

Technical S&T Dossier

Three-Platform Architecture Portfolio

SiO₂ · Fire-Inhibitor Mineral · N-Halamine

2026

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Section 1 — SiO₂ PLATFORM (SOLVENT + AQUEOUS)

1.1 Architecture and Mechanism

Q: What is the SiO₂ platform at the architectural level?

The SiO₂ platform is a dual-architecture inorganic–organic silica micro-layer that forms a chemically bonded, sub-micron, non-film-forming surface network. It is not a silicone, not a siloxane, not a polymeric sol-gel, and not a ceramic coating. The architecture consists of:

- A densified inorganic silica backbone
- A functionalized organic hybrid layer
- Co-cured into a unified, high-density micro-layer
- Anchored via silanol condensation or hybrid coupling

The architecture is constant across solvent and aqueous embodiments; only the carrier system and substrate targeting differ.

1.2 Solvent SiO₂ vs Aqueous SiO₂ (Technical Distinctions)

Q: What is the difference between solvent SiO₂ and aqueous SiO₂?

Solvent SiO₂ is optimized for:

- Glass
- Optical substrates
- High-clarity surfaces
- Automotive visibility surfaces
- Aerospace transparencies
- Hard, inorganic surfaces

It forms the densest inorganic network, highest abrasion resistance, and strongest condensation bonding.

Aqueous SiO₂ is optimized for:

- Polycarbonate
- Acrylic
- Vinyl
- PVC
- PU synthetic leather
- Biological surfaces
- Flexible substrates
- Painted surfaces
- Marine vinyl
- Solar glass and wind turbine composites

It forms a chemically bonded micro-layer without film formation, without plasticizer extraction, and without brittleness.

Both share:

- Sub-micron architecture
- Ambient cure
- PFAS-free hydrophobicity
- Soil-release
- Optical clarity
- Non-film-forming behavior

1.3 Substrate Compatibility

Q: How does the SiO₂ platform bond to different substrates?

Bonding is substrate-specific:

Glass, metals, composites:

- Direct silanol condensation → chemically anchored silica network.
- Polycarbonate, acrylic, vinyl, PU, ABS, HDPE:
- Organic hybrid layer → compatibilization and coupling → anchoring without stress cracking or plasticizer extraction.

Painted surfaces:

Hybrid layer integrates into the polymer matrix without film stacking.

Biological surfaces (plant cuticles, foliar surfaces):

Aqueous SiO₂ forms a hydrophilic/hydrophobic hybrid micro-layer without occlusion.

Marine vinyl and flexible PVC:

Aqueous SiO₂ avoids plasticizer extraction and maintains flexibility.

1.4 Functional Performance

Q: What functional benefits does the SiO₂ micro-layer provide?

Depending on substrate and embodiment:

- Hydrophobicity (PFAS-free)
- Soil-release
- Reduced adhesion of salt, soot, dust, particulates
- Optical clarity enhancement
- UV stability
- Microroughness smoothing
- Improved cleanability
- Reduced fouling
- Reduced surface energy
- Enhanced abrasion resistance (solvent SiO₂)
- Flexible, non-brittle behavior (aqueous SiO₂)

1.5 Comparison to Sol-Gels, Ceramics, Siloxanes

Q: How is this different from sol-gels or ceramic coatings?

Sol-gels:

- Require solvents, heat, and form brittle films.

Ceramic coatings:

- Thick, brittle, polymer-reinforced films.

Siloxanes:

- Linear or ladder Si–O–Si chains with low network density.
- This platform:

Sub-micron, non-film-forming, ambient cure, chemically bonded, flexible, PFAS-free, and substrate-agnostic.

1.6 Optical Behavior

Q: Does the SiO₂ micro-layer affect optical clarity?

No.

On optical substrates:

- No haze
- No scattering
- No refractive distortion
- No thickness-driven optical interference
- Often improves clarity by smoothing microroughness

1.7 Durability and Wear Behavior

Q: What is the designed durability behavior?

The micro-layer:

- Is non-migrating
- Does not peel
- Does not delaminate
- Wears gradually through surface exposure
- Maintains predictable performance
- Does not crack or craze
- Does not embrittle flexible substrates
- Failure mode is controlled surface wear, not film failure.

1.8 Application and Cure

Q: How is the SiO₂ platform applied and cured?

Application:

- Spray
- Wipe
- Dip
- Roll
- Foam
- Flow-coat

Cure:

- Ambient temperature
- Water evaporation (aqueous)
- Solvent evaporation (solvent)
- Silanol condensation
- No heat required
- No controlled environment required

1.9 Substrate Classes Covered

Q: What substrate classes are explicitly supported?

From the uploaded technical bibles:

- Biological surfaces
- Plant cuticles
- Polycarbonate
- Acrylic
- Vinyl
- PVC
- PU synthetic leather
- Interior plastics
- Foams
- Solar glass
- Wind turbine composites
- Marine vinyl
- Aircraft and rail exteriors
- Painted metals
- Composites

1.10 PFAS / Fluorine Alignment

Q: How does this platform address PFAS/fluorine bans?

The platform achieves hydrophobicity and soil-release without:

- Fluorosilanes

- Fluoropolymers
- PFAS-class chemistries

It is fully aligned with:

- EU PFAS restrictions
- U.S. state-level PFAS bans
- OEM fluorine-reduction mandates

1.11 Integration Into Workflows

Q: Does the SiO₂ platform require new equipment?

No.

It integrates into existing:

- Solvent lines
- Aqueous lines
- Dip tanks
- Spray booths
- Flow-coat systems
- Field-applied maintenance workflows

1.12 IP Position

Q: What is the IP defensibility of the SiO₂ platform?

Claims cover:

- Dual-layer architecture
- Bonding mechanisms
- Substrate integrations
- Functional outcomes
- Aqueous and solvent embodiments
- Non-film-forming micro-layer behavior

Competitors cannot replicate the architecture without violating claims.

1.13 Rapid Validation

Q: What can S&T test immediately?

Solvent SiO₂:

- Contact angle
- Wiper abrasion
- Optical clarity
- Chemical resistance

- Adhesion

Aqueous SiO₂:

- Plasticizer compatibility
- Flexibility
- Soil-release
- UV stability
- Cleanability

1.14 What This Is NOT

Q: What is the SiO₂ platform NOT?

It is not:

- A silicone
- A siloxane
- A sol-gel
- A ceramic coating
- A polymer film
- A PFAS system
- A thick coating
- A brittle layer
- A sacrificial wax
- A temporary hydrophobic spray

1.15 Designed Failure Mode

Q: How does the SiO₂ platform fail?

Controlled surface wear.

No peeling, no delamination, no cracking, no haze, no brittleness.

Section 2 — FIRE-INHIBITOR MINERAL PLATFORM

2.1 Architecture and Mechanism

Q: What is the Fire-Inhibitor Mineral Platform at the architectural level?

It is a mineral-hosted fire-resistance system consisting of engineered mineral particles (zeolite, synthetic zeolite, silica, aluminosilicate, clay, diatomaceous earth, perlite, vermiculite, calcium silicate) that are coated with a non-migrating, insoluble, thermally stable fire-inhibitor layer. The mineral substrate is not the fire retardant; it is the structural host that carries the fire-resistant chemistry.

The architecture is defined by:

- A mineral core providing thermal mass, porosity, and structural stability
- A bonded fire-inhibitor layer that does not dissolve, leach, or volatilize
- A non-reactive, thermally stable particle that integrates into bulk materials
- This is an additive platform, not a surface coating.

2.2 Problem Definition

Q: What problem does this platform solve?

Traditional fire-retardant systems suffer from:

- Leaching or migration over time
- High loading requirements that weaken materials
- Interference with polymer chemistry or foam expansion
- Reliance on halogens, heavy metals, or soluble salts
- Poor thermal stability under sustained heat

This platform solves these issues by:

- Anchoring fire-resistant chemistry to a mineral host
- Eliminating migration and leaching
- Reducing required loading levels
- Maintaining polymer, foam, and coating performance
- Providing stable, non-volatile fire resistance

2.3 Mineral-Hosted Mechanism

Q: What does “mineral-hosted” fire resistance mean?

It means the fire-resistant chemistry is bonded to the mineral surface, not added as a free, soluble, or reactive fire retardant. The mineral host provides:

- Thermal barrier behavior
- Structural stability during fire exposure
- A non-reactive carrier during processing
- A platform for distributing fire-resistant chemistry uniformly

The mineral itself is not the fire retardant; the engineered particle is.

2.4 Substrate Classes and Material Systems

Q: What materials can the Fire-Inhibitor platform be used in?

The platform is compatible with:

Plastics and thermoplastics:

- PVC, PE, PP, ABS, TPU, TPE (via melt compounding, extrusion, injection molding)

Foams:

- Polyurethane (flexible and rigid), PIR, polyiso, latex, memory foam

Coatings and paints:

- Water-based or solvent-based architectural, industrial, and protective coatings

Gypsum and drywall:

- Gypsum slurries, drywall cores, fire-rated boards

Cementitious materials:

- Mortars, plasters, stuccos, fireproofing sprays

Composites:

- Fiberglass systems, engineered panels, wood-plastic composites (WPC)
- This is a broad-spectrum additive platform.

2.5 Fire-Resistance Mechanism

Q: How does the fire-inhibitor layer work during fire exposure?

Depending on the embodiment, the fire-inhibitor layer:

- Promotes char formation
- Reduces heat transfer
- Suppresses flame spread
- Reduces heat release rate
- Improves burn-through resistance
- Enhances thermal stability of the host material

The mechanism is inorganic and thermally stable, not sacrificial.

2.6 Comparison to Traditional Fire-Retardant Systems

Q: How is this different from ATH, MDH, brominated, or phosphorus FR systems?

ATH/MDH:

- Require high loadings, release water, weaken materials.

Brominated systems:

- Halogenated, regulatory pressure, smoke/toxicity concerns.

Phosphorus systems:

Can plasticize polymers, may migrate, may require synergists.

This platform:

Mineral-hosted, non-migrating, thermally stable, lower loading, halogen-free, and compatible with polymer and foam chemistries.

2.7 Manufacturing Integration

Q: Does the Fire-Inhibitor platform interfere with manufacturing processes?

No.

The engineered particles behave as:

- Non-reactive fillers
- Thermally stable particulates
- Non-migrating additives

They do not interfere with:

- Polymerization
- Catalysts
- Curing systems
- Blowing agents in foams
- Extrusion or molding operations
- This is a drop-in additive.

2.8 Particle Size Engineering

Q: What particle sizes are used and why?

Typical ranges:

- 1–5 μm for coatings and clear films
- 1–10 μm for textiles and laminates
- 1–50 μm for plastics, foams, composites
- 5–50 μm for gypsum and cementitious systems

Particle size is selected based on:

- Dispersion
- Thermal behavior
- Mechanical impact
- Processing compatibility

2.9 Halogen-Free Architecture

Q: Is this platform halogen-free?

Yes.

The fire-resistant performance is achieved without:

- Halogenated flame retardants
- Heavy metals
- Soluble salts

Performance is driven by:

- Mineral structure
- Inorganic fire-resistant chemistry
- Stable, non-migrating architectures

2.10 Optional Antimicrobial Layer

Q: Does the platform include antimicrobial performance?

Not by default.

Some embodiments optionally include an antimicrobial precursor layer, but:

- It is not required
- It is not part of the fire-resistance mechanism
- It is not part of odor control or bedding systems
- Fire resistance stands alone.

2.11 Durability and Failure Mode

Q: What is the designed failure mode?

The designed behavior is:

- Gradual thermal and structural degradation under extreme fire exposure
- No leaching
- No dripping
- No chemical release
- No volatilization
- The mineral host remains intact.

2.12 IP Position

Q: What is the IP defensibility of the Fire-Inhibitor platform?

Claims cover:

- Mineral-hosted fire-resistant architectures

Substrate-specific integration (gypsum, foams, plastics, coatings, cementitious materials)

- Performance mechanisms
- Non-migrating, insoluble fire-resistant layers
- Dual-layer FR+AM embodiments (optional)

This is not a commodity mineral — it is a protected architecture.

2.13 Rapid Validation

Q: What can S&T test immediately?

Gypsum:

- Set behavior
- Thermal response
- Fire exposure testing
- Board integrity

Foams:

- Expansion behavior
- Thermal stability
- Burn-through resistance

Plastics:

- UL-94
- LOI
- Heat release rate
- Char formation

Coatings:

- Flame spread
- Heat release
- Smoke generation

2.14 What This Is NOT

Q: What is the Fire-Inhibitor platform NOT?

It is not:

- A surface coating
- An intumescent paint
- A halogenated FR
- A phosphorus FR
- A soluble salt
- A sacrificial additive
- A polymeric FR
- A reactive FR that interferes with polymer chemistry

It is a mineral-hosted, non-migrating, thermally stable additive.

Section 3 — N-HALAMINE PLATFORM (ALL EMBODIMENTS)

3.1 Architectural Overview

Q: What is the N-halamine platform at the architectural level?

It is a family of surface-bound, humidity-activated, rechargeable oxidative architectures that generate controlled hypochlorous acid (HOCl) at the point of moisture exposure. The platform spans multiple embodiments:

- Aqueous N-halamine coatings for porous minerals
- Hybrid N-halamine + biopolymer + organosilane surface treatments
- Mineral-hosted N-halamine oxidative media
- SAP-hosted oxidative substrates
- Zeolite-hosted humidity-activated oxidative systems
- Food-preservation oxidative media
- Bedding, litter, agricultural, and environmental oxidative systems

All embodiments share:

- Anchored oxidative species
- Non-volatile, non-off gassing behavior
- Humidity-activated HOCl generation
- Rechargeability
- Non-film-forming or thin-film architectures
- Event-driven oxidative response

3.2 Problem Definition

Q: What problem does the N-halamine platform solve?

Across industries, existing odor, VOC, ammonia, microbial, and spoilage-control systems suffer from:

- Passive adsorption with finite capacity
- Single-use oxidizers
- Fogged oxidizers with no persistence
- Biological additives with slow or inconsistent performance
- Acidifiers that are corrosive and non-persistent
- Systems that act continuously instead of event-driven
- Materials that saturate and require replacement

The N-halamine platform introduces:

- Persistent, anchored oxidative capacity
- Activation only when moisture is present
- Rechargeability
- Non-volatile, non-leaching behavior

- Compatibility with solids, surfaces, minerals, SAPs, and polymers

3.3 Mechanism of Action

Q: How does N-halamine chemistry work?

N-halamines are surface-bound oxidative reservoirs that:

- Remain chemically stable when dry
- Activate upon moisture exposure
- Generate controlled HOCl at the surface
- Oxidize VOCs, odors, ammonia precursors, ethylene, and microbial residues
- Interrupt enzymatic and microbial pathways that produce ammonia
- Recharge through aqueous halamine solutions

The oxidative species is localized, not released into the environment.

3.4 Humidity Activation

Q: What does “humidity-activated” mean in this platform?

Activation occurs when:

- Ambient humidity
- Condensation
- Biological moisture
- Cleaning water
- Purge moisture (food packaging)
- contacts the anchored halamine species.

This triggers:

- HOCl generation
- Oxidation of contaminants
- Event-driven activity
- Dry state = dormant.
- Wet state = active.

3.5 Rechargeability

Q: How does rechargeability work?

After oxidative capacity is depleted:

- A dilute aqueous halamine solution is applied
- The substrate wicks or absorbs the solution
- New halamine residues deposit
- Existing residues remain
- The system dries back to a stable, non-volatile state

Rechargeability is a core architectural feature, not an add-on.

3.6 Embodiment 1 — Aqueous N-Halamine Coatings for Porous Minerals

Q: What is the aqueous N-halamine mineral-coating system?

It is an aqueous deposition process that coats porous minerals (silica, biochar, activated carbon, perlite, pumice, expanded minerals, diatomaceous earth, clay, zeolite) with non-polymeric, non-film-forming halamine residues.

Key architectural features:

- Aqueous infiltration into pores
- Deposition on internal and external surfaces
- Drying to non-water-soluble halamine residues
- Mechanical entrapment + hydrogen bonding
- No polymer films
- No grafting chemistry
- No solvents

The coated minerals remain:

- Dry
- Flowable
- Non-volatile
- Rechargeable

3.7 Embodiment 2 — Hybrid N-Halamine Spray (Biopolymer + Organosilane)

Q: What is the hybrid N-halamine spray architecture?

It is a persistent surface-treatment system combining:

- N-halamines (fast + slow species)
- A film-forming biopolymer (e.g., chitosan derivatives)
- An organosilane antimicrobial
- A surfactant
- A water or eco-solvent carrier

The architecture forms:

- A thin, persistent surface matrix
- Covalent anchoring via organosilane
- A biopolymer film that retains halamines
- Moisture-activated HOCl generation

This is not a disinfectant spray, not a fragrance spray, and not a thick coating.

3.8 Embodiment 3 — Mineral-Hosted N-Halamine Oxidative Media

Q: How does the mineral-hosted N-halamine system work?

Mineral substrates (zeolite, silica, aluminosilicates, etc.) are coated with:

- A fast-acting N-halamine species
- A slow-release N-halamine species

This creates:

- Rapid oxidative initiation
- Sustained oxidative availability
- Humidity-activated HOCl generation
- Non-volatile, non-leaching behavior

The mineral host provides:

- High surface area
- Moisture adsorption
- Gas transport pathways
- Anchoring sites

3.9 Embodiment 4 — SAP-Hosted Oxidative Media

Q: How does the SAP-hosted N-halamine system work?

Superabsorbent polymers (SAPs):

- Absorb moisture
- Activate halamine residues
- Generate HOCl within the absorbed fluid
- Destroy VOCs, odors, ammonia precursors, and microbial residues

This is used in:

- Food packaging pads
- Agricultural substrates
- Bedding and litter systems
- Spill-control materials

3.10 Embodiment 5 — Food Preservation Oxidative Media

Q: How does the food-preservation oxidative system work?

It uses anchored, non-volatile oxidative species on porous substrates (zeolite, SAPs, silica gel, ceramics, foams, cellulose) to:

- Destroy ethylene
- Destroy VOCs
- Destroy odors

- Reduce microbial load

Activation occurs only when humidity is present (purge, respiration moisture, ambient humidity).

Key safety features

- Non-volatile
- Non-off gassing
- Anchored oxidative species
- Controlled activation
- Rechargeable

This enables oxidative chemistry in food environments without off gassing risk.

3.11 Embodiment 6 — Zeolite-Hosted Humidity-Activated Oxidative Media

Q: What is the zeolite-hosted N-halamine system?

Zeolite particles are coated with a hybrid N-halamine architecture that:

- Remains dry and stable
- Activates under 20–95% RH
- Generates HOCl in situ
- Oxidizes ethylene, VOCs, and reduced gases
- Is rechargeable
- Requires no power, UV, or airflow

The zeolite pore network enables:

- Moisture adsorption
- Gas transport
- Controlled oxidative contact

3.12 Embodiment 7 — Bedding, Litter, and Agricultural Systems

Q: How does the N-halamine platform function in bedding and agricultural systems?

Ammonia formation is moisture-triggered.

N-halamines:

- Remain dormant when dry
- Activate when bedding becomes wet
- Generate HOCl at the surface
- Interrupt enzymatic and microbial ammonia pathways
- Reduce odor formation
- Recharge through humidity or respray
- This is event-driven chemistry, not continuous chemistry.

3.13 Comparison to Other Systems

Q: How is this different from acidifiers?

Acidifiers:

- Lower pH
- Are corrosive
- Require heavy application
- Provide one-shot chemistry

N-halamines:

- Do not rely on pH
- Are non-corrosive
- Are surface-bound
- Activate repeatedly
- Recharge

Q: How is this different from biological additives?

Biological additives:

- Depend on living organisms
- Are slow
- Are moisture-sensitive
- Require frequent reapplication

N-halamines:

- Are purely chemical
- Act immediately
- Are not temperature-dependent
- Persist through wet/dry cycles

Q: How is this different from fogged oxidizers (ClO₂, HOCl)?

Fogged oxidizers:

- Act briefly
- Do not bind to surfaces
- Provide no residual protection

N-halamines:

- Are surface-bound
- Provide persistent oxidative capacity
- Activate locally
- Recharge

3.14 Stability and Failure Mode

Q: What is the designed failure mode?

The designed behavior is:

- Gradual depletion of oxidative capacity
- No leaching
- No off gassing
- No uncontrolled oxidation
- No substrate degradation
- The substrate remains intact.

3.15 IP Position

Q: What is the IP defensibility of the N-halamine platform?

Claims cover:

- Humidity-activated oxidative architectures
- Mineral-hosted halamine systems
- SAP-hosted halamine systems
- Hybrid halamine blends (fast + slow)
- Rechargeable oxidative media
- Food-preservation oxidative systems
- Surface-bound halamine matrices
- Organosilane + halamine hybrid systems
- This is a platform, not a single product.

3.16 Rapid Validation

Q: What can S&T test immediately?

Mineral-hosted systems:

- VOC oxidation
- Odor reduction
- Ethylene destruction
- Humidity activation
- Recharge cycles

Hybrid sprays:

- Persistence
- Moisture-activation
- Surface binding
- Oxidative response

Food-preservation systems:

- Ethylene reduction
- VOC oxidation
- Microbial load reduction
- Purge-activated behavior

Section 4 — CROSS-PLATFORM TECHNICAL QUESTIONS

4.1 Manufacturing Integration

Q: Do any of the three platforms require new manufacturing equipment?

No.

All three platforms are designed to integrate into existing industrial workflows:

- SiO₂ platform:

Compatible with solvent lines, aqueous lines, dip tanks, spray booths, flow-coat systems, and field-applied maintenance workflows.

Fire-Inhibitor platform:

Integrates into melt compounding, extrusion, injection molding, foam expansion, gypsum slurry mixing, cementitious blending, and coating dispersion systems.

N-halamine platform:

Integrates into aqueous coating lines, mineral coating processes, SAP impregnation, spray systems, and packaging workflows.

None require:

- New reactors
- New curing ovens
- New polymerization equipment
- New environmental controls

This is intentional: the platforms are drop-in architectures, not process-disruptive technologies.

4.2 Scale-Up Behavior

Q: Are there scale-up risks or sensitivities?

Scale-up is straightforward because:

- All platforms use ambient-temperature processes
- No exotic catalysts or controlled atmospheres are required
- No high-shear or high-pressure equipment is needed
- No thermal curing profiles are required
- No solvent recovery systems are required (aqueous systems)

The only scale-up considerations are:

- Maintaining dispersion quality (minerals, SAPs)
- Ensuring uniform deposition (N-halamine coatings)
- Ensuring consistent substrate preparation (SiO₂)
- These are standard industrial controls.

4.3 Regulatory Alignment

Q: How do the platforms align with regulatory frameworks?

SiO₂ platform:

Fully PFAS-free, solvent-free (aqueous embodiment), ambient cure, no hazardous byproducts, no VOC-driven film formation.

Fire-Inhibitor platform:

Halogen-free, heavy-metal-free, non-migrating, insoluble, thermally stable, compliant with global FR restrictions.

N-halamine platform:

Non-volatile, non-off gassing, humidity-activated, surface-bound oxidative species.

Food-preservation embodiments are designed around oxidative spoilage control, not antimicrobial claims.

Across all platforms:

- No PFAS
- No fluorosilanes
- No fluoropolymers
- No halogenated FRs
- No heavy metals
- No volatile oxidizers
- No off gassing species

This aligns with:

- EU PFAS restrictions
- U.S. state PFAS bans
- OEM fluorine-reduction mandates
- EPA VOC frameworks
- FDA food-contact safety principles (for oxidative media)

4.4 Sustainability Positioning

Q: What sustainability advantages do the platforms provide?

SiO₂ platform:

Ambient cure, water-based (aqueous), PFAS-free, non-film-forming, long-life surface performance.

Fire-Inhibitor platform:

Halogen-free, heavy-metal-free, lower loading levels, non-migrating, long-term stability.

N-halamine platform:

Rechargeable, non-volatile, non-off gassing, reduces waste by extending substrate life, eliminates single-use oxidizers.

Cross-platform sustainability themes:

- Reduced chemical load
- Reduced reapplication frequency
- Reduced waste
- Reduced energy consumption
- Reduced environmental persistence
- PFAS-free architectures
- Rechargeability (N-halamines)
- Non-migrating mineral systems (FR)

4.5 PFAS Alignment

Q: Are all platforms PFAS-free?

Yes.

All platforms are engineered to avoid:

- Fluorosilanes
- Fluoropolymers
- PFAS-class hydrophobics
- Halogenated FRs
- Persistent fluorinated surfactants
- This is a core design principle across the entire portfolio.

4.6 OEM Pull and Market Drivers

Q: What is driving OEM interest in these platforms?

SiO₂ platform:

OEMs are eliminating PFAS-based hydrophobics, seeking ambient-cure, non-film-forming, durable surface treatments for glass, plastics, composites, and visibility surfaces.

Fire-Inhibitor platform:

OEMs are eliminating halogenated FRs, reducing smoke/toxicity, and seeking lower-loading, non-migrating FR systems compatible with foams, plastics, coatings, and gypsum.

N-halamine platform:

OEMs are seeking persistent, rechargeable, non-volatile oxidative systems for odor, VOC, ammonia, and spoilage control without fogging, off gassing, or corrosive chemistries.

Cross-platform OEM drivers:

- PFAS elimination
- Halogen elimination

- Sustainability mandates
- Worker-safety requirements
- Energy-reduction mandates
- Food-waste reduction
- Indoor-air-quality mandates
- Material-performance upgrades

4.7 Division Integration

Q: Which divisions can deploy these platforms?

SiO₂ platform:

- Automotive OEM
- Aerospace
- Protective & Marine
- Architectural
- Industrial
- Packaging (glass, plastics)
- Specialty coatings

Fire-Inhibitor platform:

- Architectural coatings
- Protective & Marine
- Industrial coatings
- Gypsum and drywall partners
- Foam and plastics partners
- Composite systems

N-halamine platform:

- Architectural
- Industrial
- Packaging
- Food & beverage
- Protective & Marine
- Transit interiors
- Environmental control systems
- This is a multi-division, multi-vertical portfolio.

Section 5 — WHAT THIS IS NOT

5.1 SiO₂ Platform — What It Is NOT

Q: What is the SiO₂ platform not, and why does this matter for S&T?

The SiO₂ platform is not:

- A silicone
- A siloxane
- A sol-gel
- A ceramic coating
- A polymer film
- A PFAS-based hydrophobic
- A fluorinated surface treatment
- A thick coating
- A brittle inorganic layer
- A sacrificial wax
- A temporary hydrophobic spray
- A UV-cured polymer
- A crosslinked resin
- A nano-ceramic automotive coating
- A glass-forming sol-gel precursor
- A silicone-modified acrylic
- A polysiloxane clearcoat
- A surface sealant or polish

Why this matters

If S&T misclassifies SiO₂ as a sol-gel, silicone, or ceramic, they will:

- Use the wrong adhesion tests
- Expect film-forming behavior
- Expect brittleness
- Expect thickness-dependent optical distortion
- Expect solvent-borne curing
- Expect polymeric crosslinking
- Expect PFAS-like hydrophobicity mechanisms

The SiO₂ platform is a sub-micron, non-film-forming, ambient-cure, chemically bonded micro-layer, not a coating.

5.2 Fire-Inhibitor Mineral Platform — What It Is NOT

The Fire-Inhibitor platform is not:

- An intumescent coating
- A halogenated flame retardant
- A phosphorus-based flame retardant
- A soluble salt
- A reactive FR that interferes with polymer chemistry
- A polymeric FR
- A sacrificial additive
- A smoke suppressant
- A char-forming resin
- A coating applied to surfaces
- A film-forming FR
- A resin-bound FR package
- A halogen-synergist system
- A foaming or expanding FR
- A gas-phase radical scavenger
- A polymer-plasticizing FR
- A migratory FR that leaches over time

Why this matters

If S&T misclassifies the Fire-Inhibitor platform as an intumescent, halogenated, or phosphorus FR, they will:

- Use the wrong fire-test protocols
- Expect char-expansion behavior
- Expect gas-phase radical suppression
- Expect polymer-reactive behavior
- Expect plasticization or viscosity changes
- Expect migration or leaching
- Expect high loading requirements

The Fire-Inhibitor platform is a mineral-hosted, non-migrating, thermally stable additive, not a reactive or sacrificial FR.

5.3 N-Halamine Platform — What It Is NOT

Q: What is the N-halamine platform not, and why does this matter for S&T?

The N-halamine platform is not:

- A disinfectant spray
- A fogged oxidizer (HOCl, ClO₂, ozone)

- A fragrance or masking agent
- A biological additive
- A probiotic or enzyme system
- A pH-lowering acidifier
- A volatile oxidizer
- A bleach-release system
- A chlorine-gas generator
- A polymeric antimicrobial coating
- A quaternary ammonium compound
- A silver, copper, or metal-ion antimicrobial
- A continuous-release oxidizer
- A single-use oxidizer
- A surface sanitizer
- A food-contact disinfectant
- A corrosion-driven odor control system
- A humidity-absorbing desiccant
- A passive adsorbent (activated carbon, zeolite, silica gel)

Why this matters

If S&T misclassifies N-halamines as disinfectants, fogged oxidizers, or biological additives, they will:

- Expect off gassing
- Expect continuous oxidation
- Expect corrosive behavior
- Expect rapid depletion
- Expect regulatory classification as a sanitizer
- Expect microbial kill claims
- Expect pH-driven mechanisms
- Expect fragrance-based odor masking
- Expect adsorption-capacity limits

The N-halamine platform is a surface-bound, humidity-activated, rechargeable oxidative architecture, not a disinfectant or fogged oxidizer.

5.4 Cross-Platform — What NONE of These Platforms Are

Q: What are the three platforms collectively not?

Across all three platforms, none of them are:

- PFAS systems
- Halogenated systems
- Polymer films
- Sol-gel coatings

- Ceramic coatings
- Silicone or siloxane systems
- Reactive polymer additives
- VOC-driven curing systems
- Off gassing chemistries
- Biological systems
- Enzyme-driven systems
- Fragrance or masking systems
- Temporary surface treatments
- Commodity minerals
- Commodity adsorbents
- Commodity FR fillers
- Consumer disinfectants
- Sanitizers or antimicrobial claims systems
- Hazardous-air-pollutant systems
- Systems requiring heat cure
- Systems requiring UV cure
- Systems requiring controlled atmospheres

These platforms are architectural, not commodity chemistries.

5.5 Why This Section Exists

Q: Why is “What This Is NOT” a required section for S&T?

Because misclassification leads to:

- Wrong internal routing
- Wrong benchmarking
- Wrong test protocols
- Wrong regulatory assumptions
- Wrong competitive comparisons
- Wrong customer positioning
- Wrong division ownership
- Wrong expectations for performance

Section 6 — DESIGNED FAILURE MODES

For all three platforms — SiO₂, Fire-Inhibitor, N-Halamine

This section is critical because S&T must understand:

- These platforms do not fail like coatings
- They do not fail like polymers
- They do not fail like biological systems
- They do not fail catastrophically
- Their failure modes are predictable, controlled, and non-hazardous

This prevents misinterpretation during testing, scale-up, and OEM validation.

6.1 SiO₂ Platform — Designed Failure Mode

Q: How does the SiO₂ platform fail under real-world conditions?

The SiO₂ platform is engineered to fail through controlled surface wear, not film failure.

The designed failure mode is:

- Gradual micro-layer thinning
- Predictable reduction in hydrophobicity
- No peeling
- No delamination
- No cracking
- No crazing
- No haze formation
- No brittleness
- No optical distortion
- No substrate damage
- No residue formation

This is because the SiO₂ architecture is:

- Sub-micron
- Non-film-forming
- Chemically bonded
- Not a polymer
- Not a sol-gel
- Not a ceramic film

Why this matters

If S&T tests SiO₂ like a coating, they will expect:

- Cross-hatch adhesion failure
- Film cracking

- Film delamination
- Thickness-dependent optical changes
- None of these apply.

The correct interpretation is surface wear, not coating failure.

6.2 Fire-Inhibitor Mineral Platform — Designed Failure Mode

Q: How does the Fire-Inhibitor platform fail under fire exposure?

The Fire-Inhibitor platform is engineered to fail through thermal exhaustion, not chemical release or structural collapse.

The designed failure mode is:

- Gradual thermal degradation of the fire-inhibitor layer
- Retention of mineral structure
- No leaching
- No dripping
- No volatilization
- No toxic off gassing
- No halogen release
- No phosphorus release
- No smoke-enhancing byproducts
- No polymer-plasticizing effects
- No interference with host material integrity

The mineral host remains intact even after the fire-inhibitor layer is exhausted.

Why this matters

If S&T misinterprets this as:

- Intumescent failure
- Char collapse
- Gas-phase radical suppression failure
- Polymer-reactive FR failure
- they will use the wrong FR test frameworks.

This is a mineral-hosted, non-migrating, thermally stable additive, not a reactive FR.

6.3 N-Halamine Platform — Designed Failure Mode

Q: How does the N-halamine platform fail under repeated activation cycles?

The N-halamine platform is engineered to fail through oxidative capacity depletion, not structural degradation or chemical release.

The designed failure mode is:

- Gradual reduction in available oxidative species

- Event-driven depletion (only when moisture is present)
- No off gassing
- No chlorine release
- No corrosive behavior
- No pH-driven substrate damage
- No polymer degradation
- No biological instability
- No uncontrolled oxidation
- No residue formation
- No capacity “dumping”

Once depleted, the system:

- Remains chemically stable
- Remains non-volatile
- Remains non-reactive
- Can be recharged with aqueous N-halamine solution

Why this matters

If S&T misclassifies N-halamines as:

- Fogged oxidizers
- Continuous oxidizers
- Disinfectants
- Acidifiers
- Biological systems

they will expect:

- Off gassing
- Corrosion
- Rapid depletion
- Microbial kill claims
- pH-driven mechanisms
- None of these apply.

The correct interpretation is surface-bound, humidity-activated, rechargeable oxidative depletion.

6.4 Cross-Platform Failure Mode Summary

Across all three platforms, failure modes share these characteristics:

- Non-catastrophic
- Predictable
- Controlled
- Non-hazardous

- No off gassing
- No leaching
- No polymer degradation
- No substrate damage
- No film failure
- No brittleness
- No cracking
- No delamination

These platforms are architectural, not coatings, not polymers, not biological systems, and not sacrificial chemistries.

This section is designed so S&T can start testing immediately without misclassifying the platforms or applying the wrong protocols.

Section 7 — RAPID VALIDATION GUIDE

What S&T can test immediately for each platform

This section gives S&T fast, low-infrastructure validation paths for all three platforms.

Everything here is:

- Ambient-temperature
- No special equipment
- No new workflows
- No regulatory barriers
- No proprietary reagents
- No specialized curing or ovens
- These are first-week validation tests.

7.1 SiO₂ Platform — Rapid Validation

Objective: Confirm non-film-forming behavior, hydrophobicity, optical clarity, and substrate compatibility.

Immediate tests can run

Contact Angle Measurement

Confirms hydrophobicity (PFAS-free).

Works on glass, polycarbonate, acrylic, vinyl, composites.

Wiper Abrasion / Dry Abrasion

Confirms micro-layer durability.

Should show gradual wear, not film failure.

Optical Clarity / Haze / Transmission

Confirms no haze, no scattering, no refractive distortion.

Particularly important for glass and polycarbonate.

Chemical Resistance Spot Tests

Confirms non-film-forming, chemically bonded architecture.

Plasticizer Compatibility (Aqueous SiO₂)

Apply to vinyl, PVC, PU synthetic leather.

Confirm no extraction, no whitening, no brittleness.

Flexibility Testing (Aqueous SiO₂)

Bend, fold, compress flexible substrates.

Confirms no cracking or crazing.

Cleanability / Soil-Release Testing

Apply soot, dust, salt, fingerprints.

Confirm reduced adhesion and easier removal.

What should not test:

- Cross-hatch adhesion (not a film)
- Film thickness (sub-micron)
- Pencil hardness (not a coating)

7.2 Fire-Inhibitor Mineral Platform — Rapid Validation

Objective: Confirm non-migrating, thermally stable, halogen-free fire-inhibitor behavior.

Immediate tests can run

Gypsum Slurry Integration

Add to gypsum slurry.

Confirm no set-time disruption.

Confirm improved thermal response.

Foam Expansion Compatibility

Add to PU foam formulation.

Confirm no interference with blowing agents.

Confirm no collapse or density shift.

UL-94 Screening (Plastics)

Small-scale vertical/horizontal burn tests.

Confirms flame-spread suppression.

LOI (Limited Oxygen Index)

Confirms oxygen-demand reduction.

Heat Release Rate (Micro-Calorimetry)

Confirms reduced HRR without halogens or phosphorus.

Char Integrity Observation

Confirms mineral-hosted stability.

No intumescence expected.

Smoke Generation Screening

Confirms halogen-free, low-toxicity behavior.

What not expect:

- Intumescent expansion
- Gas-phase radical suppression
- Polymer-reactive behavior

- High loading requirements

7.3 N-Halamine Platform — Rapid Validation

Objective: Confirm humidity-activated, surface-bound, rechargeable oxidative behavior.

Immediate tests can run

Humidity Activation Test

Expose treated mineral/SAP to 50–90% RH.

Confirm controlled HOCl generation (surface-bound).

VOC Oxidation Screening

Ethylene, aldehydes, sulfur compounds.

Confirms oxidative activity without off gassing.

Odor Reduction Testing

Ammonia precursors, bedding/litter substrates.

Confirms event-driven oxidation.

Rechargeability Test

Deplete oxidative capacity.

Reapply dilute halamine solution.

Confirm restored activity.

Purge-Activated Food Packaging Test

Place oxidative media in produce packaging.

Confirm ethylene reduction under humidity.

Surface Persistence Test (Hybrid Spray)

Apply to plastic, metal, composite surfaces.

Confirm persistence after multiple wet/dry cycles.

Non-Volatility Confirmation

Gas-phase HOCl measurement.

Should show no off gassing.

What should not expect:

- Continuous oxidation
- Off gassing
- pH-driven acidification
- Biological activity
- Fragrance masking
- Disinfectant-style kill claims

Section 8 — DIVISION-BY-DIVISION FIT MAP

Where each platform fits inside internal structure

This section clarifies:

- Which divisions can deploy each platform
- Which divisions gain the fastest wins
- Which divisions gain strategic differentiation
- Which divisions gain new TAM/SAM/SOM
- Which divisions must NOT misclassify the platforms
- This prevents internal confusion and accelerates adoption.

8.1 SiO₂ Platform — Division Fit Map

Primary Divisions

Automotive OEM

Visibility surfaces, glass, polycarbonate, exterior plastics, trim.

Aerospace

Transparencies, composites, exterior surfaces, hydrophobicity.

Protective & Marine

Salt-spray resistance, soil-release, non-film-forming hydrophobicity.

Architectural Coatings

Glass, plastics, composites, interior surfaces, solar glass.

Industrial Coatings

Plastics, composites, equipment surfaces, cleanability.

Packaging (Glass + Plastics)

Hydrophobicity, soil-release, anti-fouling.

Specialty Coatings

Solar, wind, marine vinyl, flexible substrates.

Secondary Divisions

Transit Interiors

Cleanability, soil-release, non-film-forming durability.

PPG Mobility / EV Platforms

Sensor clarity, camera housings, lidar windows.

Divisions Where Misclassification Must Be Avoided

Ceramic Coatings Groups

SiO₂ is NOT a ceramic coating.

Sol-Gel Teams

SiO₂ is NOT a sol-gel.

Silicone/Siloxane Teams

SiO₂ is NOT a silicone or siloxane.

8.2 Fire-Inhibitor Mineral Platform

Primary Divisions

Architectural Coatings

Fire-resistant coatings, gypsum partners, cementitious systems.

Protective & Marine

Fire-resistant industrial surfaces, structural steel, composites.

Industrial Coatings

Plastics, foams, composites requiring halogen-free FR.

Gypsum & Drywall Partners

Core integration, fire-rated boards.

Foam & Plastics Partners

PU, PIR, polyiso, ABS, PP, PE, PVC.

Composite Systems

Fiberglass, engineered panels, WPC.

Secondary Divisions

Automotive OEM

Interior plastics, under-hood components, EV battery enclosures.

Aerospace

Composite fire-resistance, interior panels.

Divisions Where Misclassification Must Be Avoided

Intumescent Coatings Groups

This is NOT an intumescent.

Halogenated FR Teams

This is NOT a halogen FR.

Phosphorus FR Teams

This is NOT a phosphorus FR.

8.3 N-Halamine Platform

Primary Divisions

Architectural Coatings

Odor/VOC/ammonia control, humidity-activated surfaces.

Industrial Coatings

Persistent oxidative surfaces, environmental control.

Packaging

Food preservation, ethylene/VOC control, purge-activated systems.

Food & Beverage

Non-off gassing oxidative media for spoilage control.

Protective & Marine

Odor/VOC control in enclosed spaces.

Transit Interiors

Odor control, ammonia suppression, humidity-activated surfaces.

Environmental Control Systems

VOC oxidation, odor suppression, humidity-activated oxidative media.

Secondary Divisions

Automotive OEM

Cabin odor/VOC control, HVAC oxidative media.

Aerospace

Cabin air quality, odor/VOC suppression.

Divisions Where Misclassification Must Be Avoided

Disinfectant / Sanitizer Teams

N-halamines are NOT disinfectants.

Fogged Oxidizer Teams

N-halamines are NOT fogged oxidizers.

Biological Additives Teams

N-halamines are NOT biological systems.

Section 9 — REGULATORY POSITIONING & CLAIMS BOUNDARIES

What can claim, what cannot claim, and how to avoid regulatory traps

This section defines:

- Allowed claims
- Prohibited claims
- Risk-triggering language
- Regulatory boundaries
- How each platform must be positioned internally and externally

This prevents from accidentally triggering:

- EPA antimicrobial regulations
- FDA food-contact restrictions
- EU biocide classifications
- PFAS scrutiny
- Halogen-FR scrutiny
- Misleading marketing claims
- Incorrect safety classifications

9.1 SiO₂ Platform — Regulatory Positioning

What can claim

can safely claim:

- Hydrophobicity (PFAS-free)
- Soil-release
- Cleanability improvement
- Optical clarity retention
- Abrasion resistance improvement (solvent SiO₂)
- Non-film-forming micro-layer
- Ambient-cure silica architecture
- PFAS-free surface performance
- Compatibility with plastics, glass, composites
- Non-migrating, non-off gassing behavior
- These are performance claims, not regulated claims.

What cannot claim

must not claim:

- Antimicrobial activity
- Antiviral activity
- Bacterial reduction

- Mold/mildew prevention
- “Kills 99.9% of germs”
- “Sanitizing” or “disinfecting”
- “Food-contact safe” unless formally validated
- “Medical-grade”
- “FDA-approved”
- These would trigger EPA/FDA regulatory classification.
- Regulatory traps to avoid
- Do not compare SiO₂ to antimicrobial coatings.
- Do not imply biological activity.
- Do not imply sol-gel or ceramic classification.
- Do not imply PFAS-like durability mechanisms.

9.2 Fire-Inhibitor Mineral Platform — Regulatory Positioning

What can claim

can safely claim:

- Halogen-free fire-inhibitor additive
- Non-migrating, insoluble, thermally stable FR architecture
- Compatible with plastics, foams, coatings, gypsum, cementitious systems
- Reduced flame spread
- Reduced heat release rate
- Improved thermal stability
- Lower smoke/toxicity compared to halogenated FRs
- Non-reactive with polymer systems
- Lower loading requirements
- These are performance-based FR claims, not chemical claims.

What cannot claim

must not claim:

- “Fireproof”
- “Flameproof”
- “Zero smoke”
- “Zero toxicity”
- “Meets all global FR standards” (must be substrate-specific)
- “Non-combustible” (regulatory definition is strict)
- “Intumescent” (it is not)
- “Halogen-synergist compatible” (not applicable)
- Regulatory traps to avoid

- Do not imply halogen-like gas-phase radical suppression.
- Do not imply phosphorus-like char chemistry.
- Do not imply intumescent expansion.
- Do not imply UL-94 classification without testing.

9.3 N-Halamine Platform — Regulatory Positioning

This is the most sensitive platform from a regulatory standpoint.

What can claim

can safely claim:

- Humidity-activated oxidative media
- Surface-bound oxidative architecture
- Non-volatile, non-off gassing oxidative behavior
- Rechargeable oxidative capacity
- Oxidation of VOCs, odors, ethylene, and ammonia precursors
- Event-driven oxidative response
- Non-biological, non-enzymatic mechanism
- Non-continuous oxidation (activation only when wet)
- Non-corrosive, non-acidifying behavior

These are chemical-mechanism claims, not antimicrobial claims.

What cannot claim

must not claim:

- Antimicrobial activity
- Antiviral activity
- Sanitizing
- Disinfecting
- “Kills bacteria”
- “Kills viruses”
- “Eliminates pathogens”
- “EPA-registered antimicrobial”
- “Food-contact disinfectant”
- “Medical-grade oxidative system”
- These would immediately trigger EPA FIFRA regulation.
- Regulatory traps to avoid
- Do not use the word “sanitize” in any context.
- Do not use the word “disinfect” in any context.
- Do not imply microbial kill claims.
- Do not imply HOCl off gassing.

- Do not imply continuous oxidation.
- Do not imply food-contact antimicrobial claims.

9.4 Cross-Platform Claims Boundaries

- Allowed cross-platform claims

Across all three platforms, can safely claim:

- PFAS-free
- Halogen-free (FR platform)
- Non-migrating
- Non-off gassing
- Ambient-cure
- Non-film-forming (SiO₂)
- Rechargeable oxidative capacity (N-halamine)
- Thermally stable mineral-hosted FR (Fire-Inhibitor)
- Multi-substrate compatibility
- Sustainability alignment
- Reduced chemical load
- Reduced reapplication frequency
- Prohibited cross-platform claims

must not claim:

- Antimicrobial activity (any platform)
- Medical or healthcare applications
- Food-contact antimicrobial claims
- “Safe for ingestion”
- “EPA-registered”
- “FDA-approved”
- “Non-toxic” (regulatory definition is strict)
- “Biodegradable” unless formally validated
- “Zero environmental impact”
- Language that triggers regulatory review

must avoid:

- “Kills”
- “Eliminates bacteria”
- “Sanitizes surfaces”
- “Disinfects”
- “Sterilizes”
- “Pathogen control”
- “Medical-grade”

- “Hospital-grade”
- “Food-safe antimicrobial”
- These words automatically escalate to EPA/FDA/EU Biocides.

9.5 Why Regulatory Positioning Matters

Incorrect claims can:

- Trigger EPA antimicrobial enforcement
- Trigger FDA food-contact enforcement
- Trigger EU Biocidal Products Regulation
- Trigger PFAS scrutiny
- Trigger halogen-FR scrutiny
- Trigger product recalls
- Trigger OEM rejection
- Trigger legal exposure
- Trigger IP misclassification

Correct claims:

- Accelerate adoption
- Reduce regulatory burden
- Protect IP
- Enable multi-division deployment

Section 10 — COMPETITIVE LANDSCAPE

This section identifies:

- The incorrect competitive categories will default to
- Why those comparisons fail at the architecture level
- The correct competitive framing for each platform
- How to prevent S&T from benchmarking against the wrong technologies

This is essential for internal alignment and external positioning.

10.1 SiO₂ Platform — Incorrect Comparisons

S&T will instinctively compare SiO₂ to:

- Sol-gels
- Ceramic coatings
- Siloxanes
- Silicones
- Polysiloxane clearcoats
- Nano-ceramic automotive coatings
- Hydrophobic polymer films
- PFAS-based hydrophobics
- Silicone-modified acrylics
- Surface sealants and polishes
- Why these comparisons are technically incorrect

These systems:

- Form films
- Require heat or catalyst cure
- Are brittle
- Are thickness-dependent
- Are polymeric or sol-gel networks
- Use PFAS or fluorinated hydrophobics
- Rely on polymer crosslinking
- Produce optical distortion at thickness

The SiO₂ platform:

- Is sub-micron
- Is non-film-forming
- Is ambient-cure
- Is chemically bonded, not polymerized
- Is PFAS-free
- Does not rely on sol-gel condensation

- Does not form a brittle inorganic film
- Does not distort optics
- Correct competitive framing

SiO₂ competes with:

- PFAS-based hydrophobics
- Silicone/siloxane soil-release systems
- Visibility-surface treatments
- Non-film-forming surface modifiers
- It does not compete with coatings.

10.2 Fire-Inhibitor Mineral Platform — Incorrect Comparisons

S&T will instinctively compare it to:

- Intumescent coatings
- Halogenated FRs
- Phosphorus FRs
- ATH/MDH mineral fillers
- Smoke suppressants
- Char-forming resins
- Reactive FR packages
- Synergist-driven FR systems
- Why these comparisons are technically incorrect

These systems:

- Rely on gas-phase radical suppression (halogens)
- Rely on char expansion (intumescents)
- Rely on phosphorus-driven char chemistry
- Require high loadings (ATH/MDH)
- Migrate or leach over time
- Plasticize polymers
- Interfere with foam expansion
- Are sacrificial or reactive

The Fire-Inhibitor platform:

- Is mineral-hosted
- Is non-migrating
- Is insoluble
- Is thermally stable
- Works at lower loadings
- Does not rely on halogens or phosphorus
- Does not expand or intumesce

- Does not interfere with polymer chemistry
- Correct competitive framing

Fire-Inhibitor competes with:

- Halogen-free FR systems
- Low-loading FR additives
- Non-migrating FR architectures
- Thermally stable inorganic FR systems

It does not compete with intumescent or halogen/phosphorus FRs.

10.3 N-Halamine Platform — Incorrect Comparisons

S&T will instinctively compare them to:

- Disinfectants
- Sanitizers
- Fogged HOCl systems
- Fogged ClO₂ systems
- Continuous oxidizers
- Biological odor-control additives
- Enzyme systems
- Acidifiers
- Activated carbon or zeolite adsorbents
- Fragrance-based odor masking systems
- Why these comparisons are technically incorrect

These systems:

- Off gas oxidizers
- Act continuously
- Are single-use
- Are biological or enzymatic
- Are pH-driven
- Are corrosive
- Are volatile
- Are capacity-limited (adsorbents)
- Mask odors instead of oxidizing them

The N-halamine platform:

- Is surface-bound
- Is humidity-activated
- Is rechargeable
- Is non-volatile
- Is non-off gassing

- Is non-biological
- Is non-acidifying
- Oxidizes VOCs, ethylene, ammonia precursors
- Activates only when wet
- Correct competitive framing

N-halamines compete with:

- VOC/odor/ammonia oxidation systems
- Ethylene-control media
- Humidity-activated oxidative substrates
- Rechargeable oxidative architectures

They do not compete with disinfectants, fogged oxidizers, or biological systems.

10.4 Cross-Platform Competitive Summary

10.5 Misclassify These Platforms

internal structure is built around:

- Coatings
- Polymers
- Sol-gels
- FR chemistries
- Biological additives
- Adsorbents
- Fogged oxidizers
- Your platforms do not fit any of these categories.

They are architectural platforms, not coatings, not polymers, not biological systems, not sol-gels, not intumescent, not fogged oxidizers.

Section 11 — IP POSITIONING & FREEDOM-TO-OPERATE (FTO) MAP

How the three platforms avoid existing IP landmines and create defensible space

This section explains:

- How your platforms avoid infringement
- How your claims create new IP territory
- How can safely commercialize without stepping into competitor patents
- How “patent pending” applies across all platforms
- How the architecture-level claims block replication
- How the FTO map protects globally

This is the section Legal and S&T will scrutinize most closely.

11.1 Portfolio Status — All Platforms Are Patent-Pending

Across all three platforms:

- SiO₂ Platform
- Fire-Inhibitor Mineral Platform
- N-Halamine Platform

You have multiple provisional filings per platform, all already submitted, and now transitioning into:

- PCT filings
- U.S. non-provisionals
- Global national-phase entries

This means:

- All platforms are patent-pending
- All embodiments are covered
- All architecture-level claims are protected
- All substrate integrations are protected
- All functional outcomes are protected.

11.2 SiO₂ Platform — IP Positioning

Core Claim Space

Your SiO₂ filings cover:

- Dual-architecture inorganic–organic silica microlayer
- Sub-micron, non-film-forming silica networks
- Ambient-cure, PFAS-free hydrophobicity
- Solvent and aqueous embodiments
- Substrate-specific bonding mechanisms
- Non-film-forming optical-safe microlayers
- Non-brittle silica architectures for flexible substrates

Freedom-to-Operate (FTO)

You avoid:

- Sol-gel patents (you are not a sol-gel)
- Ceramic coating patents (you are not a ceramic film)
- Silicone/siloxane patents (you are not a siloxane)
- PFAS hydrophobic patents (you are PFAS-free)
- Polymer film patents (you are non-film-forming)

Why competitors cannot replicate

To copy your architecture, a competitor would need to:

- Form a sub-micron, non-film-forming silica network
- Without sol-gel chemistry
- Without silicone/siloxane chemistry
- Without PFAS
- With dual-layer inorganic/organic coupling
- With substrate-specific anchoring
- This combination is claim-blocked.

11.3 Fire-Inhibitor Mineral Platform — IP Positioning

Core Claim Space

Your filings cover:

- Mineral-hosted fire-inhibitor architectures
- Non-migrating, insoluble, thermally stable FR layers
- Engineered mineral particles with bonded FR chemistry
- Substrate-specific integrations (gypsum, foams, plastics, coatings, cementitious systems)
- Dual-layer FR + optional antimicrobial embodiments
- Low-loading, halogen-free FR systems

Freedom-to-Operate (FTO)

You avoid:

- Halogenated FR patents
- Phosphorus FR patents
- Intumescent coating patents
- ATH/MDH commodity filler patents
- Reactive FR patents
- Polymer-bound FR patents

Why competitors cannot replicate

To copy your architecture, a competitor would need to:

- Bond FR chemistry to mineral surfaces
- Without halogens
- Without phosphorus
- Without intumescence
- Without polymer reactivity
- Without migration
- Without solubility
- This is a protected architecture, not a commodity FR.

11.4 N-Halamine Platform — IP Positioning

Core Claim Space

Your filings cover:

- Humidity-activated oxidative architectures
- Surface-bound, non-volatile halamine systems
- Rechargeable oxidative media
- Mineral-hosted halamine systems
- SAP-hosted halamine systems
- Hybrid halamine blends (fast + slow)
- Food-preservation oxidative media
- Organosilane + halamine hybrid matrices

Freedom-to-Operate (FTO)

You avoid:

- Fogged oxidizer patents (you are not fogged)
- Continuous oxidizer patents (you are event-driven)
- HOCl generator patents (you are surface-bound)
- Biological additive patents (you are non-biological)
- Enzyme patents (you are non-enzymatic)
- Acidifier patents (you are non-pH-driven)

Why competitors cannot replicate

To copy your architecture, a competitor would need to:

- Anchor halamines to solids
- Make them humidity-activated
- Make them rechargeable
- Make them non-volatile

- Make them non-off gassing
- Make them compatible with SAPs, minerals, and surfaces
- This is claim-blocked across multiple embodiments.

11.5 Cross-Platform IP Strategy

Your IP strategy creates:

- Three independent platform families
- Multiple embodiments per platform
- Multiple claims per embodiment
- Multiple substrate integrations
- Multiple functional claims
- Multiple global filings

FTO is clean because:

- You avoid PFAS
- You avoid halogens
- You avoid sol-gels
- You avoid silicones
- You avoid polymer films
- You avoid reactive FRs
- You avoid biological systems
- You avoid fogged oxidizers
- You avoid intumescent

Your IP blocks:

- Direct replication
- Functional replication
- Architectural replication
- Substrate-specific replication
- Multi-embodiment replication
- This is platform-level IP, not product-level IP.

11.6 Cannot Work Around Your Claims

To work around your claims, would need to:

- Invent a new silica architecture
- Invent a new halogen-free FR architecture
- Invent a new humidity-activated oxidative architecture

Each of these would require:

- New chemistry
- New mechanisms

- New substrates
- New functional outcomes

Your filings cover:

- Architecture
- Mechanism
- Substrate integration
- Functional outcomes
- Embodiments
- Failure modes
- There is no trivial workaround.

11.7 Global FTO Map

Your PCT filings enable:

- U.S.
- EU
- UK
- Canada
- China
- Singapore
- Japan
- Korea
- Australia
- Brazil

This gives :

- Global commercialization freedom
- Global licensing freedom
- Global manufacturing freedom
- Global supply-chain freedom

And it gives you:

- Global enforceability
- Global blocking power
- Global licensing leverage

Section 12 — COMMERCIALIZATION PATHWAYS

OEM, B2B, B2C, Licensing, Private-Label, and Platform-Level Deployment

This section defines:

- How each platform enters the market
- Which channels are fastest
- Which channels are highest-value
- Which channels require partnerships
- Which channels should be avoided
- How IP and regulatory boundaries shape commercialization

12.1 SiO₂ Platform — Commercialization Pathways

OEM Pathway

SiO₂ is inherently an OEM-grade surface architecture, not a consumer coating.

Primary OEM pathways

- Automotive OEM (visibility surfaces, polycarbonate, exterior plastics)
- Aerospace (transparencies, composites)
- Rail and transit (interior plastics, visibility surfaces)
- Marine (vinyl, composites)
- Solar and wind (glass, composites)

OEM advantages

- Ambient cure
- PFAS-free hydrophobicity
- Non-film-forming clarity
- No new equipment required
- Multi-substrate compatibility

B2B Pathway

Industrial integrators:

- Glass processors
- Polycarbonate sheet manufacturers
- Composite fabricators
- Marine vinyl manufacturers
- Solar panel manufacturers

B2C Pathway

Reasons:

- Misclassification as a “ceramic coating”
- Incorrect consumer expectations
- Regulatory ambiguity
- Application variability
- IP dilution

Licensing Pathway

Ideal for:

- Glass manufacturers
- Solar panel manufacturers
- Polycarbonate sheet producers

Private-Label Pathway

Only for:

- OEM service centers
- Industrial maintenance groups
- Not for consumer retail.

12.2 Fire-Inhibitor Mineral Platform — Commercialization Pathways

OEM Pathway

Fire-Inhibitor is an industrial additive, not a coating.

Primary OEM pathways

- Gypsum board manufacturers
- Foam manufacturers (PU, PIR, polyiso)
- Plastics manufacturers (ABS, PP, PE, PVC)
- Composite panel manufacturers
- Cementitious product manufacturers

OEM advantages

- Halogen-free
- Non-migrating
- Thermally stable
- Lower loading
- No interference with polymer chemistry

B2B Pathway

Industrial integrators:

- Coatings manufacturers
- Fire-resistant panel manufacturers
- Construction materials suppliers
- Industrial foam suppliers

B2C Pathway

Reasons:

- FR claims trigger regulatory scrutiny
- Consumer misuse risk
- Misclassification as intumescent

Licensing Pathway

Ideal for:

- Gypsum board companies
- Foam manufacturers
- Plastics compounders

Private-Label Pathway

Possible for:

- Industrial FR additive suppliers
- Construction materials distributors

12.3 N-Halamine Platform — Commercialization Pathways

OEM Pathway

N-halamines are humidity-activated oxidative architectures, not disinfectants.

Primary OEM pathways

- Food packaging manufacturers
- Produce packaging suppliers
- Bedding/litter manufacturers
- HVAC filter manufacturers
- Environmental control media suppliers
- Transit interior suppliers
- Industrial odor/VOC control systems

OEM advantages

- Non-volatile

- Non-off gassing
- Rechargeable
- Event-driven
- Non-biological
- Non-acidifying

B2B Pathway

Industrial integrators:

- Packaging converters
- SAP manufacturers
- Mineral media suppliers
- Odor/VOC control system manufacturers

B2C Pathway

Reasons:

- Risk of misclassification as disinfectant
- EPA/FDA regulatory exposure
- Consumer misuse
- Misinterpretation of oxidative behavior

Licensing Pathway

Ideal for:

- Food packaging companies
- Bedding/litter manufacturers
- HVAC filter manufacturers

Private-Label Pathway

Possible for:

- Industrial odor/VOC control suppliers
- Agricultural substrate suppliers

12.4 Cross-Platform Commercialization Strategy

OEM First

All three platforms are OEM-grade architectures, not consumer products.

OEM advantages

- Controlled application
- Controlled substrates
- Controlled regulatory environment

- High volume
- High defensibility
- High IP leverage

B2B Second

Industrial integrators can adopt quickly because:

- No new equipment required
- No new curing systems
- No new regulatory frameworks
- No new supply chains

Licensing Third

Licensing is ideal for:

- Glass
- Solar
- Gypsum
- Foams
- Packaging
- HVAC media

Licensing leverages:

- Patent-pending status
- Architecture-level claims
- Multi-embodiment protection

Private-Label Fourth

Only for:

- Industrial maintenance
- OEM service centers
- Environmental control suppliers

B2C Last

Reasons:

- Regulatory exposure
- Misclassification
- Consumer misuse
- IP dilution
- Brand confusion

12.5 The Ideal Commercialization Partner

already controls:

- Automotive OEM
- Aerospace
- Protective & Marine
- Architectural
- Industrial
- Packaging
- Transit
- Composites
- Gypsum partners
- Foam/plastics partners

also has:

- Global manufacturing
- Global regulatory infrastructure
- Global OEM relationships
- Global distribution
- Global technical service teams

Your platforms:

- Require no new equipment
- Fit into existing workflows
- Expand TAM
- Create new functional categories
- Are fully patent-pending
- Are fully PFAS-free
- Are fully halogen-free
- Are fully non-biological

Section 13 — RISK MATRIX

Technical, Regulatory, Commercial, IP, Manufacturing

This section gives a structured, engineering-grade risk map for all three platforms.

It is designed to:

- Pre-answer S&T concerns
- Pre-answer Regulatory concerns
- Pre-answer Legal concerns
- Pre-answer Commercial concerns
- Pre-answer Manufacturing concerns

This is the section that reduces internal friction and accelerates adoption.

13.1 Technical Risk

- SiO₂ Platform — Technical Risk Profile

Low risk because:

- Non-film-forming
- Ambient-cure
- PFAS-free
- No brittleness
- No cracking
- No delamination
- No optical distortion
- No substrate damage
- No polymer crosslinking
- No heat cure required

Primary technical risk

Incorrect testing (treating it like a coating).

Mitigation

Use surface-wear metrics, not film-failure metrics.

- Fire-Inhibitor Mineral Platform — Technical Risk Profile

Low risk because:

- Halogen-free
- Phosphorus-free
- Non-migrating
- Insoluble
- Thermally stable
- Compatible with foams, plastics, gypsum, cementitious systems

- Does not interfere with polymer chemistry

Primary technical risk

Incorrect benchmarking against intumescent or halogen FRs.

Mitigation

Use mineral-hosted FR metrics, not intumescent metrics.

- N-Halamine Platform — Technical Risk Profile

Low risk because:

- Non-volatile
- Non-off gassing
- Humidity-activated
- Rechargeable
- Non-biological
- Non-acidifying
- Non-corrosive
- Surface-bound oxidative behavior

Primary technical risk

Misclassification as a disinfectant or fogged oxidizer.

Mitigation

Use VOC/odor/ammonia oxidation metrics, not antimicrobial metrics.

13.2 Regulatory Risk

- SiO₂ Platform — Regulatory Risk Profile

Very low risk because:

- PFAS-free
- Non-biological
- Non-antimicrobial
- Non-reactive
- Non-volatile
- No EPA/FDA triggers

Regulatory risk

None, unless incorrectly claims antimicrobial activity.

- Fire-Inhibitor Mineral Platform — Regulatory Risk Profile

Low risk because:

- Halogen-free

- Phosphorus-free
- Non-intumescent
- Non-reactive
- Non-migrating

Regulatory risk

Only substrate-specific FR testing (UL-94, ASTM E84, etc.).

N-Halamine Platform — Regulatory Risk Profile

Moderate risk if misclaimed, low risk if positioned correctly.

Safe positioning

Odor/VOC/ammonia oxidation.

Ethylene control.

Humidity-activated oxidative media.

Regulatory risk

High only if claims antimicrobial activity.

Mitigation

Avoid all antimicrobial language.

13.3 Commercial Risk

- SiO₂ Platform — Commercial Risk Profile

Low risk because:

- OEM-grade
- Multi-substrate
- No new equipment
- No new curing systems
- No regulatory barriers

Commercial risk

- Misclassification as a coating → wrong customer expectations.
- Fire-Inhibitor Mineral Platform — Commercial Risk Profile

Low risk because:

- Fits existing FR workflows
- Works at lower loadings
- Halogen-free (market demand)
- Compatible with gypsum, foams, plastics

Commercial risk

Customers expecting intumescence or halogen-like behavior.

N-Halamine Platform — Commercial Risk Profile

Low risk when sold as oxidative media.

High risk if sold as disinfectant.

Commercial risk

- Mispositioning → regulatory escalation.

13.4 IP Risk

- All Platforms — IP Risk Profile

Very low risk because:

- All platforms are patent-pending
- All embodiments are covered
- All substrate integrations are covered
- All mechanisms are covered
- All functional outcomes are covered
- Competitors cannot replicate without infringing

IP risk:

- None if they operate within your architecture.

13.5 Manufacturing Risk

- SiO₂ Platform — Manufacturing Risk Profile

Low risk because:

- Ambient-cure
- No heat cure
- No UV cure
- No special equipment
- No hazardous intermediates
- No PFAS handling

Manufacturing risk

- Incorrect mixing or dilution → easily controlled.
- Fire-Inhibitor Mineral Platform — Manufacturing Risk Profile

Low risk because:

- Dry-blend compatible
- Slurry compatible
- Foam compatible

- Plastic compounding compatible
- No reactive intermediates

Manufacturing risk

- Particle dispersion uniformity → standard QC.
- N-Halamine Platform — Manufacturing Risk Profile

Low risk because:

- Non-volatile
- Non-off gassing
- Stable in dry form
- Rechargeable
- No special handling

Manufacturing risk

- Moisture control during storage → standard packaging.

13.6 Cross-Platform Risk Summary

Overall Risk Rating:

Low, with predictable boundaries and no systemic liabilities.

- have global toll-blend capacity
- have global raw-material supply
- not need to build anything
- Scale-up is immediate
- Risk is near-zero

Section 14 — MANUFACTURING & SCALE-UP ARCHITECTURE

How each platform scales, what equipment is needed, and can produce all three immediately

This section explains:

- How each platform is manufactured
- What equipment is required
- can produce all three platforms today
- How toll blenders fit into the architecture
- Why global supply chains are already secured
- Why scale-up risk is near zero

This is the section that eliminates internal manufacturing objections.

14.1 Global Manufacturing Status — Already Operational

Across all three platforms:

- Toll blenders are already in place (U.S., Singapore, APAC).

All raw materials are supplied by global chemical companies with multi-continent redundancy.

All blends can be produced by any competent toll blender with standard equipment.

No specialized reactors, no exotic conditions, no proprietary equipment are required.

- All processes are batch-scalable from pilot → 100 kg → 1,000 kg → 10,000 kg.

All QC methods are standard (pH, solids, viscosity, particle size, oxidative capacity).

Does not need to build new infrastructure. can immediately produce all three platforms in any of its global facilities or approved tollers.

14.2 SiO₂ Platform — Manufacturing Architecture

Process Type

- Standard blending
- Ambient-temperature mixing
- No heat cure
- No UV cure
- No polymerization
- No hazardous intermediates

Equipment Required

- Stainless steel or HDPE mixing tanks
- Low-shear or medium-shear mixers
- Standard filtration
- Standard filling lines

Why can produce immediately

already operates:

- Glass-prep chemical lines
- Plastic-prep chemical lines
- Aqueous and solvent blending lines
- Industrial surface-treatment lines

Toll Blender Compatibility

Any toll blender with:

- Stainless or HDPE tanks
- Controlled addition capability
- Basic QC lab
- can produce the SiO₂ platform.

14.3 Fire-Inhibitor Mineral Platform — Manufacturing Architecture

Process Type

- Dry blending
- Slurry blending
- Foam/plastic compounding
- Cementitious integration

Equipment Required

- Ribbon blenders
- Paddle mixers
- High-shear dispersers (optional)
- Extruders (for plastics)
- Standard powder handling systems

Why can produce immediately

already operates:

- Powder-coating lines
- Cementitious additive lines
- Composite additive lines
- Industrial mineral-handling systems

Toll Blender Compatibility

Any toll blender with:

- Powder blending capability
- Slurry mixing capability

- Standard QC (particle size, solids, dispersion)
- can produce the Fire-Inhibitor platform.

14.4 N-Halamine Platform — Manufacturing Architecture

Process Type

- Dry blending (minerals, SAPs)
- Aqueous charging (for recharge solutions)
- Hybrid blending (fast + slow halamine media)

Equipment Required

- Stainless or HDPE tanks
- Low-shear mixers
- Powder blenders
- Controlled humidity storage

Why can produce immediately

already operates:

- Aqueous chemical lines
- Powder-media lines
- Packaging lines for desiccants, adsorbents, and media
- Environmental control product lines

Toll Blender Compatibility

Any toll blender with:

- Powder blending capability
- Aqueous blending capability
- Moisture-controlled storage
- can produce the N-halamine platform.
-

14.5 Cross-Platform Scale-Up Advantages

- No specialized equipment

All platforms use:

- Standard mixers
- Standard tanks
- Standard powder blenders
- Standard QC
- No hazardous chemistry

No:

- PFAS
- Halogens
- Sol-gel precursors
- Reactive monomers
- Polymerization steps
- High-temperature curing
- No new regulatory infrastructure

Manufacturing does not trigger:

- EPA antimicrobial registration
- FDA food-contact registration (unless PPG chooses to pursue it)
- EU Biocides classification
- No new supply chain

All raw materials are:

- Commercially available
- Multi-continent
- Multi-supplier
- Already in your toll-blend network
- No scale-up instability

All platforms have:

- Linear scale-up
- No exotherms
- No reaction kinetics
- No catalyst sensitivity
- No batch-to-batch drift
- No capital expenditure

can scale globally with:

- Zero new equipment
- Zero new facilities
- Zero new regulatory filings
- Zero new safety systems

14.6 Has Zero Manufacturing Risk

global footprint already includes:

- Aqueous blending
- Solvent blending
- Powder blending

- Slurry blending
- Composite additive integration
- Packaging lines
- QC labs
- Toll-blend partnerships

can:

- Produce
- Scale
- Package
- Ship
- Integrate
- License
- immediately, with no new investment.

It quantifies why these platforms matter economically, how they generate margin, and how they expand TAM/SAM/SOM without requiring new capex, new regulatory burden, or new manufacturing infrastructure.

Section 15 — ECONOMIC MODEL

Cost, Margin, OEM Value, PPG Value, and Platform-Level Economics

This section defines:

- Cost structure
- Margin structure
- OEM value creation
- value creation
- Platform-level economics
- Why these platforms outperform coatings, FRs, and oxidizers economically
- Why can scale globally with near-zero incremental cost
- This is the economic architecture, not a pricing sheet.

15.1 Cost Structure — All Platforms

Across all three platforms:

- Raw materials are globally sourced
- All inputs are commodity or specialty-commodity grade
- No PFAS, no halogens, no sol-gels, no reactive monomers
- No hazardous intermediates
- No specialized equipment
- No high-energy curing
- No high-temperature processing
- No catalyst systems
- No controlled-atmosphere requirements

This produces:

- Low COGS
- Stable supply chain
- Multi-continent redundancy
- Predictable pricing
- No regulatory cost drag

Your existing toll-blender network already produces at:

- Pilot scale
- 100 kg scale
- 1,000 kg scale
- 10,000 kg scale
- can scale immediately with no capex.

15.2 Margin Structure — All Platforms

Because the platforms are architectural, not commodity chemistries, they support:

- High gross margins
- High contribution margins
- High OEM value capture
- High licensing leverage
- High differentiation
- Low competitive pressure

Margin drivers

- PFAS-free hydrophobicity (SiO₂)
- Halogen-free FR performance (Fire-Inhibitor)
- Rechargeable oxidative media (N-halamine)
- Multi-substrate compatibility
- No competing architectures
- Patent-pending protection
- OEM-grade performance
- These are platform margins, not additive margins.

15.3 OEM Value Creation

- SiO₂ Platform — OEM Value

OEMs gain:

- Reduced warranty claims
- Reduced cleaning cycles
- Improved visibility safety
- Improved optical clarity
- PFAS-free compliance
- No new equipment
- No new curing systems
- OEM value is operational, not cosmetic.
- Fire-Inhibitor Mineral Platform — OEM Value

OEMs gain:

- Halogen-free compliance
- Lower smoke/toxicity
- Lower loading vs ATH/MDH
- No polymer interference
- No intumescence variability
- Improved fire ratings

- Lower insurance risk
- OEM value is regulatory + performance.
- N-Halamine Platform — OEM Value

OEMs gain:

- Odor/VOC/ammonia control
- Ethylene control for produce
- Rechargeable oxidative media
- Non-off gassing safety
- No EPA antimicrobial burden
- No biological instability
- OEM value is air-quality + shelf-life + safety.

15.4 Value Creation

gains:

- New TAM in PFAS-replacement hydrophobics
- New TAM in halogen-free FR systems
- New TAM in oxidative media for packaging and environmental control
- New OEM relationships
- New licensing revenue
- New cross-division synergies
- New sustainability credentials
- New IP-protected categories

also gains:

- Zero capex
- Zero regulatory burden
- Zero new equipment
- Zero new safety systems
- Zero new supply chain risk
- This is pure margin expansion.

15.5 Platform-Level Economics

- SiO₂ Platform Economics
- Low COGS
- High OEM value
- High margin
- High differentiation
- No PFAS liability
- No coating-line modifications

- No curing cost
- Economic model: high-margin surface architecture.
- Fire-Inhibitor Mineral Platform Economics
- Lower loading vs ATH/MDH
- Lower cost vs halogen/phosphorus FRs
- Higher performance per unit cost
- No migration → longer service life
- No regulatory burden
- Economic model: high-value FR additive.
- N-Halamine Platform Economics
- Low COGS (minerals, SAPs, halamines)
- High OEM value (odor/VOC/ethylene control)
- Rechargeable → recurring revenue
- Non-volatile → no packaging liability
- No EPA antimicrobial cost
- Economic model: recurring oxidative-media platform.

15.6 Why These Platforms Outperform Traditional Chemistries Economically

Traditional chemistries suffer from:

- PFAS liability
- Halogen toxicity
- Phosphorus cost volatility
- Sol-gel brittleness
- Polymer crosslinking variability
- Fogged oxidizer instability
- Biological additive shelf-life issues
- High regulatory burden
- Your platforms avoid all of these.

Economic advantages

- No PFAS
- No halogens
- No sol-gels
- No biological systems
- No off gassing
- No curing energy
- No specialized equipment
- No regulatory filings
- No hazardous waste

- This is structural economic superiority.

15.7 Can Capture Margin Immediately

already has:

- Global blending
- Global QC
- Global packaging
- Global distribution
- Global OEM relationships
- Global regulatory infrastructure

Your platforms require:

- No new equipment
- No new training
- No new certifications
- No new safety systems
- No new supply chains

can:

- Produce
- Sell
- License
- Integrate
- immediately, with zero incremental cost.

Section 16 — EXECUTIVE SUMMARY (

Condensed architecture-level summary of all platforms, risks, manufacturing, IP, and commercialization

This section gives a single-page, high-density overview of the three platforms, their architecture, their non-equivalencies, their regulatory boundaries, their IP status, and their commercialization readiness.

It is designed for executives, S&T directors, regulatory leads, and manufacturing heads.

16.1 Platform Architecture Summary

SiO₂ Platform

A sub-micron, non-film-forming, ambient-cure silica architecture that chemically bonds to substrates without forming a polymer, sol-gel, or ceramic film.

Delivers PFAS-free hydrophobicity, soil-release, optical clarity, and surface durability without brittleness, thickness, or crosslinking.

Fire-Inhibitor Mineral Platform

A mineral-hosted, non-migrating, halogen-free, phosphorus-free fire-inhibitor architecture that integrates into gypsum, foams, plastics, composites, and cementitious systems without intumescence, polymer interference, or high loading.

N-Halamine Platform

A humidity-activated, surface-bound, rechargeable oxidative architecture that oxidizes VOCs, odors, ethylene, and ammonia precursors without off gassing, continuous oxidation, biological activity, or EPA antimicrobial classification.

16.2 What These Platforms Are NOT

- Not coatings
- Not sol-gels
- Not ceramics
- Not silicones or siloxanes
- Not PFAS systems
- Not halogenated or phosphorus FRs
- Not intumescent
- Not disinfectants or sanitizers
- Not fogged oxidizers
- Not biological additives
- Not polymer films
- Not reactive chemistries

This prevents misclassification, incorrect benchmarking, and incorrect regulatory assumptions.

16.3 Regulatory Positioning

All platforms avoid:

- EPA antimicrobial registration
- FDA food-contact disinfectant classification
- EU Biocidal Products Regulation
- PFAS scrutiny
- Halogen-FR scrutiny
- Sol-gel/ceramic classification
- Polymer crosslinking regulations

16.4 IP Positioning & Patent Status

All three platforms are:

- Patent-pending
- Covered by multiple provisional filings
- Transitioning into PCT and national-phase filings
- Protected at the architecture level
- Protected across multiple embodiments
- Protected across substrate integrations
- Protected across functional outcomes

Competitors cannot replicate without infringing because the claims cover:

- Architecture
- Mechanism
- Substrate bonding
- Functional behavior
- Failure modes
- Multi-embodiment variants

16.5 Manufacturing & Scale-Up Readiness

All platforms:

- Use standard blending equipment
- Require no new capex
- Require no new curing systems
- Require no specialized reactors
- Require no hazardous intermediates
- Scale linearly from pilot → 10,000 kg
- Have stable, multi-continent raw-material supply
- Are already produced by existing toll blenders in the U.S., Singapore, and APAC
- Can be produced by any competent toll blender with standard equipment

can manufacture immediately in:

- Aqueous lines
- Solvent lines
- Powder lines
- Slurry lines
- Composite additive lines
- Manufacturing risk is near zero.

16.6 Commercialization Architecture

OEM First

Automotive, Aerospace, Protective & Marine, Architectural, Industrial, Packaging, Gypsum, Foams, Plastics, Composites.

B2B Second

Glass processors, plastics compounders, foam manufacturers, packaging converters, environmental control suppliers.

Licensing Third

Solar, glass, gypsum, foams, packaging, HVAC media.

Private-Label (Selective)

Industrial maintenance, OEM service centers, environmental control suppliers.

B2C (Avoid)

Regulatory risk, misclassification risk, IP dilution.

16.7 Economic Model

All platforms deliver:

- Low COGS
- High OEM value
- High margin
- No regulatory drag
- No capex
- No new equipment
- No new supply chain
- No PFAS liability
- No halogen liability
- No biological liability

gains:

- New TAM in PFAS-replacement hydrophobics

- New TAM in halogen-free FR systems
- New TAM in oxidative media for packaging and environmental control
- Cross-division synergy
- Licensing revenue
- Platform-level defensibility

16.8 Risk Summary

16.9 Executive Takeaway

These are three platform-level architectures, not coatings, not FR additives, not oxidizers, and not biological systems.

They are patent-pending, manufacturing-ready, regulatory-safe, OEM-grade, and commercially scalable today using existing global infrastructure.

They expand TAM, reduce regulatory exposure, eliminate PFAS/halogen liabilities, and create new defensible categories across multiple divisions.

Section 17 — GLOBAL TAM/SAM/SOM SUMMARY (THREE-PLATFORM VIEW)

High-level, non-detailed-facing market scale

This section provides a macro-scale view of the global market opportunity across the three platforms.

It is intentionally high-level, architecture-driven, and avoids granular segmentation.

It shows the scale of the opportunity

17.1 SiO₂ Platform — Global TAM/SAM/SOM

TAM (Total Addressable Market)

Global surfaces requiring hydrophobicity, soil-release, optical clarity, or PFAS-replacement performance:

- Automotive glass & plastics
- Aerospace transparencies
- Architectural glass
- Industrial plastics & composites
- Solar glass
- Marine vinyl & composites
- Transit interiors

Estimated global TAM:

- \$8B–\$12B annually
- SAM (Serviceable Available Market)

Segments where SiO₂ integrates without workflow changes:

- Automotive OEM
- Aerospace OEM
- Architectural glass processors
- Industrial plastics
- Solar panel manufacturers

Estimated SAM:

- \$1.5B–\$3B annually
- SOM (Serviceable Obtainable Market)

Realistic capture within 3–5 years through PPG's existing divisions:

- \$150M–\$400M annually

17.2 Fire-Inhibitor Mineral Platform — Global TAM/SAM/SOM

- TAM (Total Addressable Market)

Global halogen-free, phosphorus-free, non-migrating FR demand across:

- Gypsum board
- PU/PIR/polyiso foams
- Plastics (ABS, PP, PE, PVC)
- Composites
- Cementitious systems
- Industrial coatings

Estimated global TAM:

- \$15B–\$22B annually
- SAM (Serviceable Available Market)

Segments where mineral-hosted FR integrates without polymer interference:

- Gypsum manufacturers
- Foam manufacturers
- Plastics compounders
- Composite panel manufacturers

Estimated SAM:

- \$3B–\$6B annually
- SOM (Serviceable Obtainable Market)

Realistic capture within 3–5 years through PPG’s FR, Architectural, and Industrial divisions:

- \$300M–\$700M annually

17.3 N-Halamine Platform — Global TAM/SAM/SOM

TAM (Total Addressable Market)

Global demand for non-biological, non-off gassing, humidity-activated oxidative media across:

- Food packaging (ethylene/VOC control)
- Produce logistics
- Bedding/litter substrates
- HVAC filters
- Environmental control media
- Transit interiors
- Industrial odor/VOC systems

Estimated global TAM:

- \$10B–\$14B annually
- SAM (Serviceable Available Market)

Segments where N-halamines integrate without antimicrobial claims:

- Produce packaging
- Bedding/litter manufacturers
- HVAC media suppliers

- Environmental control systems

Estimated SAM:

- \$1.2B–\$2.5B annually
- SOM (Serviceable Obtainable Market)

Realistic capture within 3–5 years through PPG Packaging, Industrial, and Environmental divisions:

- \$120M–\$300M annually

17.4 Combined Three-Platform Global Opportunity

- Combined TAM
- \$33B–\$48B annually
- Combined SAM
- \$5.7B–\$11.5B annually
- Combined SOM (3–5 years)
- \$570M–\$1.4B annually

This is platform-level, not product-level, and reflects:

- Multi-division deployment
- Multi-substrate integration
- Multi-vertical adoption
- Patent-pending defensibility
- Zero-capex manufacturing
- Zero regulatory drag (when claims are correct)