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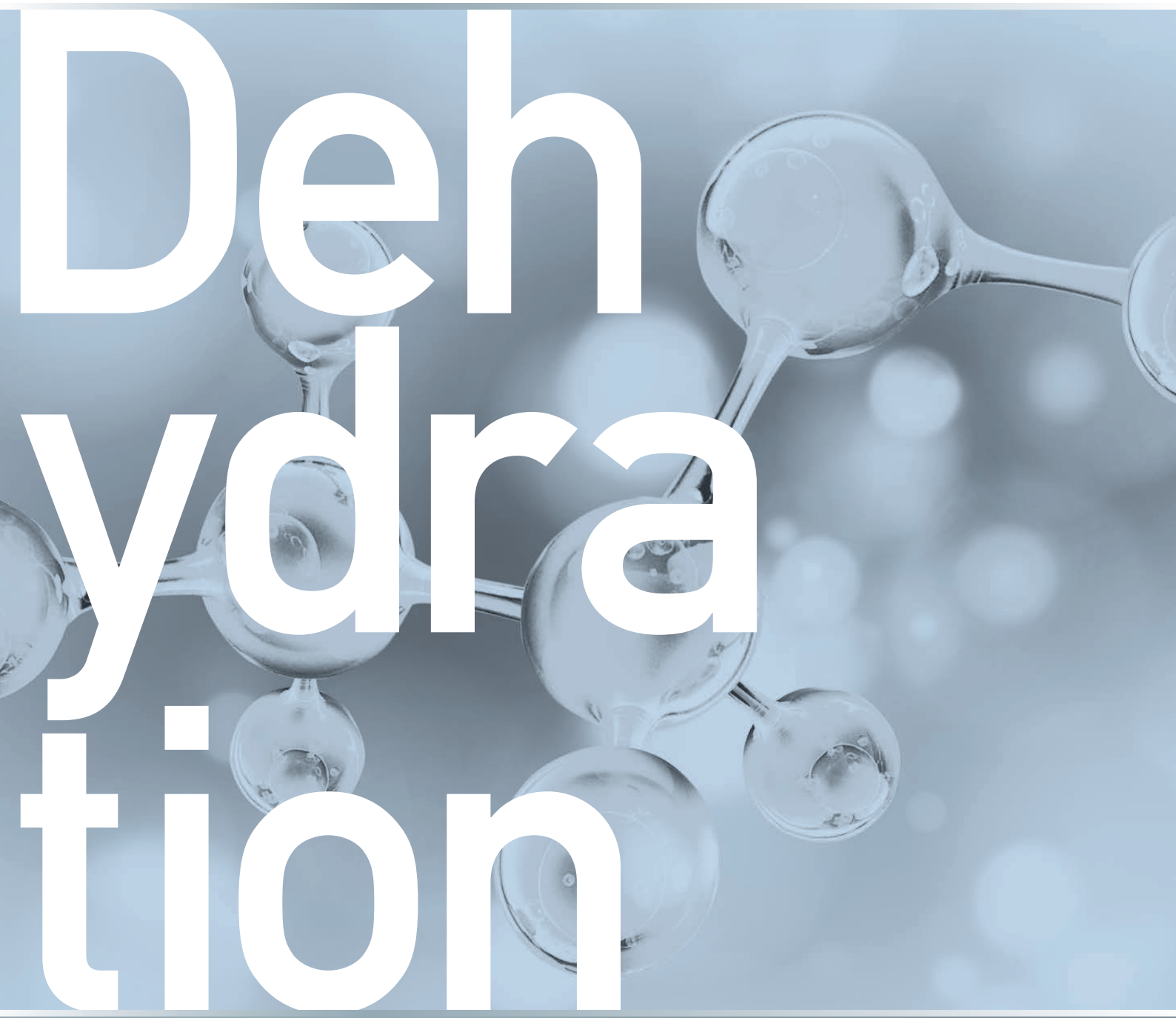
Biocommodities

Dehydration



Dehydration

Unit Operations

VOGELBUSCH MOLECULAR SIEVE DEHYDRATION
Efficient and easy to operate

By merging specialized process know-how with existing technology, Vogelbusch succeeded in pioneering the use of pressure-swing adsorption technology for ethanol dehydration. The first commercial unit was commissioned in 1981, and by the end of the decade molecular sieve dehydration technology had replaced azeotropic distillation for the production of dehydrated ethanol.

Its unparalleled experience of molecular sieve design, construction, commissioning and operation has made Vogelbusch the ethanol industry's premier supplier of dehydration packages. Vogelbusch offers state-of-the-art designs that are easy to operate, reliable, energy efficient, and low on maintenance. From process design, detail engineering, procurement, installation supervision and start-up assistance to turnkey delivery, Vogelbusch can provide all the services needed to bring in a successful project.

ETHANOL DEHYDRATION

Water and ethanol form an azeotrope, limiting the amount of water that can be removed by conventional distillation. Because of this, dehydration is used to obtain anhydrous ethanol. A molecular sieve system removes water from the ethanol/water vapor mixture leaving the rectification column. The dehydrated product can be tailored to the specific need of the client to yield anything from bioethanol with a water content of 0.5% to super dry ethanol for pharmaceutical or industrial applications with a water content of 0.01% or less.

The advantages of Vogelbusch molecular sieve systems over other ethanol dehydration processes are:

- Industry leading separation efficiency, resulting in maximum alcohol concentration
- Easy operation
- Reduced energy, operating, and capital costs
- Elimination of entrainer problems and the emission control requirements associated with azeotropic dehydration

CUSTOM-BUILT SYSTEMS

Vogelbusch supplies custom-built systems that are designed to meet the client's mechanical specifications, standards, and guidelines, and adjusted for top product quality and performance. Our engineers provide support throughout the entire project, including process design, engineering, procurement, installation supervision, and start-up assistance, as well as turnkey delivery.

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INDUSTRY REFERENCES

Vogelbusch adsorption systems have found many applications, including dehydration, separation, pollution control and solvent recovery. We have supplied numerous ethanol dehydration systems with capacities from 10,000 to 1.3 million liters/day around the globe.

Dehydrated alcohol produced by Vogelbusch plants is used as chemical feedstock and fuel, and as a base material for pharmaceuticals and cosmetics. Besides being used to dehydrate alcohol Vogelbusch adsorption systems are employed for feed gas adsorption, air drying, nitrogen and methyl acetate purification, carbon adsorption and argon purification.

SKID-MOUNTED INSTALLATION

For ease of installation, and reduced field erection time and costs, Vogelbusch can supply prefabricated molecular sieve units. These modular systems are compact, easy to install, and require only a minimum of field connections. Depending on the capacity of the plant, the systems are supplied either skid-mounted or in pre-assembled modules. A structural steel frame serves as a shipping support and is laid out to provide access to the equipment both during normal operation and maintenance. The modules are piped, wired, and fully tested prior to shipping. The components are reassembled on site. As soon as the connections to the client's utilities (steam, power, cooling water, instrument air, etc.) have been made the system can be commissioned.

Integrated dehydration system operated by Tharaldson Ethanol, North Dakota, USA

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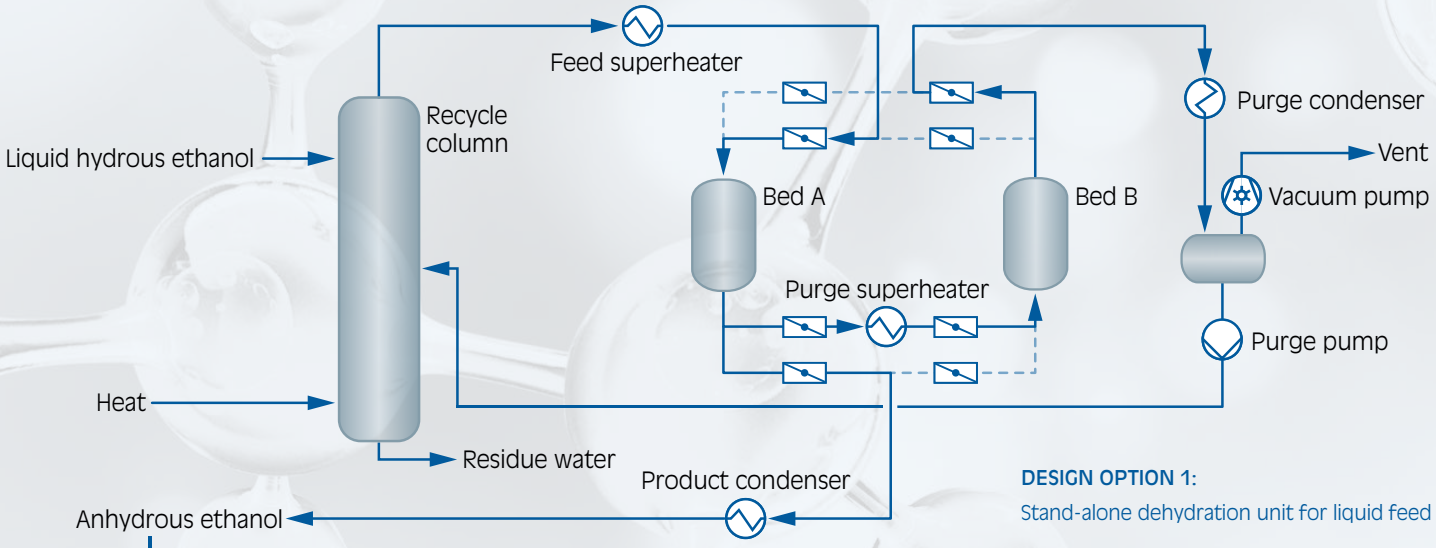
THE VOGELBUSCH ETHANOL DEHYDRATION PROCESS



DESIGN OPTION 1:
Stand-alone dehydration unit for liquid feed

Vogelbusch's standard ethanol dehydration technology employs an adsorption process using beds filled with synthetic zeolites (molecular sieves).

The molecular sieve beds are fed with superheated vapor to prevent condensation in the beds. Water vapor is adsorbed into the pores of the zeolite, and ethanol vapor passes through the bed. When the molecular sieve bed is saturated with water it must be regenerated.

The process is based on the principle that a zeolite's affinity for water changes at different pressures. The water loading of the zeolite depends on the partial pressure of the water in the feed. The partial pressure can be influenced by altering the system pressure.

Water is desorbed from the zeolite by reducing the pressure applied to it. Because of this the process is known as pressure swing adsorption (PSA).

PRESSURE SWING ADSORPTION

Continuous production is achieved by a pressure swing adsorption system with two molecular sieve beds. While one bed is in dehydration service the other is regenerated under vacuum.

During the regeneration phase the bed pressure is lowered and the desorbed water is swept out of the bed by product vapors from the other bed in dehydration service. This regeneration, or purge, stream is then condensed and pumped to the distillation unit for recovery of ethanol.

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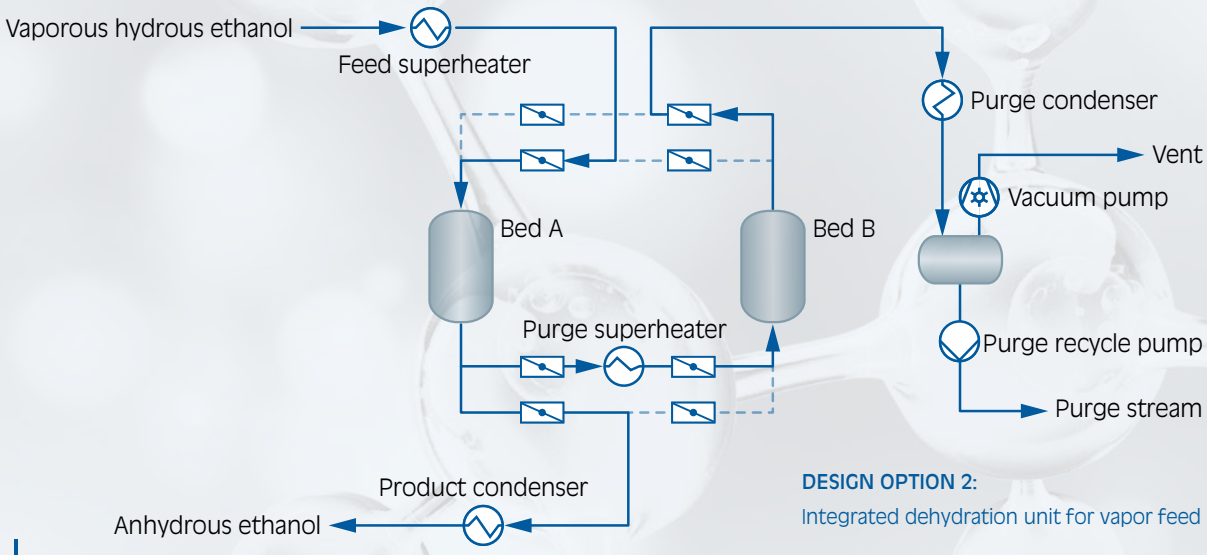


DESIGN OPTION 2:
Integrated dehydration unit for vapor feed

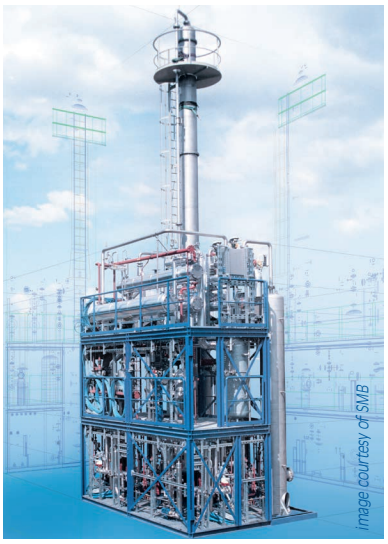
CUSTOMIZED DESIGN OPTIONS

There are two different design options to supply the vaporized feed used in the molecular sieve unit:

DESIGN OPTION 1
Liquid feedstock
Stand-alone units are fed with wet ethanol liquid from storage. The wet ethanol is vaporized in a recycle column. The purge stream is returned to the recycle column where the ethanol is recovered. To save energy, product vapors are used to preheat the liquid feed.

DESIGN OPTION 2
Vapor feed
Integrated units are linked to an existing operation and receive wet ethanol vapors directly from the distillation/rectification system. The purge stream is returned to the distillation/rectification system where the ethanol is recovered.

The main advantage of an integrated system is the much lower energy use than with uncoupled systems. By using the latent heat of the feed vapors the steam requirement of the dehydration is practically zero. This proprietary Vogelbusch technology also reduces initial capital costs.



The stand-alone dehydration system supplied to Harbin Winery, China

Integrated dehydration system operated by Agroetanol Lantmännen, Sweden

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MOLECULAR SIEVES

Molecular sieves, or zeolites, are highly porous crystalline materials made up of aluminosilicates. These synthetic crystals are characterized by a three-dimensional pore system, with pores of precisely defined diameter. The pores can be adjusted to precisely determined, uniform openings, enabling molecules smaller than the pore diameter to be adsorbed whilst excluding larger molecules.

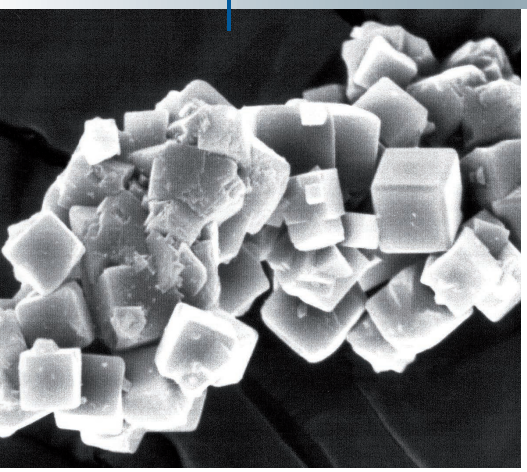
Synthetic zeolites are available with openings from 3 to 10 Ångströms (Å). By tailoring the chemistry and structure of the materials used to create them, zeolites can be modified to provide a wide range of desired adsorption characteristics and selectivities, and can be used as separators in many commercial applications.

In ethanol dehydration, 3Å zeolites (pore diameter of 3Å) are used to separate water from ethanol. The small water molecules, with a diameter of 2.5Å, are retained in the crystals by adsorption, but the larger ethanol molecules (4Å) cannot enter and therefore pass through the bed.

MOLECULAR SIEVE TESTING

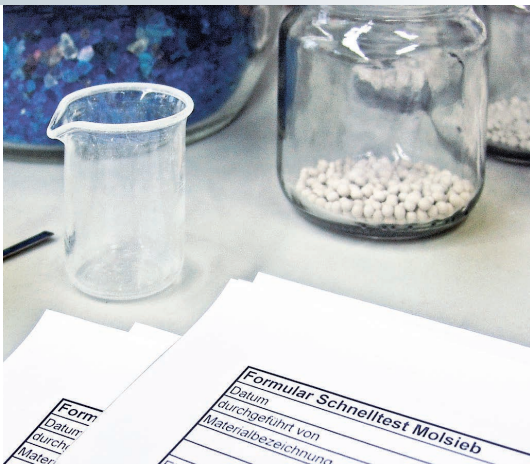
Understanding the physical processes that occur in a molecular sieve is the key to efficient industrial scale designs. Vogelbusch laboratories are equipped specifically to research adsorption processes. The test facility is capable of adsorbing components from continuous vapor streams and simultaneously measuring the adsorbate mass. The physical properties of molecular sieve materials can be determined, leading to improved molecular sieve adsorption processes and, in turn, designs that reduce system and equipment size, lowering investment and operational costs.

The test facility is also equipped with a test station for examination of various manufacturers' molecular sieve materials. In a standardized quick test developed by Vogelbusch, the key performance parameters are analyzed and compared. This quick test is done on molecular sieve material before it is loaded into a commercial molecular sieve unit. Advanced testing can be carried out in a molecular sieve pilot plant operated by Vogelbusch in the United States. This facility is capable of testing mole sieve performance parameters under near-industrial conditions.



Aggregation of 3Å zeolite monocrystals (scale 1:10,000 - image courtesy of UOP)

Vogelbusch test equipment for adsorption process research



Every batch of molecular sieve material is subjected to a quick test before loading

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Stand-alone unit operated by Green Power WLL, Kingdom of Bahrain, comprising a pre-assembled skid, a rectification column with a reboiler and molecular sieve vessels

SHOWCASE: GREEN POWER WLL

Our largest skid-mounted installation to date is a plant capable of dehydrating 400,000 liters of alcohol per day. Designed to dehydrate synthetic alcohol, the unit was pre-assembled in Austria, shipped, installed, and started up by Vogelbusch at the client's location in Bahrain.

A rectification system was included to recover alcohol from the purge stream and remove impurities entering the plant with the feedstock – primarily low-boiling compounds such as acetaldehyde and diethyl ether. Feedstock from client's storage facility is preheated before entering the rectification column. Wet alcohol vapor leaves the column and is routed to the molecular sieve unit where water is captured in one of the zeolite beds, leaving only dehydrated alcohol.

The stripped, low-boiling compounds then enter the top section of the rectification column where they are concentrated and where ethanol is removed before the gaseous mixture of impurities is sent to an enclosed flaring system. The rectification column bottoms, composed of water and traces of high-boiling compounds, are carried to a municipal waste water treatment plant.

The dehydration plant was delivered as a skid-mounted unit which included all the equipment except the rectification column, reboiler, and molecular sieve vessels. The skid was manufactured, pre-assembled, and tested in Austria before being shipped to Bahrain in 12 containers. On site, the equipment was re-assembled and erected, the internal pipework was re-established, and the plant was connected to client's utilities.

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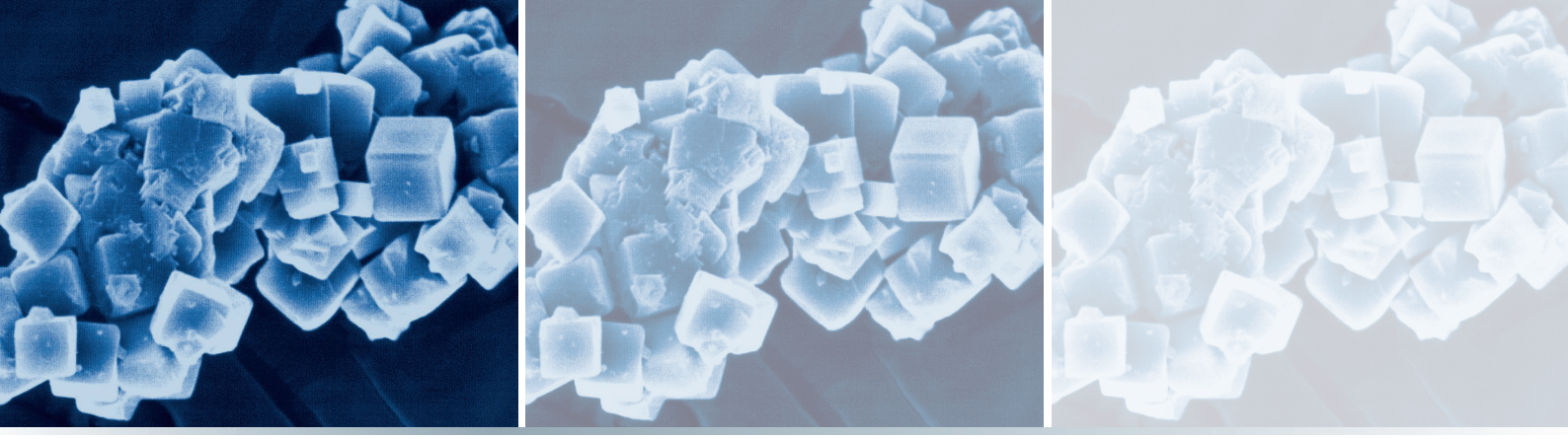

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