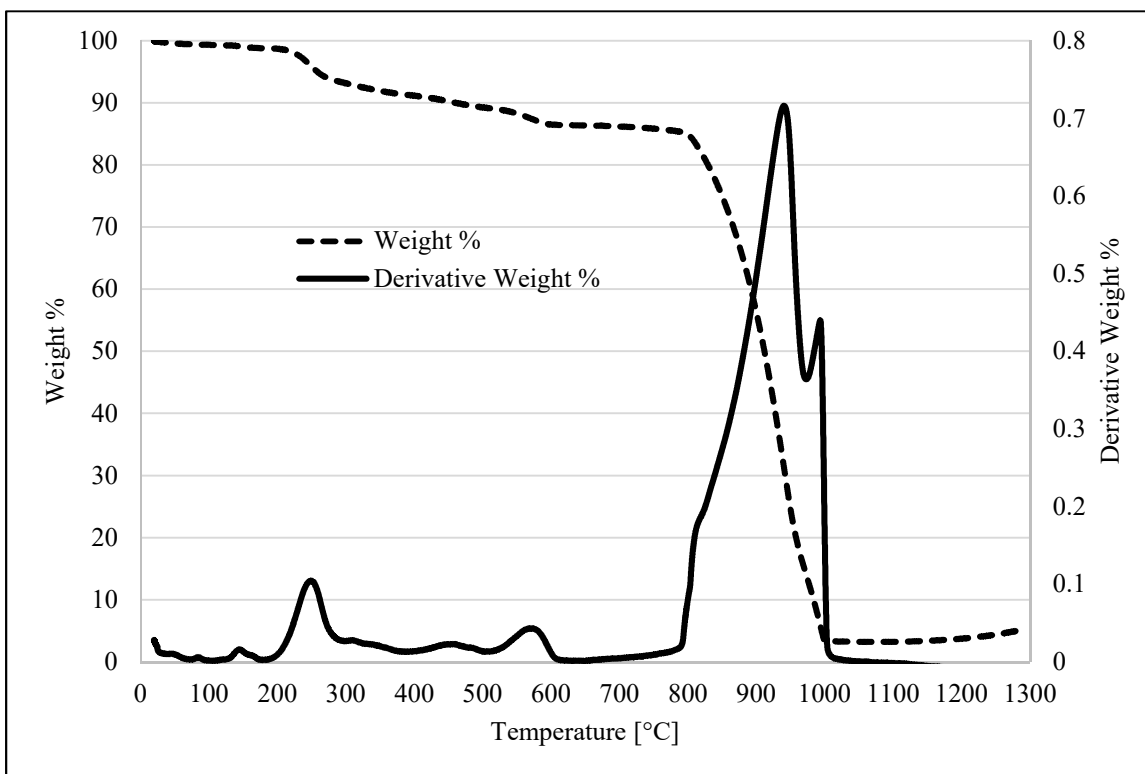


Fig. B-3 (Mass Loss – Met-L-X)

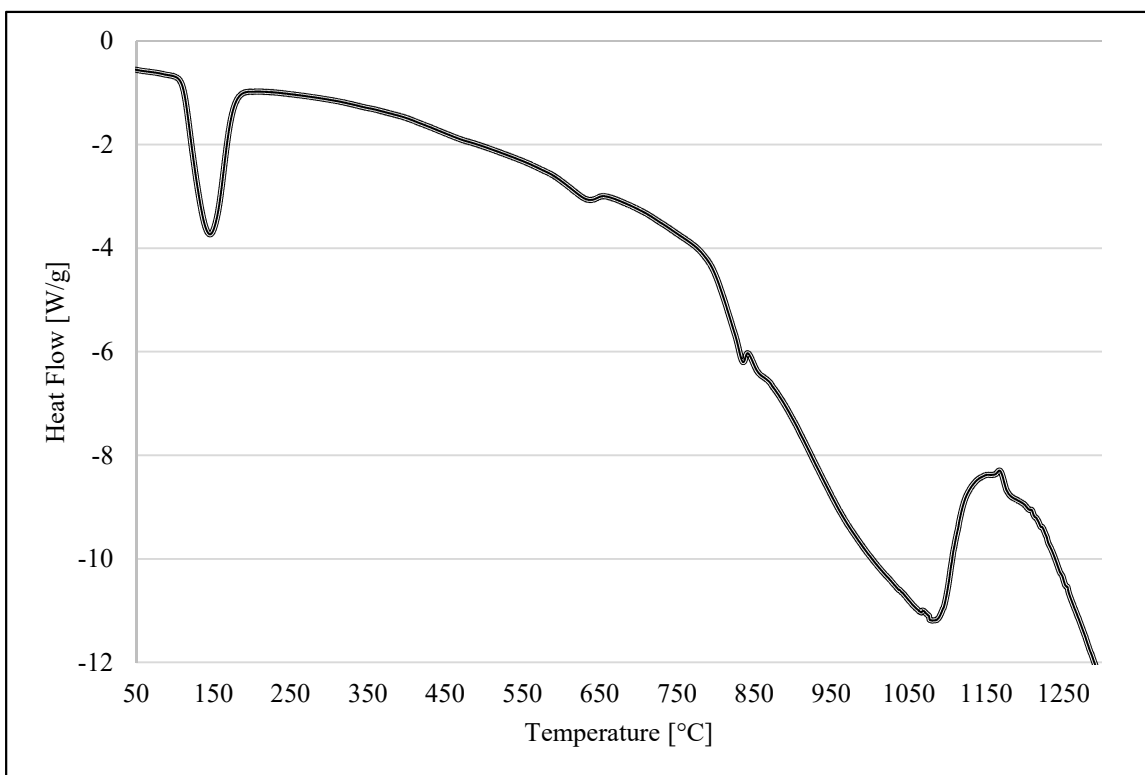


Fig. B-4 (Heat Flow - SBC)

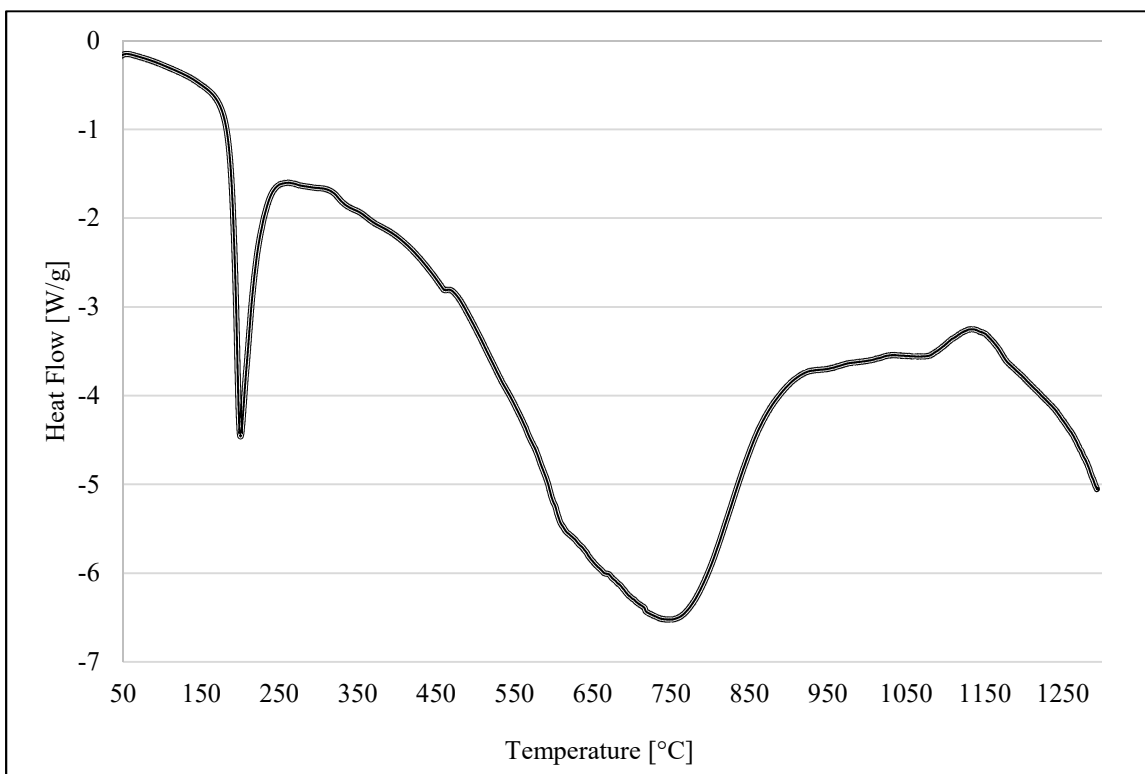


Fig. B-5 (Heat Flow - MAP)

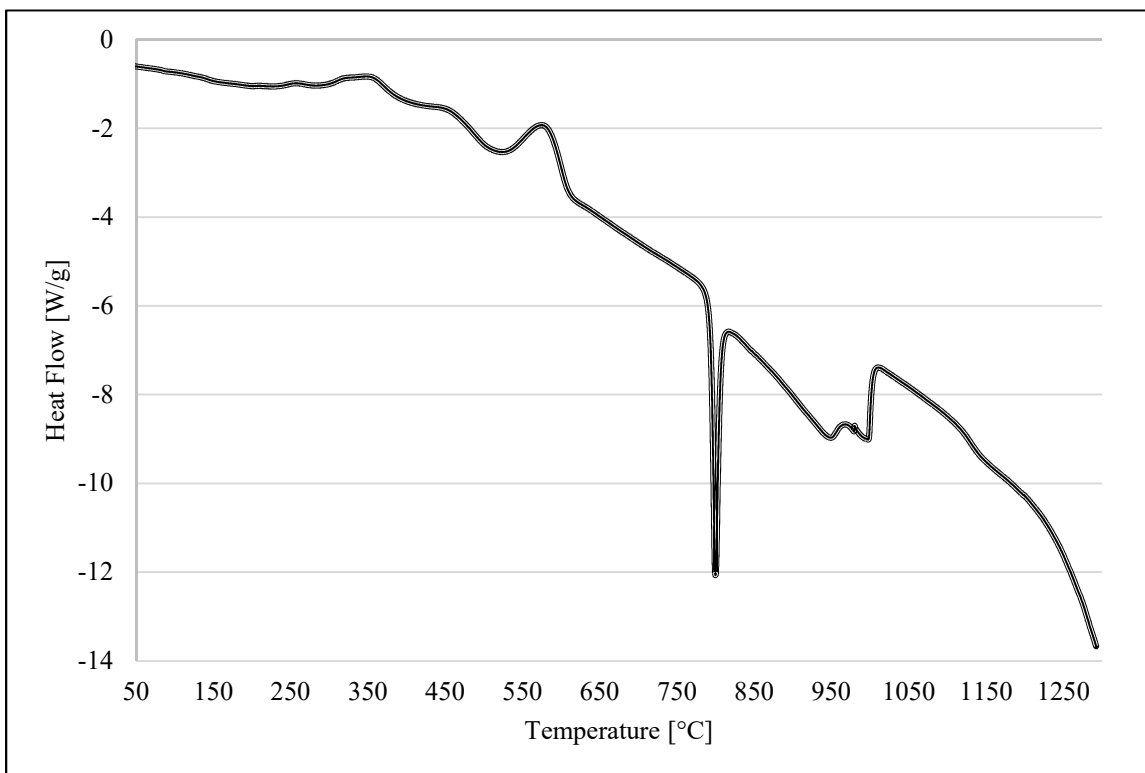


Fig. B-6 (Met-L-X)

Particle Size Analysis (PSA) Distributions Profiles for Fuels and Agents

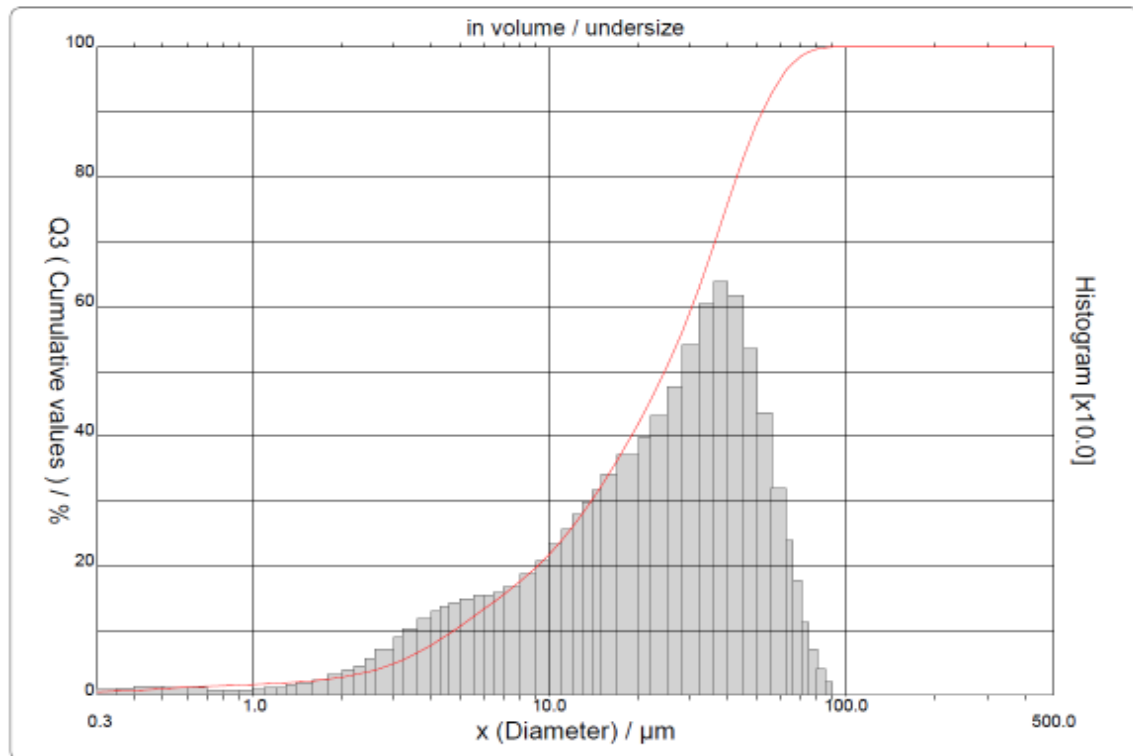


Fig. C-1 (Fe-101 - Iron Powder)

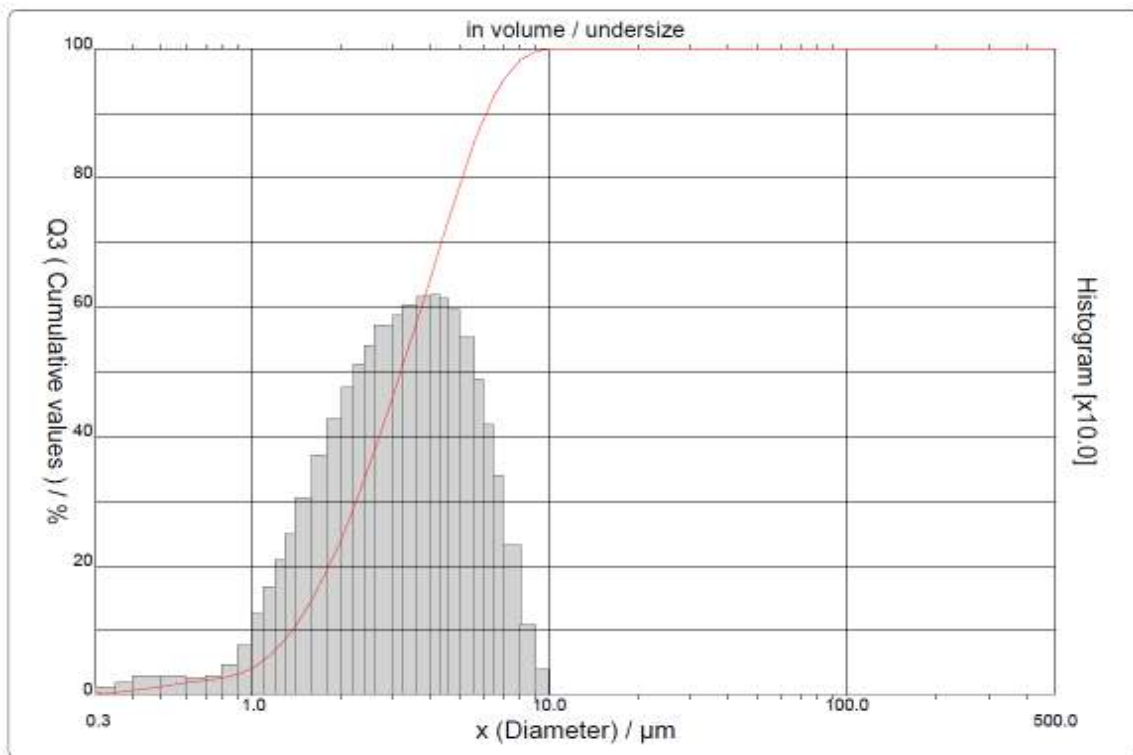


Fig. C-2 (Al-100 - Aluminum Powder)

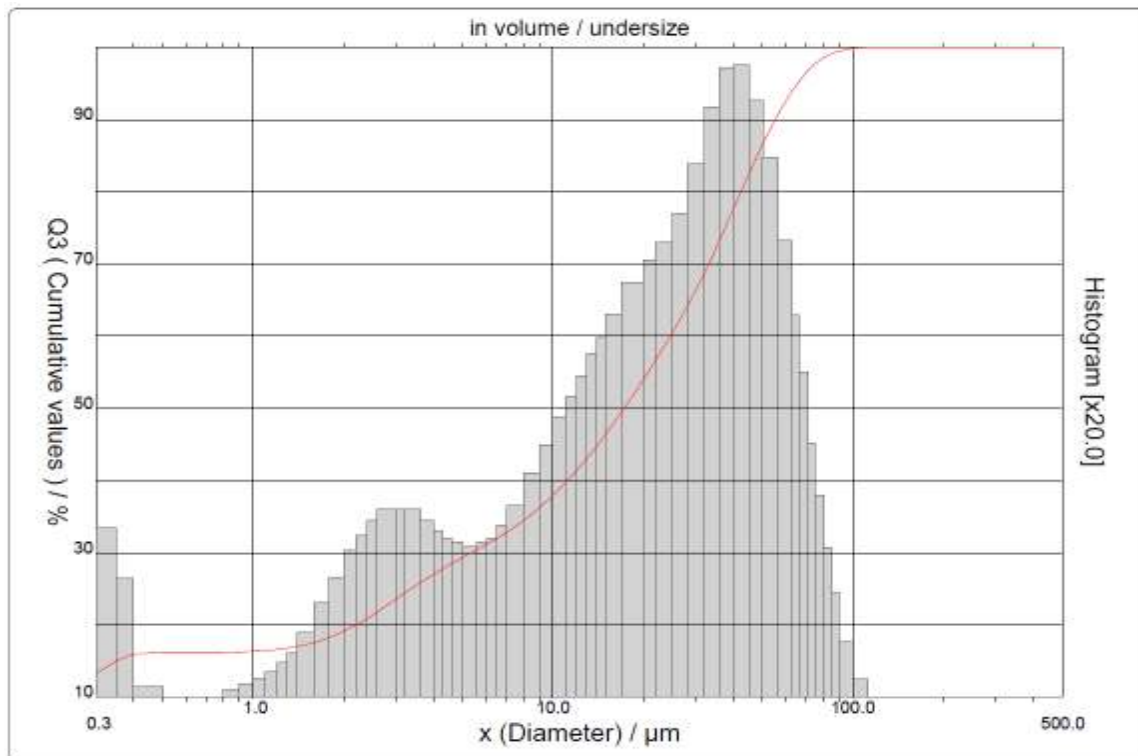


Fig. C-3 (SBC)

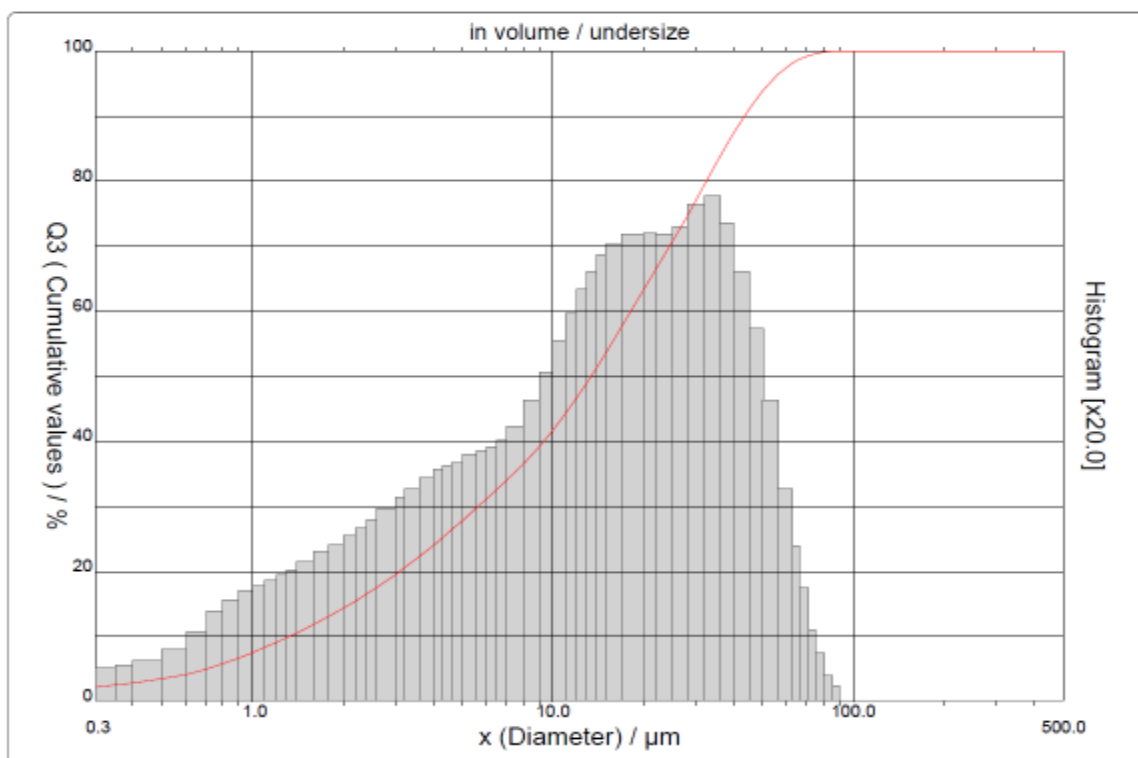


Fig. C-4 (MAP)

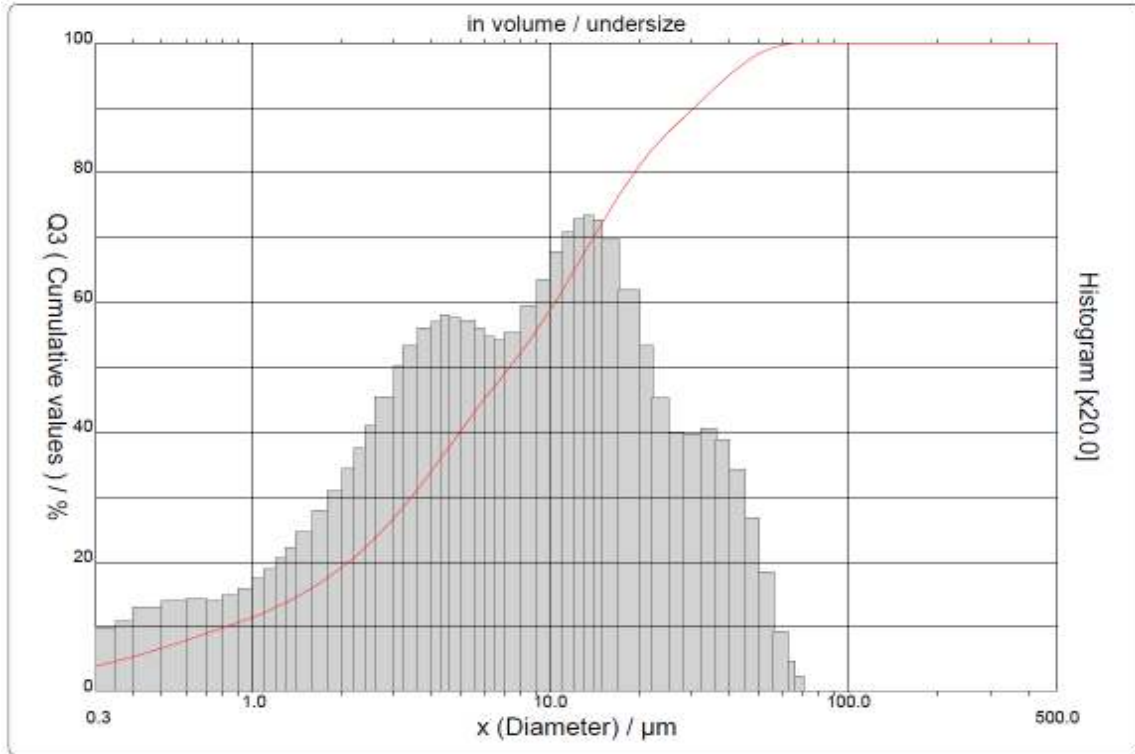


Fig. C-5 (Met-L-X)

Fuel:	Iron (Fe-101)	Aluminum (Al-100)
D10	4.76 μm	1.37 μm
D50	24.49 μm	3.18 μm
D90	52.3 μm	6.15 μm
Mean Diameter	26.86 μm	3.51 μm

Fig. C-6 (Statistical Data - Fuels)

Suppressant:	SBC	MAP	Met-L-X
D10	0.13 μm	1.33 μm	1.23 μm
D50	17.29 μm	13.42 μm	10.47 μm
D90	55.16 μm	43.47 μm	46.34 μm
Mean Diameter	23.11 μm	18.36 μm	17.63 μm

Fig. C-7 (Statistical Data – Suppressant Agents)

Suppressant Agent Evolved Gas Analysis via Mass Spectrometry (NETZSCH)

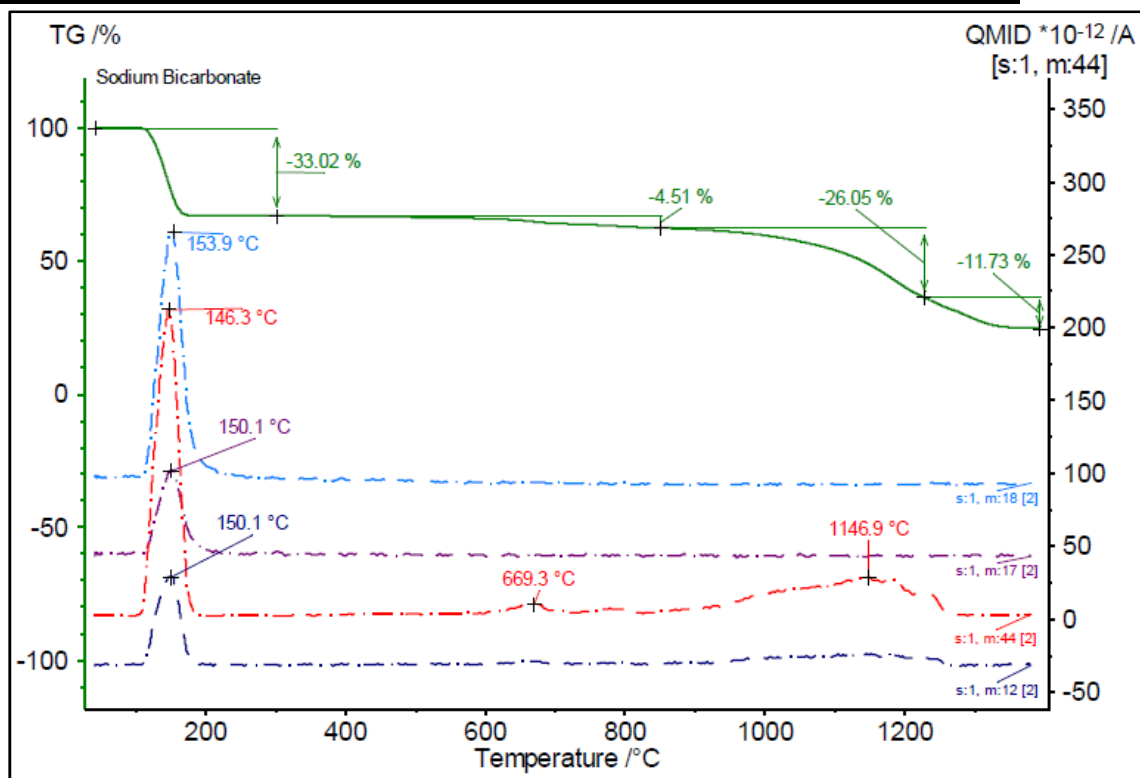


Fig. D-1 (MS Analysis – SBC, Plot 1 of 1)

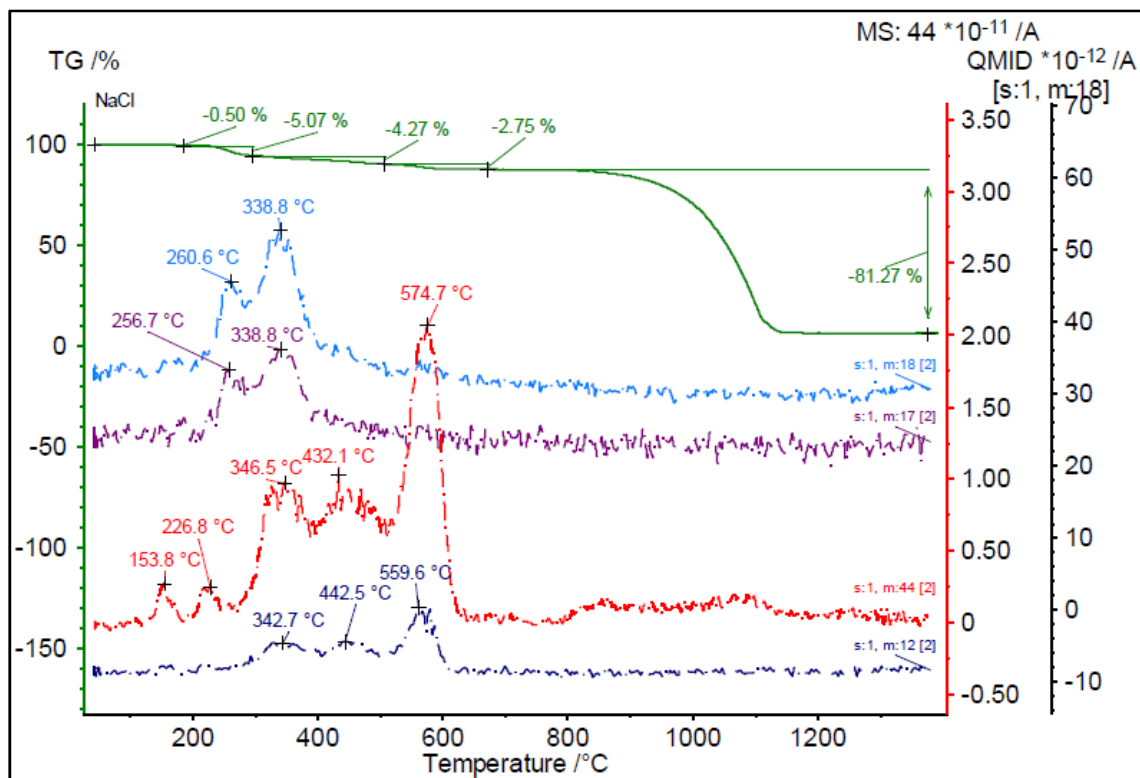


Fig. D-2 (MS Analysis – Met-L-X, Plot 1 of 3)

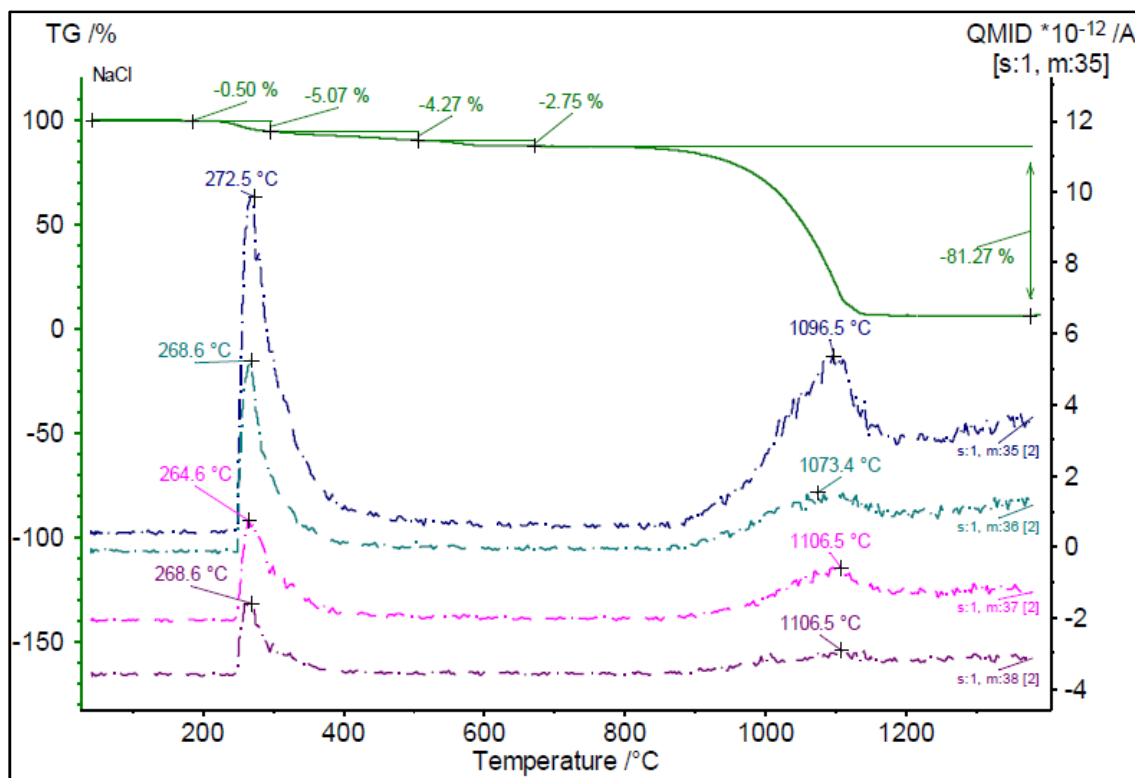


Fig. D-3 (MS Analysis – Met-L-X, Plot 2 of 3)

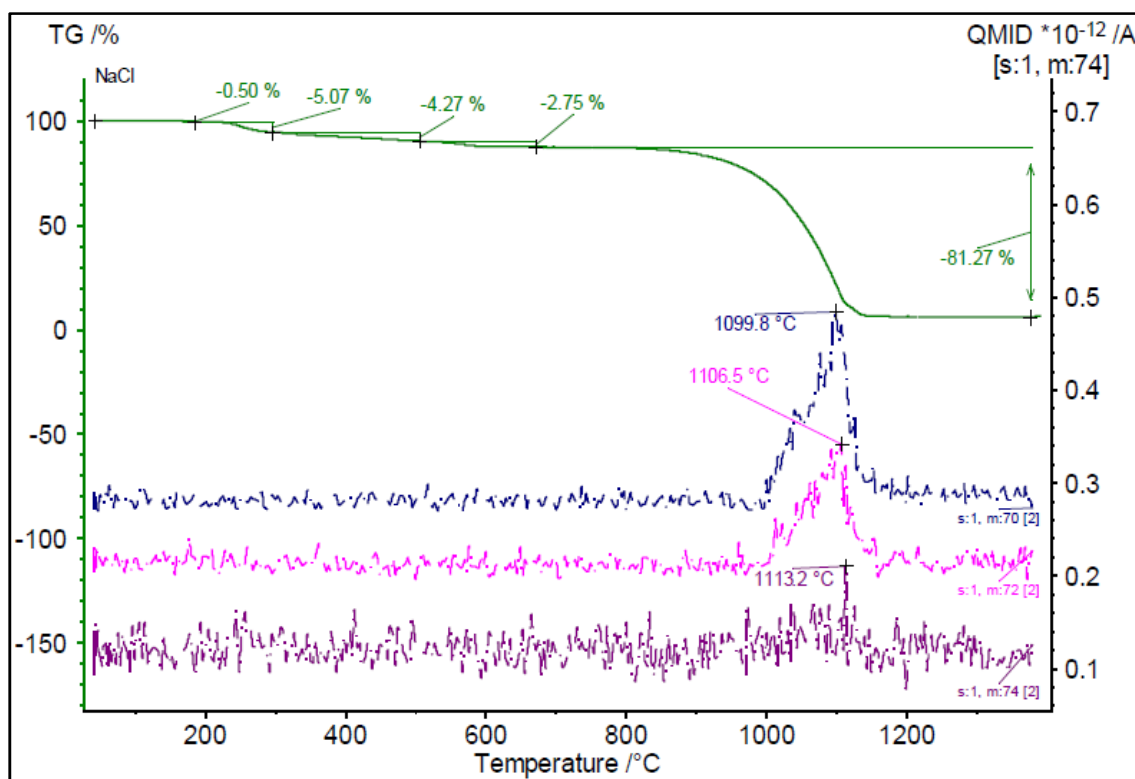


Fig. D-4 (MS Analysis – Met-L-X, Plot 3 of 3)

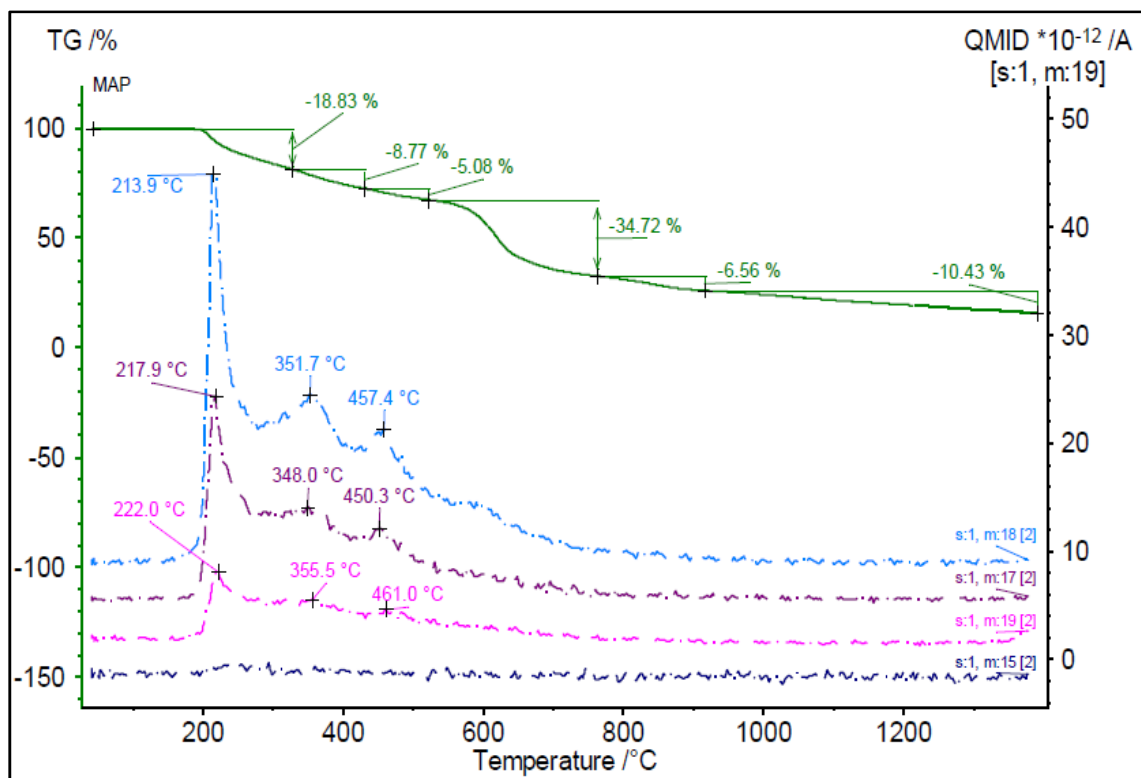


Fig. D-5 (MS Analysis – MAP, Plot 1 of 3)

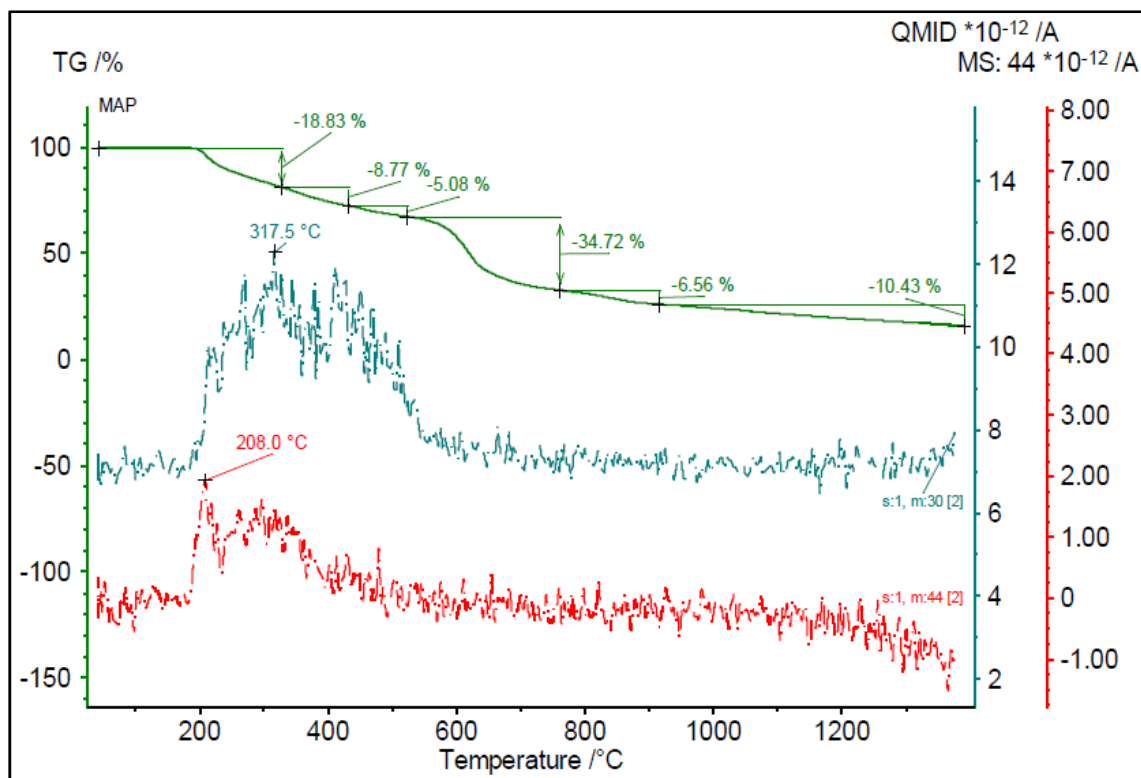


Fig. D-6 (MS Analysis – MAP, Plot 2 of 3)

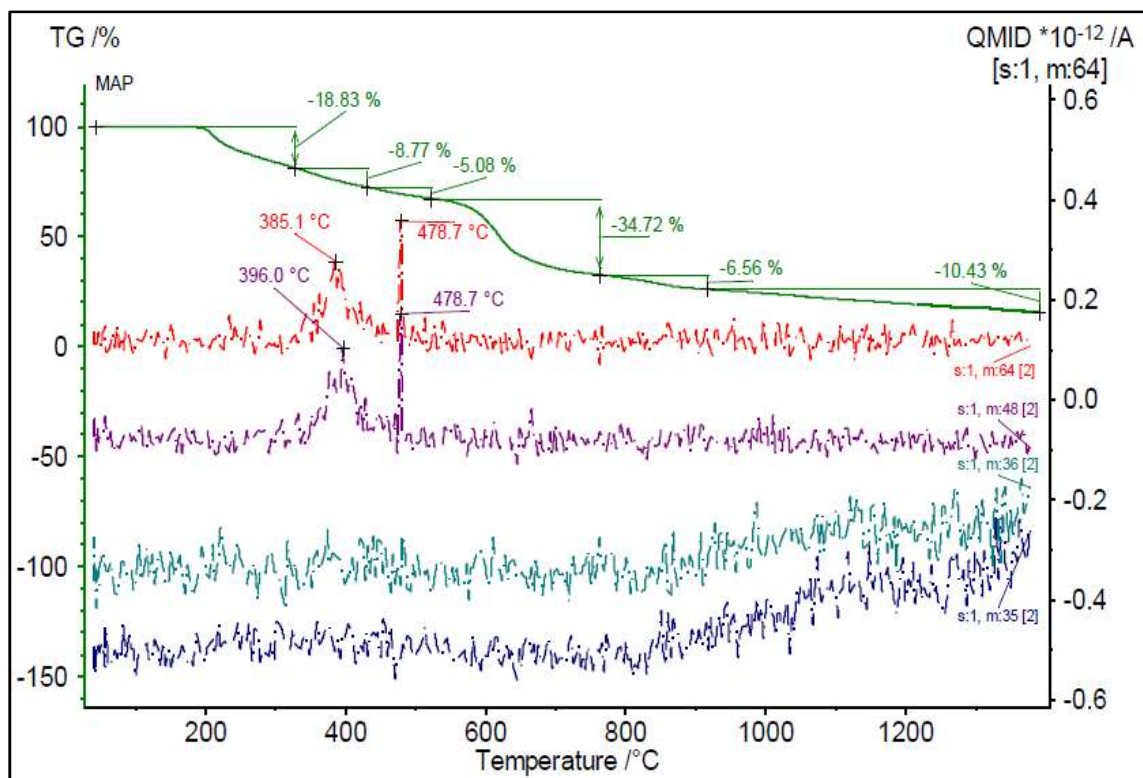


Fig. D-7 (MS Analysis – MAP, Plot 3 of 3)

Open-Air Dispersion Testing

Suppressant Material	Packed Density (kg/L)	Agent Fill Weight (kg)
SBC	1.33	9.07
Met-L-X	0.89	5.90
MAP	0.63	4.08

Table E-1 (Measured Suppressant Agent Packed Densities and Agent Fill Weights during Open-Air Dispersion Testing)

Target Throw Distance (ft)	SBC (Test 1 & 1-R1, AVG)		Met-L-X (Test 2 & 2-R1, AVG)		MAP (Test 3 & 3-R1, AVG)	
	Instantaneous Inverse Velocity	Bulk Inverse Velocity	Instantaneous Inverse Velocity	Bulk Inverse Velocity	Instantaneous Inverse Velocity	Bulk Inverse Velocity
	Inverse Velocity (ms/ft)	Inverse Velocity (ms/ft)	Inverse Velocity (ms/ft)	Inverse Velocity (ms/ft)	Inverse Velocity (ms/ft)	Inverse Velocity (ms/ft)
3	1.95	1.88	2.10	1.93	1.86	1.81
6	5.50	3.11	5.76	3.20	8.12	3.38
9	7.81	4.99	7.39	4.55	10.45	5.13
12	7.65	5.44	8.64	5.48	11.24	6.71
15	8.89	5.96	9.87	6.27	16.81	7.64

Table E-2 (Average Inverse Velocity Numerical Data)