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Polyurethane Blowing Agents Can Be Environmentally Friendly and Still Offer Superior Insulating Properties

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As far as outstanding insulating properties, it is hard to beat polyurethanes. The versatile chemistry allows the materials to solve many challenges, while providing underlying value to both industrial and consumer products.

Polyurethanes are formed by reacting a polyol with a diisocyanate or a polymeric isocyanate in the presence of suitable catalysts and additives. Because a variety of diisocyanates and polyols can be used in polyurethane production, a spectrum of materials can be produced to address specific applications.

Since its invention in the 1940s, polyurethane has emerged as one of the best insulators available. Most refrigerators and freezers are made with a metal outer shell, a plastic inner liner, and a layer of polyurethane foam insulation sandwiched in between. The foam material's thermal properties help control the heat exchange and enable a streamlined manufacturing process.

Critical to making compact yet highly efficient polyurethane is the blowing agent. The blowing agent is a substance capable of producing a cellular structure by a foaming process. It is typically applied when the material is still liquid. During the manufacturing process, the blowing agent expands the foam, enabling it to fill cavities and providing excellent physical properties. The cellular structure helps reduce density even as it increases the material's thermal insulation and stiffness.

Emerging Concerns

Starting in the 1980s, concerns emerged that some blowing agents damage the Earth's ozone, a layer of atmospheric protection against harmful solar radiation. This is referred to as a blowing agent's ozone-depletion potential (ODP). More recent concerns focus on blowing agents' global warming potential (GWP). A GWP of one means the compound is no more damaging to the atmosphere than carbon dioxide. So, the higher the value, the more damaging it is relative to the carbon dioxide benchmark.

Negotiated global agreements such as the Montreal Protocol, the Kyoto Protocol, the Kigali Amendment and the Paris Climate Agreement all contain provisions to phase out and replace less environmentally friendly blowing agents.

In the U.S., a 2015 rule under the EPA's Significant New Alternatives Policy (SNAP) program called for the phase out of certain high-GWP blowing agents and mandated a switch to products with lower GWP values. The rule expanded the list of alternatives and prohibited high-GWP hydrofluorocarbons (HFCs) for foam blowing.

In 2017, a number of companies challenged the 2015 EPA SNAP rule in court. They said the EPA lacked authority to extend the SNAP program (originally formed to reduce ozone depletion) to global warming. A federal court agreed with that point of view in early 2018. However, that decision is now being appealed to the U.S. Supreme Court for a final decision. In addition, 11 states have recently filed a lawsuit against the EPA, attempting to force the implementation of the 2015 rule.

Regulatory Challenges

The court challenges should not distract attention from what has become a global shift away from blowing agents (as well as refrigerants) with high GWP values. For one thing, the Paris Climate agreement and the Kigali Amendment to the Montreal Protocol set out voluntary goals for signatory nations to achieve. Also, major U.S. markets — most notably California — have enacted rules to achieve similar environmental results. And a bill in the U.S. Senate would authorize the EPA to write rules to phase out HFC use. Plus, the U.S. could sign on to the Kigali Amendment at any time.

With all of these factors in place, the future of HFC blowing agents is very much in question, to say the least. So, while regulatory and policy decisions advance, companies are looking for more environmentally friendly polyurethanes and blowing agents for their manufacturing processes.
The History of Blowing Agents

The foam industry is now in its fourth distinct generation of blowing agents. The first blowing agent was actually water, which is still a good option for some applications, but does not provide enough thermal insulation to be a viable option in HVAC/R applications.

Starting in the 1960s, chlorofluorocarbons (CFCs), such as CFC-11, were the original blowing agents for insulation, offering thermal efficiencies twice those of earlier insulation. A drawback, however, was that when CFCs break down they destroy ozone molecules. What's more, they had a GWP value of up to 4,750 and could linger in the atmosphere for as long as 45 years. Because of their damaging effects on the environment, CFCs have long been banned nearly worldwide.

In the 1990s, manufacturers introduced the second generation of blowing agents, HCFCs (hydrochlorofluorocarbons). HCFCs, such as 141b, offered lower ODP, but also provided reduced thermal values. Continuing concern over ozone depletion led to the phase out of HCFCs in most developed countries.

In the early 2000s, the third generation of blowing agents, hydrofluorocarbons (HFCs), were introduced. HFCs, including 134a and 245fa (which are still in use today) have no ODP. However, as with the change from CFCs to HCFCs, the new blowing agents once again reduced thermal efficiency. Plus, it was later found that HFCs contribute to global warming, leading the industry to once again develop new alternatives.

Fourth-generation blowing agents – with no ODP and greatly reduced or no GWP – now include three main options:hydrofluoroolefins (HFOs), hydrocarbons (HCs) and Ecomate. All have positive and negative qualities, which are briefly discussed below.

Hydrofluoroolefins

HFO blowing agents, currently produced by Honeywell, Arkema and Chemours, are the newest of the fourth generation blowing agents. They offer better thermal performance than the third generation HFCs and are non-flammable. However, they have high molecular weights, meaning more blowing agent is required, which increases costs. A widely reported issue with HFOs is in-situ acid formation, which has detrimental effects on catalysts and hence, shortens shelf-life stability. Further, some HFOs have been found to produce trifluoroacetic acid (TFA), which bioaccumulates and could have a potential long-term environmental impact.

Hydrocarbons

HCs such as cyclopentane, n-pentane and isopentane have a low molecular weight and can offer lower costs than other blowing agents. But they also offer lower thermal efficiency than the other fourth generation options. In addition, they are highly flammable, requiring upfront investment in safety equipment. They are also volatile organic compounds (VOCs), meaning they produce smog.

Ecomate

Ecomate, based on naturally occurring methyl methanoate and produced by Foam Supplies, Inc., has been in commercial use since 2002, making it a proven option. It offers excellent thermal properties (similar to HFOs) and has a low molecular weight, so less quantity is required to reach needed densities. Ecomate is a liquid at room temperature and is flammable in its "neat" form, but not when blended into a polyurethane system – so no special equipment is needed.

Conclusion

Polyurethanes will continue to be used in a broad variety of industrial and consumer applications due to their flexibility and insulating properties. The good news for HVAC/R manufacturers is that two of the fourth generation blowing agents – Ecomate and HFOs – end the historical tradeoff between insulating performance and environmental safety, and eliminate past concerns over the environmental impact of polyurethane foam. As a result, foams made with these blowing agents can help manufacturers meet both environmental regulations (national and international) and energy efficiency standards.

Ecomate has a well-established track record and represents what is perhaps the most environmentally benign product available in the industry. HFOs, while newer and not as proven, also offer great potential. Only time will tell if new options come along, but rest assured that these currently available blowing agents are the solutions manufacturers need to eliminate HFCs, meet pressing regulatory concerns and never compromise on performance.

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