Dielectric fluids for immersion cooling

Formulate coolants for EV batteries, motors and power electronics with high performance, low viscosity dielectric ester base oils.

Cargill®

Immersion cooling – overview

- The automotive market is rapidly changing and interest in vehicle electrification is growing as countries enact new emissions legislation and move to ban new sales of internal combustion engine (ICE) vehicles.
- Battery capacities and power densities are increasing and consumers desire even faster charging rates, increasing heat output which must be managed.
- There is a growing interest in immersion cooling – where the battery is cooled directly with a dielectric fluid, rather than indirectly via cooling plates.
- As interest in immersion cooling grows, there is a desire for fluids that can be shared across the battery, motor, and power electronics. This requires coolants with low electrical conductivity, low viscosity, and good thermal heat transfer properties.

Why use immersion cooling?

We are working with UK-based D2H Engineering to understand the difference between direct (immersed) and indirect cooling. Using computational fluid dynamics (CFD) and a physical rig, D2H analysed a water glycol-based cold plate cooled system and an ester-based dielectric fluid-cooled (immersion) system under a simulated ultra-fast charging scenario.

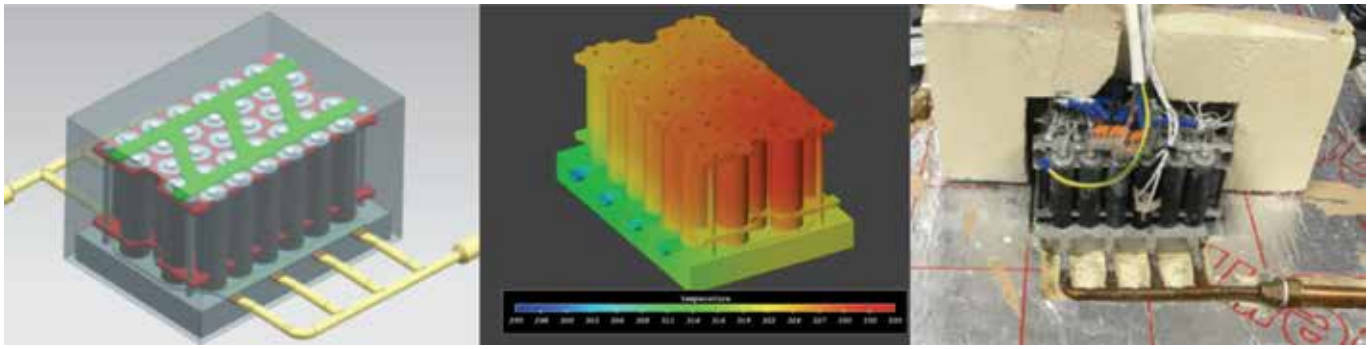

Figure 1 Cold plate cooled scenario. Computational fluid dynamic set-up (left); temperature variation across the battery pack (middle); physical rig set up (right)

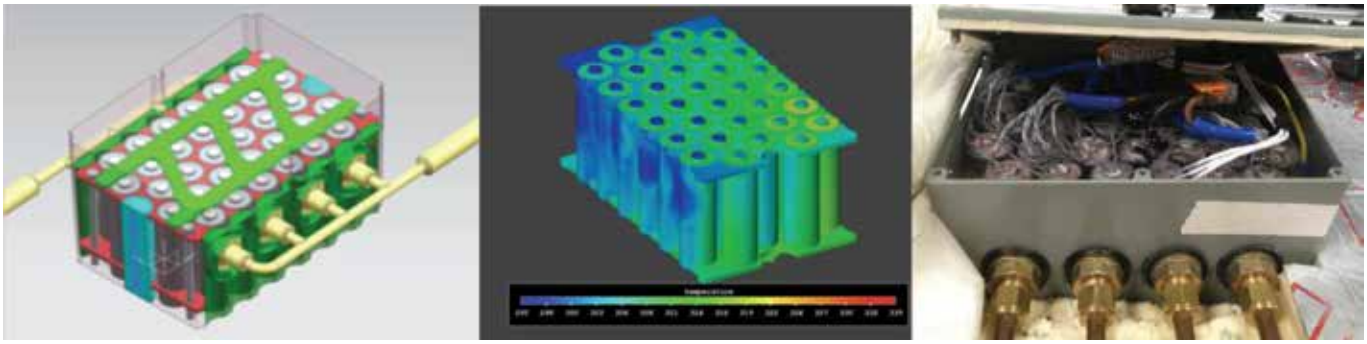

Figure 2 Immersion cooling scenario. Computational fluid dynamic set-up (left); temperature variation across the battery pack (middle); physical rig set up (right)

Using the physical rig set-up, we found that that:

- **Maximum cell temperature** was up to 26% lower when using immersion cooling compared to cold plate cooling (40°C vs. 54°C).
- **Temperature variation** within a cell for an immersion cooled system was up to 76% lower than in the cold plate cooled version (1.0°C vs. 4.1°C).
- **The pumping power** required to circulate the fluids was roughly equal for the two systems.

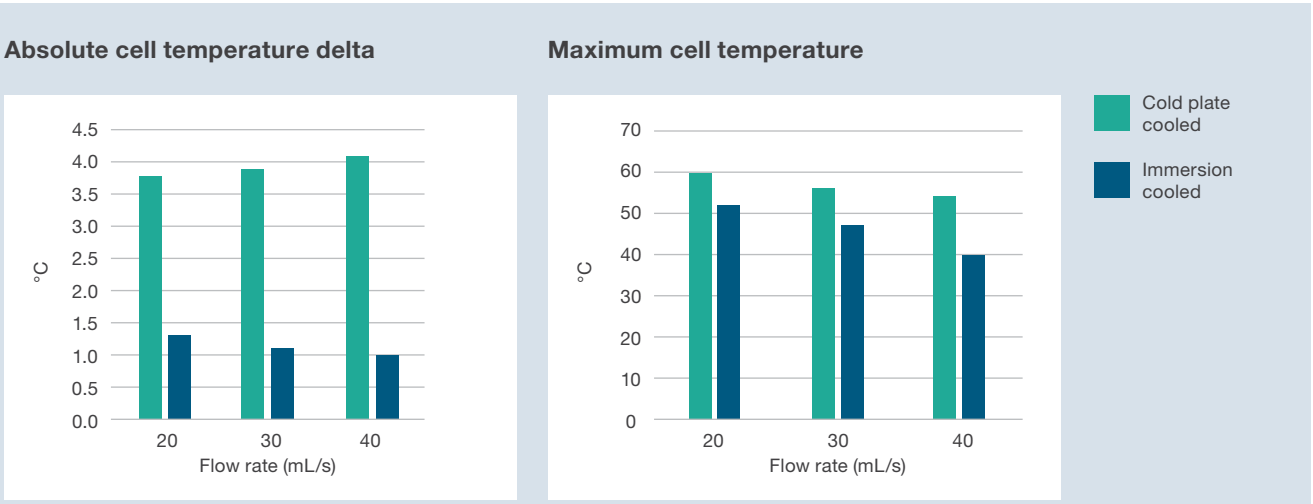

Figure 3 Comparing thermal properties of an immersion cooled system versus a cold-plate cooled system. Data generated from the physical rig set up.

What are the key performance areas for an effective immersion cooling fluid?

The thermal performance of a heat transfer fluid is defined by the equation: $k = \frac{\rho \lambda C_p}{v}$ and an ideal heat transfer fluid has:

- High density
- High thermal conductivity
- High specific heat capacity
- Low viscosity

What other performance criteria are important?

Features	Benefits
Good electrical properties	Must have limited electrical conductivity to prevent arcing and a high breakdown voltage
Good material compatibility	Must not harm elastomer seals, copper, insulation materials or any other materials found within the cooling system
Low volatility	Lower volatility reduces evaporative losses, reducing the need to top up the fluid
High flash point	Increases fluid safety and reduces fire risks in elevated temperature conditions
Low pour point	The fluid must not freeze or become too viscous to pump at low temperatures
High oxidation stability	The fluid must be stable at elevated temperatures and may be expected to perform over the lifetime of the vehicle

Our products and how we can help

We are experts in the manufacture of low viscosity Group V ester base oils, and are developing novel dielectric cooling fluids for safe and effective immersion cooled EV battery and drivetrain systems. Our ester technology is tuneable to your exact needs.

Priolube EF 3221

A fully synthetic, low viscosity dielectric ester base oil that has been designed, tested, and manufactured to meet high standards of electrical insulation and cooling performance. With full control over our manufacturing processes, we have engineered Priolube EF 3221 to be highly oxidatively stable, readily biodegradable with low viscosity, to help formulators optimise electric vehicle fluid formulations. Priolube EF 3221 is designed to be blended into other base oils, depending on your specific performance requirements.

New products in development

We are developing new dielectric coolants that have very low viscosity coupled with high thermal performance. Our coolants are suitable for use in the formulation of next-generation drivetrains including battery, motor, and power electronics.

Other application areas

We are developing a portfolio of products for electric vehicle applications including:

Lithium-ion battery additives: Including next generation dispersants for the efficient manufacture of carbon slurries.

Low viscosity, low traction fluids for the next generation of lubricants for efficient EV gearboxes, transmissions, and e-axles

Traction reducing Perfad™ co-base fluids for e-axles and transmissions: Increase film strength without impacting traction.

Who are we?

The Energy Technologies business in Cargill Bioindustrial creates, makes and sells specialty chemicals and additives for the global energy market. Working in close collaboration with our customers, we apply sustainable concepts and deep scientific expertise so that together we can efficiently power the world of tomorrow.

At our core, we are experts in synthetic ester and polyalkylene glycol chemistries, taking products from lab scale through to full manufacturing. Investing in the development of new chemistries allows us to support our customers in meeting new industry challenges.

For those who dare to imagine a brighter future, we establish long lasting relationships and create bespoke industry solutions through our integrated research & development and global manufacturing capabilities. Being both global and local, you have direct access to our network of technical experts. We look forward to talking to you.

Further information

Cargill Bioindustrial sales and distribution are coordinated through an extensive worldwide network of technical and commercial experts. For further information or guidance please contact us:

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