Industrial hemp and its cannabidiol (CBD) derivatives have pushed to double-digit growth rates in the last few years, bringing with it substantial growing pains. New, efficient methods for growing, harvesting, processing, testing and packaging industrial hemp are needed — in addition to quality requirements and standards — to meet the escalating demand for this product. Many requirements are being prescribed or likely soon to be enforced by the bodies that govern industrial hemp, including the USDA, FDA and state governments.

Yet along with these requirements comes opportunity for innovation. Developments are evolving at a rapid pace. In addition, existing technologies are extending into this growing industry to help meet the quality and quantity market demands of industrial hemp.

One example of existing technology that is finding application in the industrial hemp industry is cryogenic cooling with liquid nitrogen (LIN). LIN, which has been used for decades to “super-refrigerate” or cool products in the food processing, pharmaceutical and nutraceutical industries, is proving to be advantageous in the industrial hemp industry. As one of the coldest liquids on earth with a boiling point of -320°F (-196°C), liquid nitrogen can be used to cool materials quickly because of its very low temperature. LIN has found great utility in many industries due to its freezing and cooling efficiencies — and the environmental benefits that come with its use.

**The Evolving Role of Industrial Hemp**

For centuries, hemp has been used for its fiber and oilseed in...
industrial and consumer products such as paper, textiles and plastics. It can be confused with its sister plant, marijuana. Industrial hemp is not marijuana, however. Industrial hemp is a different variety of the same plant species, *Cannabis sativa L.*, a substance that has historically been classified in the United States as a Schedule I controlled substance regulated under the Controlled Substance Act.

The passage of the 2018 farm bill, however, established a legal framework to allow production of industrial hemp as an agricultural commodity. The farm bill also removed hemp from the list of controlled substances.

The difference between industrial hemp and marijuana is that the hemp plant contains low levels of delta-9-tetrahydrocannabinol (THC), which is an ingredient that gives marijuana its psychoactive properties. The legal threshold level of allowable THC for industrial hemp is 0.3 percent on a dry-weight basis. Since the federal law regarding industrial hemp changed, licensing to cultivate, harvest and process industrial hemp has become a burgeoning part of the U.S. economy. The hemp industry is primarily focused on the sale of high value oils used in many consumer products.

**Using Cryogenic Solutions for Hemp Processing**

Due to its extremely cold temperature, when used in a cryogenic system, LIN can cool a process or freeze products like food or hemp within minutes instead of the hours required with more traditional methods like mechanical freezing. The major benefits of cryogenic freezing are speed and controlled cooling. This consistent, repeatable temperature control enables the process standardization needed to help meet compliance requirements for Good Manufacturing Practice guidelines and other required measures. The array of applications to which cryogenic cooling can be applied in the industrial hemp industry spans a large part of the value chain, from harvesting to processing to packaging.

In the harvesting process, it is critical to the value of the crop to preserve the plant's sensitive chemical compounds such as CBD. Preserving hemp directly after cutting can take days or weeks using conventional drying methods. Contamination from mold or other material changes resulting from these drying techniques may decrease the value of the crop due to loss of valuable compounds or other issues.

LIN can be used in a cryogenic tunnel freezer to quickly freeze hemp directly after harvesting. freezer LOD (low operating density) hemp in minutes can help prevent mold formation and lock in the plant's chemical content. This results in quality and preservation benefits. In addition, freezing allows further biomass handling without smearing the oil-containing trichomes.

Low temperature freezing also promotes the formation of much smaller ice crystals, which causes less damage to a plant's cellular structure. This benefit has been seen in the food freezing industry, where freezing fragile foods like raspberries or strawberries has benefited from this technique. Because the cryogenic nitrogen tunnel-freezing technology was designed for the food industry, the use of such established freezing techniques provides a level of safety, hygiene and process control. This can help industrial hemp processors meet regulations and quality standards while streamlining operations.

Keeping hemp cold and ready for the next step of the processing operation — oil extraction — also can greatly benefit from cryogenics. Industrial hemp typically is ground, chopped or milled to yield a manageable size product. Because hemp contains 10 to 20 percent oil, it tends to become sticky when heated. Therefore, during grinding, mill screens and equipment can easily get plugged by the oils, causing downtime. Heat generated during the milling operation also can contribute to the loss of oils and compounds within the plant biomass.

Adding a cryogenic cooling system to either the mill or the conveyor eliminates these issues and helps
produce a higher quality product. Because nitrogen is inert and does not react with other substances under normal conditions, it will not distort product aroma or flavor.

Extraction of valuable compounds from the hemp biomass is the key step in producing CBD oil. CBD is one of more than 60 compounds produced in the hemp plant. CBD and other key compounds are isolated from the plant trichomes and biomass using extraction methods by way of solvents, cold pressing or supercritical carbon dioxide.

Solvent extraction is a popular method for extraction of cannabinoids and terpenes without the need for extreme pressures or temperatures. Ethanol usually is the solvent of choice for high quality, large-scale processing. In this process, the biomass must first be moved into the extraction unit by way of conveying. Here, cryogenics can provide process efficiency and quality benefits.

In such an installation, a cryogenic cooling conveyor sprays LIN onto the material as it moves along the conveyor. The LIN helps to efficiently maintain the desired cold temperature (as cold as -148°F [-100°C]) needed for repeatable process control. The safe use of LIN to aid in process temperature control keeps the material at or near the extraction-processing temperature to help meet processing requirements.

Once cold biomass enters the extraction unit, it is ready for the extraction process. Cannabinoids, terpenes and other compounds are stripped from the biomass. The temperature of the ethanol used in the process generally controls the processing time required to remove the compounds and the quality of the extract. The use of cold ethanol at -58 to -112°F (-50 to -80°C) typically removes the cannabinoids and terpenes from the biomass without bringing along the waxes and chlorophyll. The colder temperatures make it more difficult for the unwanted polar plant waxes and chlorophyll to dissolve in a polar ethanol solvent.

With such cold extraction processing temperatures, less...
downstream purification should be needed to achieve the desired product. These cold temperatures can be achieved by direct heat exchanger with LIN for systems in the size range of 1,000 gal/hr or smaller.

For systems larger than 1,000 gal/hr, cryogenic heat exchange is more cost effective by adding a mechanical chiller in series to first cool the solvent to the 32 to 50°F (0 to 10°C) range and then using a cryogenic unit to complete the chilling to the desired temperature. Hence, the use of cryogenic nitrogen can be an effective tool to establish a consistent process to deliver quality product with the benefit of fewer processing steps.

Finally, nitrogen also can be useful in the industrial hemp packaging process to promote quality and shelf life. Dosing the final package with a small amount of nitrogen — with its inert properties in the case of oils such as CBD — can serve as a protective layer from oxidation or moisture. Effectively, the LIN blanket protects the material from conditions that could negatively affect its quality and characteristics.

In conclusion, as both state and federal regulations continue to unfold, and the utility and popularity of hemp-derived products continues to grow, industrial hemp manufacturers will need to be positioned to adhere to strict quality, safety and market demands. Reliable temperature control provides many benefits in industrial hemp processing. The extremely cold temperature of LIN can provide an option to help improve product quality and process efficiency as well as meet standards like Current Good Manufacturing Practices and Brand Reputation Compliance Global Standard for Food Safety certificates. Working with an industrial gas company that has knowledge and experience in cryogenic technology applications can help ensure the optimum solutions are identified and employed safely. **PC**

Sandy Kushner, Michael R. Himes and Timothy D. Lebrecht are with Air Products. Sandy Kushner is the chemicals strategy and market manager for the Americas; Michael R. Himes is the cryogenic technology lead for the Americas; and Timothy D. Lebrecht is the industry manager, chemicals, refining and cryogenic applications for the Americas. The Allentown, Pa.-based company can be reached at 800-654-4567 or visit www.airproducts.com.

**Author’s Note:** Air Products will only conduct business with industrial hemp growers that provide proof of compliance with applicable state and federal laws and regulations.

---

**Take the guess work out of your hemp processing. Let Air Products help.**

In the fast-growing industrial hemp market, industrial gases can play an important role in harvesting, processing and packaging. Our team of experts can review your process and help you identify opportunities where industrial gases, such as CO₂, or liquid nitrogen, can enhance product quality and shelf-life, increase productivity, and improve safety. We have a state-of-the-art applications lab to test your product, or we can visit your site for field testing.

Put our experts to the test. Contact us to discuss your needs.

*800-654-4567 • Email: info.airproducts.com • airproducts.com/hemp*

---

**For more information, please contact us at:**

**Americas**

Air Products
7201 Hamilton Boulevard
Allentown, PA 18195-1501 U.S.A.
T 800-654-4567 or 610-706-4730, press 3
F 800-272-4449 or 610-706-6890
info@airproducts.com

**Asia**

Air Products
Floor 2, Building #88
Lane 887, Zu Chongzhi Road
Zhangjiang Hi-tech Park
Shanghai, 201203, P.R.C.
T +021-3896 2000
F +021-5080 5585
Sales hotline: 400-888-7662
infochn@airproducts.com

**Europe**

Air Products PLC
Hersham Place Technology Park
Molesley Road
Walton-on-Thames
Surrey KT12 4RZ
UK
T +44(0)800 389 0202
apukinfo@airproducts.com

---

© Air Products and Chemicals, Inc., 2020 (43096)