

## FireQuit: Multi-Mechanistic, Bio-Based Wetting Agent for Advanced Fire Suppression Abstract

FireQuit is a bio-derived, multi-constituent wetting agent formulated to suppress Class A, B, D, and K fires through integrated physicochemical mechanisms. The system is designed to achieve rapid and sustained extinguishment across both polar and non-polar fuel matrices while minimizing corrosivity and environmental persistence.

### 1. Functional Overview

FireQuit's extinguishment performance is governed by three interdependent mechanisms: controlled endothermy, molecular wetting and penetration, and formation of a multi-mode protective matrix. Together, these processes yield synergistic effects that enhance thermal stability, limit re-ignition potential, and optimize energy dissipation from the combustion zone.

### 2. Controlled Endothermy: Moderated Heat Absorption

The formulation exhibits staged endothermic behavior, wherein heat absorption occurs via discrete reaction phases. This staged process enables efficient thermal reduction while moderating heat flux to the fuel interface, thereby preventing sharp thermal gradients. Such moderation mitigates thermal shock, vapor overpressure events, and re-aerosolization of volatile fuel fractions. This thermodynamic control is particularly critical for reactive or metallic Class D fuels, where uncontrolled quenching can trigger secondary reactions.

### 3. Molecular Wetting and Penetration Dynamics

FireQuit employs a balanced surfactant ensemble designed to reduce surface and interfacial tension, facilitating deep infiltration into porous substrates and microcapillaries.

Enhanced penetration promotes uniform moisture distribution and extinguishment of sub-surface smoldering zones by restricting oxygen diffusion and disrupting localized exothermic microreactions.

This mechanism is crucial for cellulose-based fuels, composite laminates, and materials with complex chemistries.

### 4. Multi-Mode Protective Matrix Formation

Upon thermal activation, FireQuit generates a thin, cohesive interfacial film that performs several critical protective functions:

**Radical Encapsulation:** Sequestration of free radicals ( $\cdot\text{OH}$ ,  $\cdot\text{H}$ ,  $\cdot\text{O}$ ) and reactive intermediates to interrupt chain-propagating oxidation reactions.

**Physical Barrier Formation:** Deposition of a stable coating that inhibits oxygen ingress and suppresses vapor-phase fuel transport.

**Thermal Stabilization:** Regulation of conductive and convective heat transfer, effectively lowering localized heat flux and mitigating re-ignition probability.

The composite matrix is the outcome of controlled polymerization and micellar aggregation of the bio-based constituents, yielding a self-limiting, adherent film at the fuel surface.

### 5. Component Synergy and Environmental Profile

Each constituent in the FireQuit formulation fulfills a defined physicochemical role—wetting enhancement, endothermic buffering, film stabilization, radical scavenging, or ecotoxicity mitigation.

The formulation's bio-based architecture leverages molecular synergy, producing nonlinear performance amplification relative to individual component efficacy.

FireQuit demonstrates low corrosivity, favorable biodegradation kinetics, and minimal aquatic toxicity, supporting deployment in both industrial and ecologically sensitive contexts.

## 6. Formulation Variants

### 6.1 Pre-Mix

The pre-mixed variant incorporates a higher water fraction, enhancing thermal mass and enabling more uniform conductive heat transfer.

This configuration supports efficient cooling to temperatures below 40 °F under controlled operational conditions.

Although theoretical thermodynamic modeling predicts further cooling potential due to the presence of bio-derived cryogenic modulators, this has not yet been field-validated or independently certified.

### 6.2 Concentrate

The concentrate formulation exhibits increased density and viscosity, which attenuate convective and conductive heat transfer.

Attempts to force sub-ambient cooling through external dilution or additive incorporation may induce phase instability or micellar separation, compromising product homogeneity.

As such, sub-40 °F operational regimes are technically feasible for the Pre-Mix but not recommended for the Concentrate.

## 7. Application Domain

FireQuit is applicable across a broad spectrum of combustible materials, including hydrocarbon and oxygenated liquid fuels, vegetable oils, polymer composites, textiles, lignocellulosic substrates, and metallic Class D materials.

Its multi-modal suppression kinetics and eco-compatible formulation profile establish FireQuit as a next-generation solution for high-performance, sustainable fire control.