FLUOROKETONE FK 5-1-12 MICROENCAPSULATION & THERMOREACTIVE MATERIALS TECHNOLOGY

(Advanced Solutions for Lithium Battery Safety & General Fire Protection)

It is well known that fluoroketone (FK 5-1-12) is one of the most efficient fire suppression agent at the market.

FK 5-1-12 is recommended for use as a part of industrial gas fire extinguishing systems, consisting of liquid FK 5-1-12 storage containers and an advanced fire detection system with various sensors acting on devices to release fluoroketone from containers into the fire area. With the proven effectiveness of FK 5-1-12 as combustion suppression agent itself and extinguishing systems based on it, a significant drawback of the solution is technical complexity and cost of systems developed.

Due to that here are certain obstacle factors preventing its wider usage in some of market segments.

These factors are:

- Necessity to arrange fluoroketone storing in containers or bottles under pressure.
- Quite complicated infrastructure to distribute and deliver the fluoroketone from the storage place to the scene of fire.
- For initiation of fire, suppression by releasing fluoroketone to the area of combustion it is required to use a system of various detectors triggering release activation. As regular, these are traditional sensors used in fire alarm systems detecting fire factors appeared already at the phase of active burning, which is too late and make firefighting much more difficult.
- Fire detecting sensors and triggering fluoroketone systems require external power supply, which can be a fatal factor in case of power loss.

EXTO Technologies solution resolves the majority of these pending factors!

It must be acknowledged, there are solutions for automatic fluoroketone release based on thermally controlled valves, but these solutions activate fluoroketone release at late stage of fire development, when ambient temperature in the protected area reached high level and the fire is already in the phase of intensive burning and propagation.

Microencapsulation technology in its core

Microencapsulation of liquid substances is a technique used to enclose tiny droplets of liquid within a protective shell to control their release, enhance stability, and prevent degradation.

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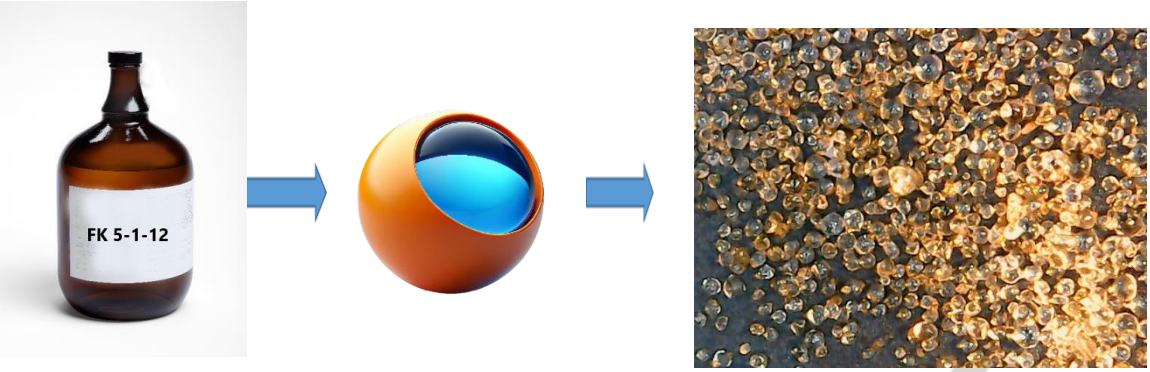
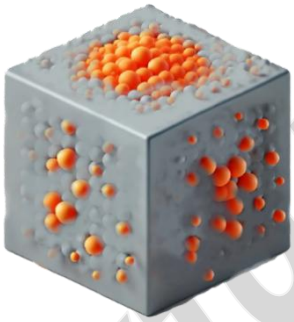
EXTO Technologies applied this technique to fluoroketone FK 5-1-12.



The core of EXTO Technology processing is based on coacervation and emulsion-based methods applied to fluoroketone to put it in polymer shell made of modified gelatin or URF resin + PVA as the main shell materials.

Fluoroketone microencapsulation includes multi-stages processing consisting of fluoroketone emulsification in water down to micro-droplets, further programmed adding of various additives and catalysts together with temperature control to ensure stable chemical reaction of the microcapsule shell growth around micro-droplets and further polymerization (solidification) of the shell material.

The technology converts liquid fluoroketone to powder phase material!



The main microcapsules application technology is its usage as a fill material together with various binding polymers and adhesives (like silicones, synthetic resins, etc.) forming in this combination a thermoreactive applied material. Important limitation – the binder should not be water or acrylic based, as that can damage the microcapsules.

Verification tests and operational experience with products containing our microencapsulated fluoroketone have demonstrated the high quality and reliability of microcapsules produced using EXTO technology.

It must be mentioned that fluoroketone microencapsulation technique is in focus of many researches and developers. However, according to public information on fluoroketone microencapsulation, EXTO Technologies owns a pioneering technology of industrial scale process. We have built and tested prototype production units with output of 500 kg/month, which is a big step forward from laboratory level experiments.

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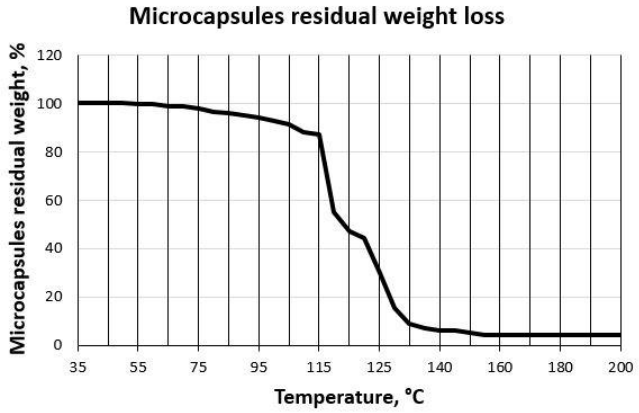
Microcapsules specification data

Parameter	Specification
Core substance	Fluoroketone FK 5-1-12
Shell material	Modified gelatin / URF resin with PVA
Microcapsule size	100 – 500 µm
Fluoroketone content	80 – 95% of total mass
Release temperature range	70 - 170°C (variable based on binding material)
Shelf-life and operational lifecycle	>5 years (< 3% mass loss in 5 years)
Storage & long-term operating temperature	-40 to +50°C (up to +60°C for short durations)
Environmental considerations	Water exposure may degrade the shell (short-term contact <15 min is acceptable)



TGA analysis provided demonstrate fluoroketone release rate.

Release from thermoreactive material filled with microencapsulated fluoroketone is a subject of binding material features.

APPLICATIONS

Our philosophy in developing fire prevention and firefighting products is simple: the earlier a fire is detected and suppression begins, the more effectively it can be mitigated.

Fire suppression

In terms of application, this solution has a crucial advantage for firefighting. It does not require separate fire detection devices or controllers for fluoroketone release. The release occurs automatically when the microcapsules are heated beyond a controlled critical “release temperature.” This happens within a fairly narrow and low temperature range, ensuring the function of “self-activation".

This greatly simplifies and reduces overall cost of fire extinguishing mean, increases reliability and ensures initiation at the very early stage of ignition.

The main focus applications (but not limited by these):

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- Lithium-Ion batteries of general application
- Energy Storage Systems (ESS)
- Electric Vehicles
- Fire blankets (including special ones, like Electric Vehicle fire blankets, various fire suppression covers, fire protected containers, etc.)
- Other general purpose firefighting and protection means

Lithium Batteries thermal runaway and overheat detection

EXTO Technologies has tested another important application of microencapsulated fluoroketone. It can be used for the early detection of thermal runaway and overheating in lithium batteries.

Due to completely-synthetic nature of fluoroketone and its fast degradation caused by UV radiation in ambient atmosphere, natural ground level of fluoroketone is practically zero. That significantly simplifies and guarantees its detection at very low concentrations in the air. According to our verification tests, at current level of sensors technology development fluoroketone in gas phase can be easily detected when 1.4 grams of it evaporated in 1 m3 volume.

Our solution utilizes this feature to detect lithium batteries thermal runaway and overheat by detecting fluoroketone in lithium batteries mountings/cases space in case of its release from microcapsules attached to failed single battery cell surface.

Thermoreactive material incorporating microencapsulated fluoroketone offers a significant opportunity to effectively mitigate both the risk and impact of lithium battery fires.

Closing remark

If you would be interested in further discussions on how this technology can be integrated into your specific applications, our team is available for technical consultations and collaboration opportunities.

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