



Biodegradability of Phase Change Material

Biobased PCMs, like PureTemp, are the only category of PCMs that are considered to be widely readily biodegradable. They will fully decompose within months of being introduced into the environment and will not produce long-term negative impacts on the environment.

Phase change materials (PCMs) are being developed for use in new products every day, from heating and cooling systems to athletic gear and food storage. Because of this growth, the potential for PCMs to be introduced into the environment has increased dramatically in recent years. Fully understanding the biodegradability of phase change materials is important because some PCMs can have a negative impact on the environment. Environmental impact may often be a key factor in determining which PCM is chosen for a particular application.

What is biodegradability?

Biodegradable products are able to be broken down, by biological means, into compounds found in nature¹. They tend to decompose into nontoxic soil components, water, carbon dioxide or methane. As a product degrades, its impact on the environment decreases. However, being classified as biodegradable does not mean that a product has no long-lasting environmental impact. Some biodegradable products may take years or decades to fully decompose.

Biodegradability is the measurement of how well a product can be degraded by microorganisms over time. Various tests are used to determine biodegradability², depending on the types of environmental exposure of a given product. For example, a company that produces a PCM that is a liquid at

room temperature may have it analyzed for biodegradability in an aqueous setting, in case it enters lakes or rivers. Each analysis will assign a biodegradability classification based on how well a product decomposes in that assessed situation. There are several recognized testing procedures that have can be used to determine the biodegradability of PCMs, including ASTM 6400 and OECD 301.

Classifications of biodegradability

The main type of biodegradability classification is based on a substance's ultimate degradation. Ultimate degradation, also known as secondary degradation, analyzes the complete decomposition of a substance, resulting in the production of carbon dioxide, water or inorganic compounds³. The other classification, primary degradation, measures the partial degradation of a product in which large portions of the original substance may remain intact. The ultimate degradation classification tends to be the reported degradation analysis because it analyzes a holistic view of biodegradability. Phase change materials have been analyzed and classified using the ultimate degradation classification.

Substances that undergo ultimate biodegradation testing are analyzed for 28 days. They are then given one of three classifications: 1) readily biodegradable, 2) inherently biodegradable or 3) non-biodegradable³. Readily biodegradable substances pass the most stringent biodegradability tests and criteria, which includes that the substance will degrade >60% over the 28-day test and must statistically undergo full decomposition within three years. Inherently biodegradable substances have characteristics of being biodegradable but do not meet the readily biodegradable standards. Inherently biodegradable substances must degrade between 20-60% during the 28-day analysis but do not need to pass a complete decomposition timeframe analysis. Inherently biodegradable materials may take years to fully decompose and may require long-term remediation due to environmental persistence². Non-biodegradable substances do not have any characteristics of being biodegradable.

Biodegradability and environmental effects of various types of PCMs

Petroleum-based products theoretically will degrade by 0-45%³ over the course of the 28-day biodegradability analysis. Paraffin products have proved to be 21-55%⁴ biodegradable over the course of the analysis, giving them a classification of inherently biodegradable. This means that paraffin PCMs may take years, or decades, to fully decompose. These products will have long-term effects on the environment since paraffins, and other petroleum-based products, are known to be carcinogenic and are toxic to plants and wildlife.

Vegetable biobased products, on the other hand, will theoretically degrade by 75-100%² over the course of the 28-day analysis. PureTemp biobased PCM products, on average, are 80% biodegradable within 28 days, which classifies PureTemp as a readily biodegradable product. This favorable result indicates that PureTemp biobased PCMs will fully decompose in just months. By being readily biodegradable, PureTemp products will not produce negative long-term effects on the environment and waterways. PureTemp products, unlike paraffins, are non-carcinogenic and tend to be non-toxic to plants and wildlife.

Biodegradability analyses are not performed on salt hydrate PCMs because the salt compounds in those PCMs will disassociate into their respective ions while in the liquid phase. This phenomenon does not mean that salt hydrate PCMs are necessarily safe for the environment. Salt hydrates have corrosive characteristics and are known to be toxic to plants and wildlife⁵.

Conclusion

Biobased PCMs, like PureTemp, are the only types of PCMs that are readily biodegradable. They will fully decompose within months of being introduced into the environment and will not produce long-term negative impacts on the environment. A brief summary of the biodegradability characteristics of three types of PCMs are given below.

	PureTemp PCM (vegetable-based)	Paraffin PCM (petroleum-based)	Salt hydrate PCM (mineral-based)
Theoretical ultimate biodegradation (28 days)	75–100% ²	0-45% ³	NA
Known ultimate biodegradation (28 days)	80% (avg.)	21-55% ⁴ (published results)	NA
Total decomposition within	6 months	Unspecified (years)	NA
Classification	Readily biodegradable	Inherently biodegradable	NA
Long-term environmental effects	No known long-term effects due to being readily biodegradable. Most PureTemp products are nontoxic to plants and wildlife.	Known to be carcinogenic and toxic to plants and wildlife.	Known to be corrosive and may be toxic to plants and wildlife.

¹ "Biodegradable Definition". *Green Good*. Retrieved November 18, 2014 from www.greengood.com.

² Johnson, Mike, and Mark Miller. *Eco-friendly fluids for the lubricants industry*. Tribology and Lubrication Technology, October 2010, p. 28-34.

³ "Understanding Biobased/Biodegradable and the Industry's Standardized Tests and Definitions". *Renewable Lubricants*. Retrieved November 18, 2014 from www.renewablelube.com.

⁴ "CAS# 8002-74-2, Biodegradation screening tests 4, 6, 7, 8, 9." *European Chemicals Agency*. November 18, 2014, <http://echa.europa.eu/>

⁵ Sutterlin, William R. *Phase Change Materials, A Brief Comparison of Ice Packs, Salts, Paraffins, and Vegetable-derived Phase Change Materials*. Pharmaceutical Outsourcing. July 01, 2011. Retrieved from www.pharmoutsourcing.com.