

Aerospace & Defense Practice

Numat CEO Ben Hernandez on mitigating the risks of hazardous chemicals

Numat's solutions enabled by metal-organic frameworks operate at the nanoscale to neutralize chemical hazards. Interest is growing in their application in chemical defense equipment.

by Karl Hujsak



Outside the chemical industry, few business leaders are likely familiar with metal-organic frameworks (MOFs); however, MOFs are garnering significant attention because of their unique combination of material properties. Composed of metal ions and organic molecules, MOFs form a highly porous 3D-networked structure in which the pores can be “tuned” to capture, interact with, or release a variety of targets. Companies across industries are exploring using MOFs in applications such as storing gases (for instance, carbon emissions), separating chemicals, delivering drugs to the body, and protecting against hazardous chemicals, including chemical weapons.

Despite the Chemical Weapons Convention, an official ban of chemical weapons by the international community, the risk chemical weapons pose still necessitates solutions to mitigate their hazardous and harmful effects. McKinsey associate partner Karl Hujsak sat down with Ben Hernandez, founder and CEO of Numat, to understand more about the potential of this material in chemical defense equipment. Numat, based in Chicago, provides filtration technologies whose MOF-enabled solutions are specifically designed “to reduce the negative impact of chemical products and processes on human health and the environment.”¹ The following is an edited version of their conversation.

Karl Hujsak: How would you describe MOFs?

Ben Hernandez: MOFs are like nanoscale sponges capable of capturing, holding, and even destroying substances with incredible precision. In my view, they represent the world’s best filtration technology. Integrating MOFs into industrial products and processes has the potential to drive profound improvements in environmental performance and innovation. For example, semiconductor companies are using our MOF platform to effectively remove hazardous gases produced during manufacturing.

Karl Hujsak: Can you tell us more about the defense applications for MOFs?

Ben Hernandez: From Numat’s perspective, deploying MOFs in defense applications holds significant promise. Numat’s MOF-enabled reactive garments are improving defense gear by offering significantly improved protection against chemical agents. Unlike traditional suits, which act as merely shields but don’t neutralize toxins, Numat’s advanced fabrics capture and destroy chemical agents. Plus, while conventional gear relies on PFAS [per- and polyfluoroalkyl substances] for durability, Numat’s gear is PFAS-free, which not only addresses the emerging requirements to remove PFAS from supply chains but also results in gear that is lighter and less bulky, with reduced thermal burden, compared with conventional gear. This innovation has sparked considerable interest among defense customers that have a strong commitment to enhancing the safety and effectiveness of protective wear for military and first responder personnel.

In addition to the reactive garments, we are also advancing MOF-enabled respiratory and filtration defense technologies. These technologies aim to provide superior protection against a broad spectrum of chemical threats.

Karl Hujsak: When it comes to developing products aimed at defense applications, how do you adjust your approach?

Ben Hernandez: We align our material portfolio strategy with our manufacturing infrastructure to ensure we create economies of scale, regardless of whether we sell into commercial or defense end markets. We do this by developing dual-use platform MOF structures that serve as “universal templates” that can be tuned to capture targeted chemicals. In this way, we can solve many challenges using the same core material structure, manufacturing infrastructure, and talent pool. In our SENTINEL product portfolio, for example, we apply the same core material technology to different end markets and applications, including defense, industrial health and safety, and emergency response.

¹ Numat company website.

Karl Hujsak: How do defense customers respond to the value of universal dual-use platforms?

Ben Hernandez: Many of our defense end customers are prime contractors that sell into defense and commercial markets themselves, so framing the value of universal, dual-use platforms to them is easy. For example, when we show the effectiveness of Numat's products against toxic industrial gases and common chemical agents, defense end customers see the efficacy of using these materials in commercial applications, such as for first responders.

Karl Hujsak: What hurdles are you facing in bringing MOF solutions to defense companies and scaling up?

Ben Hernandez: Achieving economies of scale means maintaining a delicate balance between innovation and production costs. Defense is also a notoriously difficult sector to sell into. Crossing the moat is the hard part. You need to learn an entirely new language, invest in compliance far earlier than most start-ups do, and weather extensive product testing and long procurement cycles. We made it through by developing products that solved pressing issues and delivered value to the end user as well as by working closely with diverse stakeholders to build broad support for procurement transition at scale. That said, once you cross the moat, you have direct access to a trillion-dollar customer. We're currently manufacturing SENTINEL products, including respiratory, reactive-garment, and filtration products, for the US Department of Defense [DOD] and allied countries. The DOD recently awarded us a government contract that suggests growing confidence in MOF-based technologies.

One barrier to entry is having the facilities and analytical capabilities to test materials and products in real-world, high-hazard conditions. This testing is expensive and requires custom equipment, deep material-characterization capabilities, know-how, and partnerships. Designing an MOF to capture

a chemical agent is one thing; getting it qualified for use in a product that is at the front line of human survivability and building the supply chain to deliver this product to the field in high volumes under stringent quality requirements is something completely different.

Karl Hujsak: In terms of strategy, how do you weigh the importance of private investment against government funding, and how does this balance affect your approach to innovation and growth?

Ben Hernandez: Used strategically, government funding is an accelerator. Without strategy, it is a distraction. This is especially true when government funding is not tied to a real product with a real business case. It's important to develop your own strategy, and if government funding can accelerate the execution of this strategy, that's great.

In defense funding and development, we learned that success fundamentally relies on three elements. First, engaging with end users is paramount because understanding and addressing their needs directly influences the trajectory of product development and the likelihood of securing funding. Their feedback is invaluable in shaping products that meet real-world requirements.

Second, fostering strong relationships with procurement professionals is crucial. These connections are key to effectively navigating the complex landscape of defense contracting and ensuring that the path to product adoption and procurement is as smooth as possible.

Third, collaboration with the DOD's science and technology groups is important. Such partnerships ensure that product development is in lockstep with the latest research and defense priorities and align innovation with strategic needs. A cohesive mission and product strategy that spans these critical areas is indispensable for not only securing defense funding but also advancing the development of new and innovative products.

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Karl Hujsak: How do defense and commercial qualification and approval processes differ?

Ben Hernandez: The qualification and testing processes for MOF-enabled defense products, including ours, can be more stringent than those for commercial products because of specific operating environments, needs, and testing standards of defense applications. However, the rigorous testing and qualification demands of defense applications allow us to design and scale MOF solutions that deliver performance and cost of ownership that are several magnitudes better than what is currently available commercially. Most defense approvals come in the form of scaled contracts that lead to programs of record, much like the recent award I mentioned earlier.

Karl Hujsak: What advice can you offer start-ups eager to leave their mark on defense innovation?

Ben Hernandez: Treat it like any other business opportunity. Seek product–market fit. Focus on

end users and their real needs. Understand the procurement and budgeting processes. Tactically, your approach will be very different from selling into nondefense end markets. Learn the language, write good plans, report honestly to your sponsors, and do not let the allure of continued R&D funding distract you from your path of revenue-generating products.

Karl Hujsak: Any closing thoughts you'd like to share?

Ben Hernandez: We've focused our discussion today on the defense sector, but we're also seeing significant MOF adoption for industrial-decarbonization efforts. Today, MOFs are deployed to capture CO₂, separate chemicals in the energy industry, and manufacture semiconductor chips. Even so, MOFs are early in the adoption curve, and we're excited to be at the forefront of creating a new industry.

Ben Hernandez is founder and CEO of Numat; **Karl Hujsak** is an associate partner in McKinsey's Silicon Valley office.

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