FCL-X

INNOVATIVE LITHIUM-ION BATTERY FIRE EXTINGUISHING AGENT

FULL CIRCLE LITHIUM | FCL-X TECHNICAL OVERVIEW

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1. INTRODUCTION

Lithium-Ion Batteries (LIBs) are increasingly present in industrial and consumer technologies, presenting severe fire risks.[1] LIB fires differ fundamentally from conventional fire classes due to battery chemistries, highly toxic emissions, and sustained Thermal Runaway (TR).[2] Only one fire extinguishing agent on the market today is capable of extinguishing LIB fires, with numerous public demonstrations proving its capabilities.[3]

FCL-X is an effective, efficient, and environmentally safe solution designed specifically for LIB fires. It is a Fluorine-free, PFAS-free solution that presents no danger to the user and no forever chemicals to the environment. It attacks LIB combustion by physically and chemically suppressing the fire, while simultaneously mitigating hazardous emissions.

2. COMPOSITION AND PROPERTIES

FCL-X consists of a proprietary white powder that dissolves rapidly in water at prescribed concentrations.[4]

Key material characteristics include:

- Fluorine-free and PFAS-free formulation - no "forever chemicals"[5]
- Non-combustible, non-explosive[4]
- Chemically stable and non-reactive under normal conditions[4]
- No hazardous decomposition products[4]
- No known toxicological classifications[4]

These properties allow FCL-X to be deployed in environments where responder safety and environmental protection are critical.

3. MECHANISM OF ACTION

FCL-X suppresses lithium-ion battery fires through **four sequential and interdependent mechanisms**:

3.1 Combustion Interruption

The active ingredient in FCL-X interferes with key chemical reaction steps required for combustion. By binding with reactive species in the flame chemistry, the agent interrupts chain reactions that sustain fire. This immediately reduces flame intensity, thermal output, and fire spread.[6]

This step is especially critical during active TR, where rapid heat reduction allows the agent to remain effective long enough to perform subsequent suppression actions.

3.2 Enhanced Cooling

Compared to pure water, FCL-X absorbs more heat per unit volume before reaching steam conversion temperature. This enhanced heat absorption provides two advantages:

- Greater cooling efficiency per gallon[6]
- Longer dwell time on hot surfaces before evaporation[6]

The solution remains in contact with the battery longer, allowing deeper heat extraction and penetration into damaged cells. This results in reduced water demand and faster stabilization. [6]

3.3 Charge Neutralization

Burning LIB cells will have an opening to the atmosphere, whether through a relief vent, a puncture, or a hole made by the

fire. Due to its enhanced cooling, FCL-X is able to survive the hot environment and penetrate the cell through that opening. [6]

Once inside, the active ingredient rapidly neutralizes the battery's electrical charge, reducing thermal output by approximately 20%. This thermal reduction is derived from studies on State of Charge (SOC)'s influence on thermal output and peak temperatures during TR. Reducing SOC can drive down peak temperatures across a wide range, 20-60%.[1,7] Since FCL-X suppresses via multiple mechanisms, charge neutralization will not maximize thermal reduction on its own without other mechanisms interceding, but charge neutralization alone will reduce thermal output by at least 20%.

3.4 Electrolyte Dilution and Removal

The primary fuel source in LIB fires is the flammable electrolyte. Electrolytes can ignite from external heat, overcharge, or simply with exposure to ambient air, yielding a fire threat from cell punctures. [1,8]

Upon penetration, FCL-X dilutes and displaces the electrolyte within the cell, removing the dominant fuel source. [6] This process is essential for complete extinguishment and long-term prevention of re-ignition. [8]

4. ADDITIONAL PERFORMANCE BENEFITS

4.1 Toxic Gas Mitigation

LIB fires commonly release hazardous acidic gases, including:

- Hydrofluoric Acid (HF)[6]
- Hydrochloric Acid (HCl)[7]

HF is frequently released at lethal concentrations during LIB events. FCL-X chemically reacts with these acidic gases during fire suppression, converting them into non-hazardous salts.[6] This significantly reduces inhalation risk for responders and bystanders.

4.2 Hydrogen Explosion Prevention

During LIB fires, battery anodes decompose and release hydrogen gas. In confined spaces, hydrogen accumulation can lead to catastrophic explosions. [1]

FCL-X mitigates this risk by:

- Cooling the cell, slowing anode decomposition6
- Coating internal anode materials and surfaces, preventing further decomposition6

4.3 Residual Fire Prevention Barrier

When carrier water evaporates, the dissolved components of FCL-X re-form into a thin solid residue that adheres to surfaces, including vertical surfaces. This residue continues to absorb heat and interrupt combustion. [6]

Preliminary studies suggest this layer provides temporary fire prevention until removed. Further research on this process and how it can be further used in suppression and prevention is ongoing.

4.4 Multi-Class Fire Capability

Beyond LIBs, FCL-X is capable of extinguishing all traditional fire classes. For any fire scenario, its properties of combustion interruption and enhanced cooling make it significantly more capable than water alone. [6]

FCL-X proved its enhanced capabilities, as compared to water, in a live fire experiment.[12] Thermocouples measured

temperature as the same fuel package, burned under the same conditions in the same container, was suppressed separately by water and FCL-X at the same flow rate (160 GPM). Water alone (Burn 1) caused a 13% drop in temperature over 210 seconds. FCL-X (Burn 5) at the same rate of application caused a 50% drop in temperature over 70 seconds.

Evidenced by the drastic difference in temperature drop, FCL-X is drastically more capable of suppressing Class-A fires. In this experiment, FCL-X had over 3 times the suppression effect in one third of the time – thereby using only one third of the volume of water. Whether minimal time, temperature drop or minimal suppression agent volume are your priority, FCL-X outperforms water by at least a factor of 3.

5. USER SAFETY

- PFAS-free: Fluorine testing consistently measured **< 0.5 ppm**, well below the >100 ppm threshold commonly associated with intentionally added PFAS.[5]
- Non-flammable, non-explosive. Not a DHS-listed chemical.[4]
- Chemically stable. May only react with acids or bases.[4]
- Not oxidizing or self-heating, not water reactive.[4]
- No hazardous polymerization.[4]
- No hazardous decomposition products.[4]
- No toxicology classifications.[4]
- Standard PPE (gloves and eye protection) is recommended during handling.[4]

Importantly, FCL-X presents no additional hazards beyond those inherent to the fire itself. Firefighters should wear appropriate PPE, and non-emergency users should ventilate areas to avoid harmful LIB fire emissions.

6. ENVIRONMENTAL SAFETY

FCL-X does not meet criteria for environmental or transportation hazards and is:

- Not a Reportable Quantity (RQ) substance[4]
- Not classified as a marine or severe marine pollutant[4]

Aquatic toxicity testing demonstrated the following concentrations:

- **48-hour LC50 (Ceriodaphnia dubia)**: >3× solution concentration[9]
- **96-hour LC50 (Pimephales promelas)**: Above solution concentration[9]

In runoff scenarios, further dilution is expected. Test results: no known or anticipated ecological damage under normal use conditions.[9]

Critically, FCL-X contains **no PFAS and no persistent environmental contaminants**.

7. CERTIFICATIONS

- UL listed Class A suppression agent[10]
- Passed suppression testing from NTA 8133 performed by KIWA laboratories[11]

8. CONCLUSION

FCL-X is the only product on the market capable of extinguishing LIB fires and mitigating hazardous LIB emissions. It presents no danger to the user or the environment.

With proven real-world performance, strong safety credentials, environmental responsibility, and broad regulatory compliance, FCL-X is the best option for LIB fire suppression and safety.

9. REEFERENCES

1) Mahdy, Omar S et al. (2025) "Quantitative evaluation of thermal runaway in lithium-ion batteries under critical heating conditions to enhance safety." *Scientific reports* vol. 15,1 24004
2) Ghiji, M., et al. (2020). "A Review of Lithium-Ion Battery Fire Suppression." Energies, 13(19), 5117
3) FCL-X Product Sell Sheet
4) Safety Data Sheet: March 18, 2025
5) Analysis of Total Fluorine in Liquid and Powder Samples from Textile Protection and Comfort Center (TPACC), Wilson College of Textiles, North Carolina State University, Raleigh, North Carolina
6) FCL-X Technical Overview: May 2025
7) Golubkov, A.W., et al. (2015). "Thermal runaway of commercial 18650 Li-ion batteries with LFP and NCA cathodes—Impact of state of charge and overcharge." RSC Advances, 5(70), 57171–57186
8) Feng, X., et al. (2020). "Mitigating Thermal Runaway of Lithium-Ion Batteries." Joule, 4(4), 743–770
9) Acute Toxicity Evaluation With the Water Flea Species *Ceriodaphnia dubia*, and the Fathead Minnow Species *Pimephales promelas*, conducted by EnviroScience, Inc. Jan 2025
10) UL Solutions Certificates of Compliance, Certificate Numbers: UL-US-2570415-0, UL-CA-2556368-0, Report Reference EX29532-20250714
11) Test Report: NTA 8133 fire extinguisher tests on Li-ion batteries, conducted by Kiwa Fire Safety & Security, Aug 2024
12) FCL-X Class-A Fire Suppression Performance Capabilities