Rethinking fire safety with Anogas:

How Hydrogel transforms lithium-ion battery fire suppression

Anogas
Hydrogel

Inside Anogas

Anogas is a materials innovation company focused on rethinking fire safety through environmentally responsible technology. Based in the Netherlands and built on more than 20 years of expertise in advanced materials, developed in close collaboration with its parent organisation, The Materials Factory, the company combines technical depth with a clear sustainability agenda.

At the centre of Anogas is a firm principle: never compromise on health, safety, or the environment. This approach guides both its strategic direction and product development. The company is committed to creating solutions that meet demanding functional requirements while reducing environmental impact across their lifecycle, including responsible end-of-life outcomes.

That philosophy is most clearly expressed in Anogas' Hydrogel fire extinguishing technology. Developed as a sustainable alternative to conventional suppressants, Hydrogel is composed of water and modified natural clay, making it safe for humans and compliant with strict European chemical standards. It is entirely PFAS-free and has a carbon footprint of less than 1%.

The technology works through a temperature-sensitive mechanism: a low-viscosity liquid transforms into a thicker gel when exposed to heat, allowing it to adhere directly to the fire source. This ensures sustained cooling while forming a barrier that limits oxygen and flammable gases.

When deployed as a foam, either through handheld extinguishers or sprinkler systems, it can cling to vertical surfaces or float on fuels, making it effective across a wide range of fire types, including lithium-ion battery fires. Crucially, the material itself is non-flammable and does not contribute to combustion.

In a sector often shaped by legacy solutions, Anogas positions itself as a forward-looking partner – focused not just on extinguishing fires, but on doing so in a way that aligns with the environmental and safety demands of the future.

How Hydrogel combats the growing challenge of lithium-ion battery fires

Lithium-ion batteries now underpin much of modern infrastructure. They power consumer electronics, support the rapid expansion of electric vehicles (EVs), and play a critical role in large-scale energy storage systems that enable the transition toward electrification. Their high energy density, efficiency, and long operational life have made them indispensable across industries.

However, these advantages come with an increasingly visible and complex risk.

Lithium-ion battery fires are not conventional fire events. Unlike traditional fires, which rely on an external fuel source, these incidents are driven by internal chemical reactions within the battery itself. Once initiated, those reactions can sustain and even intensify without external input, making them particularly difficult to control.

As lithium-ion systems become more widespread – in vehicles, warehouses, industrial settings, and critical infrastructure – the frequency and visibility of these incidents are increasing. What was once considered a niche or emerging risk is now recognised as a distinct category of fire hazard, requiring more specialised and technically informed approaches to suppression.

Anogas: Engineering fire safety for modern risks

Anogas has positioned itself at the forefront of this shift. The company focuses on developing fire-extinguishing technologies specifically for modern energy systems, balancing performance with environmental responsibility.

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Rather than adapting legacy firefighting methods, Anogas applies a materials science-driven approach. Drawing on more than two decades of experience in environmentally conscious material development, the company develops solutions that address both the physical and chemical dynamics of contemporary fire risks.

At the centre of this work is Hydrogel, a fire suppression technology engineered specifically for lithium-ion battery fires. Its design reflects a clear understanding that these fires behave differently, and therefore require a fundamentally different response.

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Understanding how lithium-ion battery fires develop

To understand why a new approach is necessary, it is important to examine how lithium-ion battery fires begin and evolve.

Lithium-ion batteries are composed of multiple individual cells, each containing reactive materials stored under controlled conditions. These cells are enclosed within protective housings, but when one becomes compromised through mechanical damage, overheating, or improper charging, the system can destabilise rapidly.

The failure typically begins at the level of a single cell. As the internal temperature rises, it initiates a process known as thermal runaway. During this phase, heat generation accelerates uncontrollably, causing the materials within the cell to break down and release flammable gases. Pressure builds rapidly until the casing ruptures, releasing these gases into the surrounding environment.

If ignition occurs, the result is an intense and fast-moving fire. However, the initial ignition is only part of the problem. The heat generated by the failing cell can transfer to adjacent cells, triggering further reactions and creating a cascading chain of failures.

This propagation is what makes lithium-ion battery fires particularly difficult to manage. What begins as a localised issue can escalate into a large-scale incident within seconds or minutes.

At the same time, these fires produce a complex mixture of gases that introduces additional hazards. Among the most significant are hydrogen (H_2), methane (CH_4), and hydrogen fluoride (HF). Hydrogen and methane are highly flammable, increasing the risk of explosion, while hydrogen fluoride is both toxic and corrosive, posing serious risks to responders and the surrounding environment.

These gases can continue to be released even after visible flames have subsided, meaning that the danger persists beyond the initial fire event. This combination of heat, gas release, and chemical instability defines the unique challenge of lithium-ion battery fires.

Why traditional fire suppression falls short

Traditional firefighting systems were not designed with these conditions in mind. Many rely on foam-based extinguishing agents that contain PFAS (per- and polyfluoroalkyl substances), which enhance performance by improving spreadability and thermal stability.

While effective in certain applications, PFAS-based systems introduce significant environmental and health concerns. These chemicals are highly persistent and do not degrade naturally, leading to long-term contamination of soil and groundwater. They can accumulate in living organisms and have been linked to serious health risks, including cancer.

The scale of the issue is considerable. PFAS compounds are now detectable in the blood of most people worldwide, and the associated health costs in Europe alone are estimated to reach tens of billions of euros annually if no action is taken.

Regulatory frameworks are evolving in response. Under EU Regulation (EU) 2025/1988, the use of PFAS-containing extinguishing agents is being phased out through a structured timeline, culminating in a complete ban by 2031.

This regulatory pressure is accelerating the need for alternative technologies – solutions that can deliver effective fire suppression without introducing long-term environmental consequences.

Hydrogel: A multi-layered response to lithium-ion battery fires

Hydrogel represents a new generation of fire suppression technology. It is designed not as a single-function extinguisher, but as a multi-layered system that addresses the full lifecycle of lithium-ion battery fires – from ignition through to complete stabilisation.

This approach is particularly important in scenarios where fire behaviour is driven by overlapping thermal and chemical processes rather than a single fuel source.

Rapid and sustained cooling

Hydrogel's high water content enables immediate heat absorption, rapidly reducing temperatures at the source of the fire. This rapid cooling is critical in interrupting thermal runaway before it can escalate further.

What distinguishes Hydrogel from water alone is its behaviour under extreme conditions. The material exhibits thermally activated thickening, meaning it becomes more viscous when exposed to high temperatures. This allows it to adhere strongly to hot battery surfaces, forming a stable and persistent cooling layer.

In addition, Hydrogel can expand during application, improving coverage and enhancing heat dissipation across the affected area. This expansion increases the efficiency of cooling by ensuring more complete contact with hot surfaces. Together, these properties ensure that cooling is not only immediate but sustained, continuing until temperatures are reduced to safe levels.

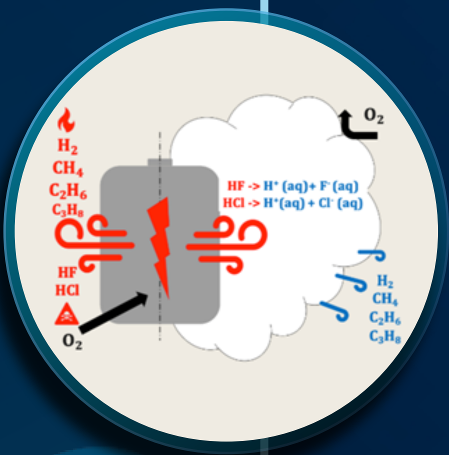
Neutralisation of toxic and flammable gases

A defining feature of lithium-ion battery fires is the release of hazardous gases, including H_2, CH_4, and HF. Hydrogel actively interacts with these gases, reducing their concentration and mitigating their impact.

Through chemical interaction with the water contained in the gel:

- Toxic gases such as HF are neutralised into less harmful ionic components
- Flammable gas concentrations are reduced, lowering the risk of explosion
- Oxygen availability is restricted, suppressing combustion

This multi-layered interaction transforms Hydrogel into more than a cooling agent. It becomes an active barrier that addresses both fire behaviour and atmospheric hazards simultaneously.

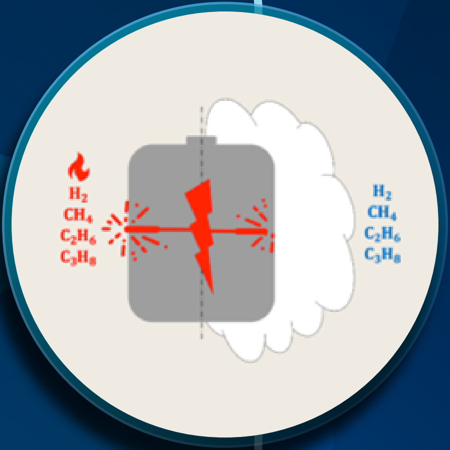


Physical insulation and containment

As Hydrogel is applied, it forms a thick, adhesive layer that acts as a physical barrier between the heat source and the surrounding environment.

This barrier prevents oxygen from feeding the fire while also isolating escaping gases from ignition sources. In lithium-ion battery fires, where gas release can continue even after flames are suppressed, this insulation is critical in preventing secondary ignition events.

It also helps to interrupt thermal propagation between battery cells, limiting the spread of the fire and reducing the scale of the incident.



Chemical stabilisation of lithium components

Beyond cooling and containment, Hydrogel addresses the chemical processes that sustain the fire. Clay particles within the gel penetrate damaged battery structures and bind with reactive lithium ions (Li^+).
By reducing lithium reactivity, Hydrogel helps stabilise the battery at a chemical level. This reduces the likelihood of further reactions and contributes to long-term fire suppression.

This mechanism is particularly important because it targets the root cause of lithium-ion battery fires, rather than simply managing their external effects.

A system-level approach

Individually, each of these mechanisms contributes to fire suppression. Together, they create a system capable of managing the entire fire lifecycle – from the initial ignition phase through to full stabilisation. This integrated approach is what differentiates Hydrogel from conventional extinguishing agents.

From suppression to full fire control

Lithium-ion battery fires can reach extreme temperatures, typically in the range of 850 to 1500°C during thermal runaway. At these temperatures, many conventional suppression methods struggle to remain effective.

Hydrogel is designed to operate across this full temperature range. It supports the extinguishing process from peak thermal conditions through to ambient stability, continuing to act on heat, gases, and reactive materials until the system is fully stabilised.

This capability is critical in preventing re-ignition. Even after flames are extinguished, residual heat and chemical activity can persist within the battery. By maintaining cooling and stabilisation over time, Hydrogel reduces the likelihood that these underlying processes will reignite the fire.

In practical terms, this represents a shift from simple fire suppression to comprehensive fire control.

Applying Hydrogel in real-world scenarios

Hydrogel has been validated through extensive testing under both controlled and real-world conditions, demonstrating its effectiveness across a range of applications.

The required volume depends on the scale of the battery system involved:

- Small devices (smartphones, laptops): minimum 2 litres
- Medium systems (e-bikes, power tools): minimum 6 litres
- Industrial systems:
    - o 25–50 litres for smaller installations
    - o 300–10,000+ litres for large-scale battery safety systems

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In larger installations, access to the ignition source may be restricted by protective enclosures. In these cases, Hydrogel can be deployed from a safe distance to suppress and contain the fire until emergency services arrive.

Application and safety considerations

Effective application is essential. Hydrogel should be applied in controlled intervals to maintain a consistent cooling layer, with the extinguishing stream directed toward visible flames and areas where gas is being released.

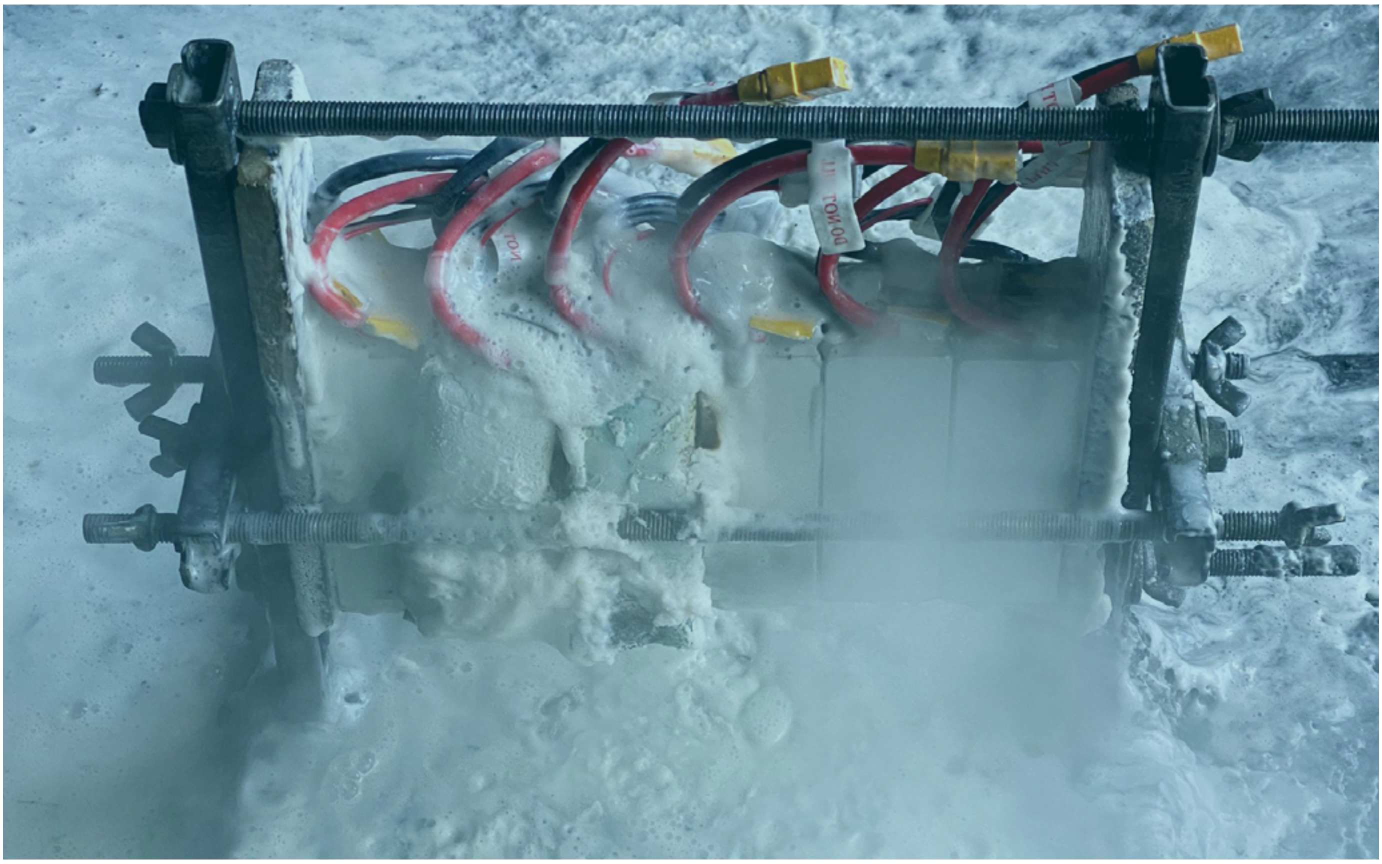
Focus first on extinguishing all visible flames to prevent the fire from spreading. Once the flames are under control, apply Hydrogel to the surface of the battery pack, aiming to penetrate into the internal structure for localised cooling.

If the internal components of the battery pack cannot be reached, stop applying additional Hydrogel and reassess. Continuously monitor the situation for signs of further de-gassing or new flames, especially from adjacent batteries that may already be in an advanced stage of thermal runaway.

Repeat this process—extinguishing flames and applying Hydrogel where effective—until:

- No visible flames remain
- No new flame eruptions occur
- Audible gas emissions (such as hissing or sizzling) have stopped

At this point, the thermal runaway of the affected battery pack is considered stabilised. The Hydrogel will continue cooling the battery to a safe state, typically producing white water vapor (steam) as part of the cooling process.



Operators should maintain a safe distance and use appropriate respiratory protection. Although Hydrogel reduces the release of toxic gases, it does not eliminate them entirely, and exposure risks remain during intervention.

Post-incident management and cleanup

Even after extinguishment, lithium-ion battery systems require careful monitoring. A minimum observation period of 20 minutes is recommended to detect any signs of re-ignition or instability.

Once stabilised, batteries should be transferred to a water-filled containment vessel and/or stored in a well-ventilated area or outdoors, isolated from combustible materials. A cooling period of at least 48 hours is required before disposal.

Residual Hydrogel can be removed by absorbing excess material and rinsing affected surfaces with water, making post-incident cleanup relatively straightforward.

Environmental performance without compromise

Hydrogel also addresses one of the most pressing challenges in firefighting: environmental impact. It contains no detectable PFAS, aligning with both current regulations and future restrictions.

In addition, the material supports a circular lifecycle. After use, it can be collected and recycled, with its natural clay-based components suitable for reuse as compost enhancers.

This positions Hydrogel as a solution that delivers both operational effectiveness and environmental responsibility.

A future-facing solution for lithium-ion battery fires

The rise of lithium-ion battery fires is closely tied to broader trends in electrification and energy storage. As these technologies continue to expand, so too will the risks associated with them.

Addressing these risks requires solutions that are specifically designed for the complexity of modern fire scenarios. Hydrogel reflects this shift, offering a comprehensive, science-driven approach to fire suppression.

By integrating cooling, gas neutralisation, insulation, and chemical stabilisation, it provides a more complete and reliable response to lithium-ion battery fires.

Conclusion

Lithium-ion battery fires represent one of the most complex fire risks in modern industry. Their ability to escalate rapidly, release hazardous gases and reignite makes them fundamentally different from traditional fire scenarios.

Anogas' Hydrogel technology provides a response that matches this complexity. It moves beyond conventional suppression, offering a system that cools, contains, neutralises, and stabilises the fire environment from extreme temperatures down to safe conditions.

As reliance on lithium-ion batteries continues to grow, Hydrogel is an essential tool in managing the risks of an increasingly electrified world.

Hydrogel by Anogas BV PFAS-free fire extinguishing technology

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