The cold chain must remain intact at all times

MINUS 70 DEGREES CELSIUS.

During the COVID-19 pandemic, this figure was coupled to great hopes and significant challenges. Its inextricable link to one of the first mRNA vaccines came about due to the innovative technology which requires very cold storage temperatures. But what exactly does this mean when it comes to using the vaccine we have all been hoping for? Since the pandemic, this subject has not been a key topic reserved solely for discussion among experts. In transport logistics for medical and pharmaceutical products, silica from Evonik can contribute to the solution – playing a role as a small, yet highly efficient part of the cold chain. Vacuum insulation panels filled with silica guarantee optimum heat insulation in transport boxes, while allowing the wall thicknesses to be kept thin.

Since the COVID-19 pandemic began, people around the world have placed their hopes on a vaccine to protect against the highly contagious infection. Now, not just one, but several vaccines are available and a unique, global vaccination campaign has begun. The logistical challenges are enormous, in part due to the cooling requirements: How can these temperature-sensitive substances reach the vaccination centers, doctor's practices and those people in hard-to-reach areas of the world without losing their efficacy between leaving the production site and reaching their destination? Vaccines require reliable and consistent cooling throughout the entire supply chain.

Initially, it was said that the innovative mRNA vaccine produced by Pfizer/BioNTech had to be stored and transported at minus 70 degrees Celsius. However, based on stability studies, the conditions for storage and transport have been modified, with the studies showing that ultra-cold storage is only required for the period until delivery and that the thawed, undiluted vaccine can be stored for up to a month at refrigerator temperatures between 2° C and 8° C. Despite this, the widespread reporting on the temperature sensitivity of the different COVID-19 vaccines has resulted in a renewed focus on cooling in medical and pharmaceutical logistics. An uninterrupted cold chain is vital when transporting

medicine, blood bags, clinical samples – or vaccines. However, using electricity to power refrigerators requires great amounts of energy and is expensive. If refrigerated goods are transported over hundreds of kilometers, the cooling can – under certain circumstances – consume more energy than that required to power the vehicle. The CO_2 balance of the transport would therefore be impacted negatively.
And beyond that, a lack of infrastructure and climatic conditions can also cause a number of issues. "The power supply in many countries can be unstable, or the outside temperatures can far exceed 30 degrees Celsius," clarifies Christine Kahmann, a speaker for UNICEF which organizes vaccine campaigns around the globe.

PASSIVELY COOLED USING VACUUMS AND SILICA

The possible solution to such challenges are passive cooling methods that do not require external energy supply. For example, insulated containers with innovative vacuum insulation panels (VIP) in the walls. They can reliably maintain the temperature inside for a very long time. This technology is also very suitable for small, handy transport boxes for the „last mile". But it is not only in remote regions that the independence from external energy supply for cooling is advantageous.

"Vacuum insulation panels with AEROSIL® fumed silica from Evonik can achieve insulation values up to ten times better than those achieved by conventional materials while also being significantly thinner."

Dr.-Ing. Gabriele Gärtner, Head of Research and Applied Technology Thermal Insulation at Evonik

"Passively cooled transport units are an important part of our PharmaChain. They use VIPs and, depending on the required temperature, either cool packs or dry ice," confirms logistics service provider Kühne+Nagel, which is involved in the delivery of COVID-19 vaccines.

Inside the VIP is a core made of a mineral insulation material – for example made from AEROSIL® fumed silica from Evonik. Silica is a proven and environmentally friendly insulation material.
"Vacuum insulation panels with AEROSIL® fumed silica are an alternative to active cooling components. They are highly efficient and can achieve the same effect as other insulation materials while being considerably thinner. They are therefore ideally suited for the manufacture of insulated containers or boxes for temperature-controlled goods transport which cannot be subjected to any temperature fluctuations. VIPs guarantee a consistent temperature in the boxes, regardless of the surrounding temperature," says Carina Geier, Global Marketing Manager Thermal Insulation at Evonik. The internal vacuum ensures that the insulating panels stop either heat or cold from passing through them, as without air, temperature compensation from warm to cold cannot occur through air flow. The physical term for this process is convection.

WHAT IS SILICA?

Sand is the starting material for silica. The particles are based on silicon dioxide, a natural mineral. By the way, the two components in this compound, oxygen (approx. 47%) and silicon (approx. 27%) are some of the most common elements in the Earth's crust when measured by weight. Evonik creates silica from these compounds with custom properties for industrial applications. It truly is a product with many talents: Silica is common in many everyday applications, such as in powders to help them flow, as carrier substances for catalysts or ingredients, as reinforcement fillers for polymers or as insulating materials. They optimize the flow capability of fluids and improve the storage properties of powders. AEROSIL® is a fumed silica that is synthesized in a 1,200° C hydrogen flame. AEROSIL® fumed silica is used as thermal insulation in everyday applications, such as in insulation panels for refrigerators and under ceramic cooktops.

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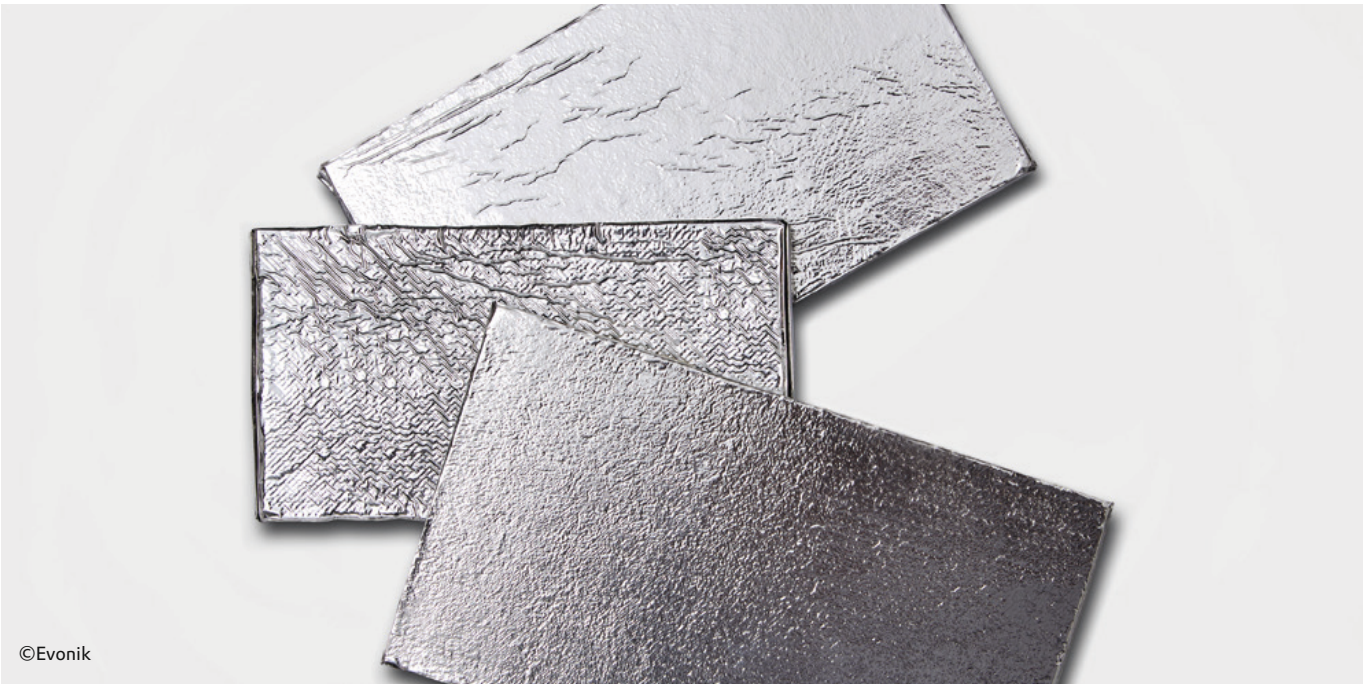
From sand to silica: silica is a natural component of rock and sand. Evonik manufactures different types of silica with specific properties for various industrial applications.



Vacuum insulation panels (VIP): A support core made from compressed silica powder is shrink-wrapped in a multi-layer special film. Insulation panels filled with fumed silica provide excellent insulation against heat and cold.

INCREASED FREIGHT VOLUME THANKS TO THINNER INSULATION

Volume and weight of the freight cost money in transport logistics and impact the energy consumption during transportation. In addition to the excellent insulation performance, VIPs with silica have another benefit: They are used to create very thin insulation panels which allows the wall thickness of transport boxes to be reduced significantly. As such, containers with standardized external dimensions have up to 20 percent more usable volume for goods. And in comparison to trucks with refrigerating devices, cooling trucks insulated with VIPs are more energy efficient.

Polystyrene boxes are used for the transportation of some medical and pharmaceutical products. "But polystyrene takes up lots of space!" says Dr. Veronika Brixner from the blood donation service in Hesse | Baden-Württemberg, adding that space-saving alternatives can help save storage costs.

AT A GLANCE:

5 benefits of VIP with AEROSIL® fumed silica for cooled transportation

- **Reliable passive cooling**
- **Lower energy consumption and CO_2 emissions thanks to energy retention**
- **Up to 20% more transport and storage volume thanks to thin-walled boxes**
- **Low weight**
- **Sustainable thanks to long life cycle of over 30 years**

INSIDE A VIP

In very simplistic terms, a vacuum insulation panel with a silica core is similar to a vacuum pack of coffee: a tightly compacted but very porous material wrapped in a film. However, this is where the comparisons end, as both the AEROSIL® fumed silica and the film are high-tech functional materials.

The external shell of a VIP consists of a multi-layer special film which is impermeable to both water and air. However, simply extracting the air from this cover layer to create a vacuum does not work, as it would simply fall in on itself. And it is practically impossible to remove all the air out of the interior. A supporting core between the film walls is therefore necessary. It must also transfer as little heat as possible and prevent the residual gas molecules from convection. Silica, such as AEROSIL® fumed silica is ideal for this.

AEROSIL® INSULATES AND STABILIZES

AEROSIL® plays two roles in this application: one as an insulating material, and the other as a supporting body. The material has three properties that qualify it for this task: Firstly, the special, synthetically manufactured silica has an inherently low solid body thermal conductivity. Secondly, a silica core can withstand immense pressure as the particles form a structure with well over 90 percent micropores, which retains its shape even under the conditions in a vacuum insulation panel. It is virtually impossible, in technical terms, to generate an absolute vacuum. As individual air molecules remain in the shell, convection continues to take place, even on a minimal scale. The silica core prevents this, as its microporous structure and the chain-shaped structure of the particles restricts the movement area of the air molecules – and this is the third benefit.

"The already very good insulation performance provided by AEROSIL® is increased by between three to five times by the vacuum in a VIP," says Dr.-Ing. Gabriele Gärtner, Head of Research and Applied Technology Thermal Insulation at Evonik.

AEROSIL® THERMAL CONDUCTIVITY

- **Non-vacuum state: λ = 20 mW/m.K**
- **Vacuum state: λ ≈ 5 mW/m.K**

VIP WITH AEROSIL®: STRONG PERFORMANCE AND LONG LIFE CYCLE

In transport logistics, VIPs with silica can help reduce the CO_2 footprint. And this insulating material can also be part of a customer's sustainability strategy for other applications. Vacuum insulation panels with silica last around 30 years, but often even longer.

"This durability of VIP is only possible with silica. Once the product has reached the end of its life, the AEROSIL® core can simply be removed and ideally reused – or, if this is not an option, be disposed of with other same-type materials, emphasizes Global Marketing Manager, **Carina Geier**.

As the synthetic silica does not differ from naturally occurring silica, it can be reintroduced into the natural geological cycle or, for example, be used in construction materials.

However, before this repurposing is necessary, the transport boxes with VIPs with silica cores will have helped to keep cold chains up and running for many years, ensuring that countless amounts of medical and pharmaceutical goods safely reach their destinations.

APPLICATION AREAS OF VIPS WITH SILICA

- **Household: Refrigerators and freezers**
- **Medical and pharmaceutical: Transport boxes and containers, refrigerators and freezers**
- **Logistics: Transport of cooled and frozen goods**
- **Construction sector: Insulation for buildings and water cisterns**
- **Heavy industry: Insulation pipelines**

THREE QUESTIONS FOR LOGISTICS COMPANY KÜHNE+NAGEL

Kühne+Nagel is involved in the global vaccine logistics process and is a partner to Moderna in Europe, Asia, the Middle East, Africa and parts of America, as well as for Sinovac Biotech. The logistics specialists are also involved in distributing the COVID-19 vaccines in the "last mile" of transport, for example in North Rhine-Westphalia in Germany and the canton of Zurich in Switzerland. The company has over 250 certified pharmaceutical sites around the world.

Does Kühne+Nagel use passive cooling technology with vacuum insulation panels?

"Along with active cooling options, passively cooled transport units are a vital part of the Kühne+Nagel PharmaChain. Ideally, these units use a combination of VIPs and cool packs or dry ice, depending on the required temperature. Passively cooled transport containers are primarily used in air and road transport."

What benefits do transport boxes with VIPs provide logistics companies with?

"They are lightweight and space-saving. This saves costs during transport, as cubic volume and weight are the primary factors in calculating the freight. And the flexibility of use for this type of packaging is irreplaceable. Particularly in regions with less extensive infrastructures, transport containers which do not require an external energy supply provide great benefits."

What role does sustainability play?

"At Kühne+Nagel, sustainability is one of our primary goals. The company has committed to being 100% CO_2 neutral for the entire scope of the greenhouse gas protocol with the help of our Net Zero Carbon Program by 2030. One prerequisite is to reduce CO_2 emissions through lower weight and volume, but also the ability to reuse transport containers, which prevents waste."

TRANSFUSION PHYSICIAN LOOKS FOR SPACE-SAVING AND ENVIRONMENTALLY FRIENDLY TRANSPORT BOXES

The right temperature is a key factor when transporting and storing blood bags. "We have several different blood products and each of them has a different optimum temperature," explains Dr. Veronika Brixner from the blood donation service in Hesse | Baden-Württemberg. Whole blood, which describes an unfiltered donation, should be stored at room temperature. However, this temperature is not easy to guarantee, for example in winter during long transport journeys following blood donations in more rural areas. Contrastingly, red blood cells must be transported at temperatures of between 4° C and 6° C, while the sensitive blood platelets require a constant 22° C. If deep-frozen, blood plasma can remain viable for up to two years.

"This requires great effort for storage and temperature monitoring as any deviations can result in the blood products no longer being reliable and as such, they can no longer be used," says the transfusion doctor. The blood products are transported in polystyrene boxes. "But polystyrene takes up so much space!" The required insulation effect demands thick walls, which means the boxes take up more space during transport and storage, which in turn costs money. "Every single square meter of space is very expensive when storage temperatures below minus 35 degrees Celsius are required." Furthermore, the polystyrene boxes often need replacing, as the material turns brittle over time. This high resource consumption is a burden on the environment.

According to Dr. Brixner, transport boxes with vacuum insulation panels have three main benefits: They are space-saving, durable and environmentally friendly. However, she points out that a return system would be sensible for such high quality boxes, for example when they initially remain in the care of the recipient. There are already technical solutions in place, such as integrated data loggers, which enable the box to be tracked and which also provide a temperature log.

The doctor also spontaneously came up with another area of use for cool boxes with VIPs, as she is currently helping set up a breast milk storage facility at the Uniklinik (university clinic) in Frankfurt: "We could use these boxes to transport breast milk donations." The life-saving food for extremely premature babies must be properly cooled.

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