

Hydrocerol™ Chemical Foaming Agents

FOR USE IN INJECTION MOLDING

CHEMICAL FOAMING AGENTS

Benefits of Hydrocerol™ Chemical Foaming Agents

They are endothermic chemical foaming agents that provide the following benefits in the injection molding process:

- Reduced part weights, saving material and costs
- Reduced cycle times
- Smoother surface
- Fine cell structure
- No discoloration or odor
- Suitable for standard machinery
- Flexibility in production
- Smaller machines, due to lower clamping forces
- Higher stiffness-to-weight ratio
- Elimination of warpage
- Elimination of sink marks
- Improved dimensional accuracy
- Improved flowability
- Improved thermal insulation
- Decreased sound transfer
- Creation of new effects

Chemical foaming agents versus other technologies

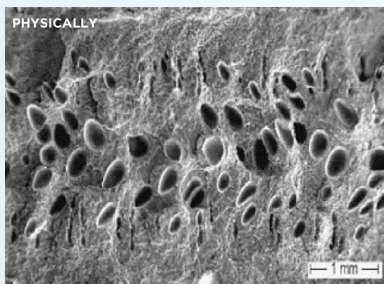
Chemical foaming agents are substances, which get activated at typical thermoplastic polymer processing temperatures, liberating gases such as CO₂ and/or N₂. These gases form a cellular foam structure from the inside to the outside of the plastic part when they are used in an optimized injection molding process.

As gases may also be delivered into the system by direct injection (then called physical blowing agents), one needs to differentiate between the physical

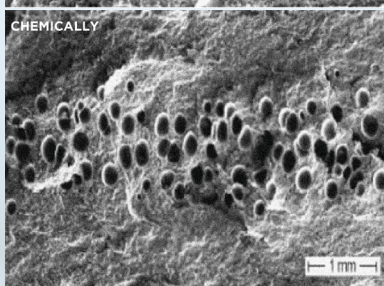
blowing agents (PFAs) and chemical foaming agents (CFAs). PFAs which are injected into the polymer melt may be the same as CFAs (i.e. CO₂ or N₂), or may be hydrocarbon or halogen-carbon-based. The latter are obviously less attractive in today's market. The physical blowing agent system requires engineering modifications, such as a high-pressure injection unit, extended screws and barrels, and gas storage or compression units.

Hydrocerol Chemical Foaming Agents simply require an accurate additive or color concentrate feeder/blender, which is usually on hand at most molders.

To generate a uniform, fine and more durable cell structure, the gases—whether injected or heat generated—need to be dispersed thoroughly in the polymer melt and then properly nucleated upon the pressure drop at the end of the injection process. Key factors contributing to the fine cell structure are the particle size of the blowing agent, the dispersing capability of the molding machine, the decomposition rate of the foaming agent, the melt viscosity and the molecular structure of the thermoplastic resin itself.



PP T20 with physical foaming agent (PFA), large cell structures, thin outer cover layer



PP T20 + 3% Hydrocerol concentrate, small cell structures, thick outer cover layer

Photo source:
Neue Materialien Bayreuth
(GmbH)

Endothermic versus exothermic

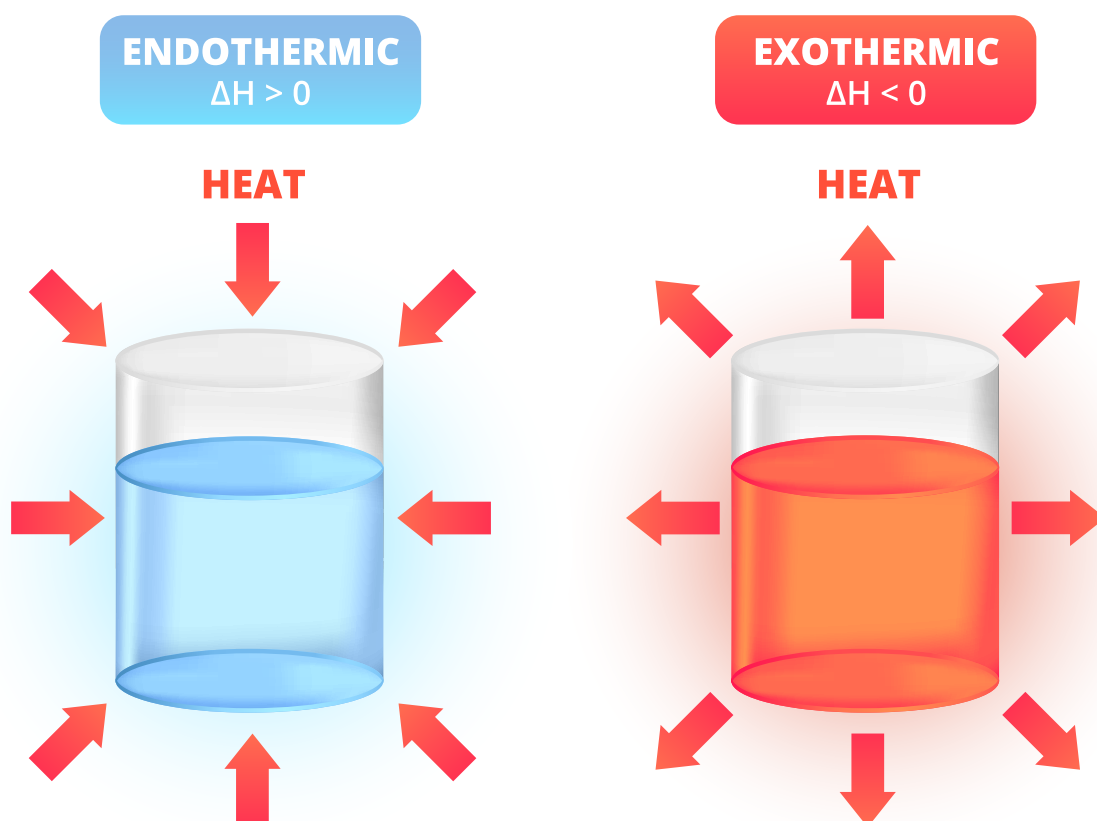
During the activation reaction, chemical foaming agents principally react in two ways:

- exothermic
- endothermic

Exothermic CFAs release more energy during decomposition than needed for the reaction. Once the decomposition has started, it continues spontaneously and for some time even after the energy supply is stopped. Thus, parts which have been foamed with exothermic CFAs, must be cooled for a longer period of time to avoid post-expansion. This product group includes hydrazides and azo compounds. Due to possible skin irritation it is recommended to take precautionary measures when handling such substances. Furthermore,

azo compounds are characterized by a yellow color, which can lead to undesired color changes.

Endothermic CFAs need energy for their decomposition. This is why the gas release quickly stops after the heat supply is discontinued, resulting in shorter cycle times. Endothermic CFAs are based on bicarbonate and citric acid derivate compounds. Hydrocerol Chemical Foaming Agents are ready-to-use CFAs in either pellet or powder form. The portfolio consists of formulations which have specifically been developed for a broad range of applications. Hydrocerol concentrates in pellets are available in different carriers and loadings and a variety of endothermic components.



PROCESSING GUIDE

Typical injection molding machinery

In principle, CFAs can be processed on almost any commercially available injection molding unit. The use of a shut-off nozzle or valve gating, as well as the screw position control, is advantageous to prevent premature foaming. If a shut-off nozzle is not available, it is helpful to keep the barrel/nozzle pushed against the mold without retraction or decompression during the dosing sequence between the injections.

To achieve a uniform foam distribution and a solid skin, the gas should expand from the inside to the outside of the polymer melt after injection.

Therefore, it is important to select the fastest possible injection speed—without causing gas burn—to keep pressure on the melt front, which keeps gases solubilized in the melt. In some injection molding machines, the injection rate can be adjusted by means of a gas pressure accumulator. Structural foam molding machines (Figure 1) are equipped with a plasticizing extruder and a separate transfer cylinder for quicker injection.

In contrast to conventional molding, it is not necessary to use holding pressure for foaming, as it would suppress the foam formation. As a result lower cycle times, lower clamping forces and relatively large platens are the main characteristics of structural foam molding machines.

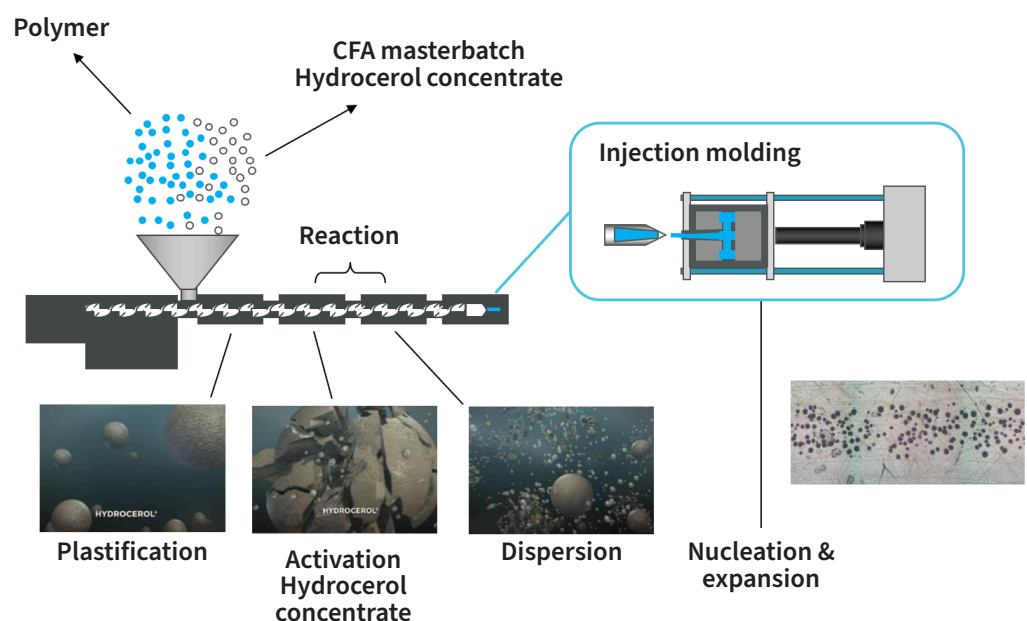
Mold design also influences the optimization of weight reduction, surface aesthetics and cell uniformity.

Our experience has shown that the following adjustments are effective:

- The gates and runners should be designed to achieve a quick and uniform filling of the mold
- The melt flow should be directed from thin-walled to thick-walled sections
- It is important for the mold to have good venting at the end of the flow path, in “dead-end” recesses and at the ejection pins

The tooling strength for foam injection molds need not be as high as for solid injection molds as the internal pressure is now lower, due to the reduced viscosity of the base polymer, when the dissolved gases plasticize it. When designing the cooling channels, they must provide sufficient cooling to avoid post-expansion, particularly in thick-wall parts, and even more so, when using an exothermic CFA. Steel/chromium alloys (approx. 13% Cr) are the preferred mold material due to their longevity and resistance.

PROCESSING WITH HYDROCEROL CONCENTRATE ON COMMON INJECTION MOLDING MACHINES



Processing stages

Foaming agents in the melt—whether physical or chemical—are changing the melt flow behavior and some melt properties, making it comparable to a higher MFI level polymer. Thus, to obtain an even foam distribution, some processing steps need to be adjusted.

ADDITION LEVELS OF FOAMING AGENTS

Both the foaming agent and the thermoplastic resins are metered into the injection molding machine. Typical let-down ratios for Hydrocerol concentrates are 1–3%. The mixing is done either batch by batch in separate blenders or in an automatic metering unit directly on top of the press. When processing Hydrocerol concentrates in powder form it is advantageous to add small amounts (0.1%) of adhesion promoters to avoid separation from the resin.

TEMPERATURE PROFILE

When setting the cylinder temperature, the melt temperature in the feed section should be lowered. Ideally, depending on the polymer and screw length, the melt temperature should be lower than the activation temperature of the CFA to avoid gas losses through the material hopper.

The activation of Hydrocerol Chemical Foaming Agents should happen approximately in the middle of the barrel exceeding the temperature indicated in the technical data sheet of the processed Hydrocerol concentrates grade. In the following section of the barrel, the generated gas should be mainly kept in the solution with the melt being dispersed and homogenized. The mold temperature usually needs no adjustment, but can still be considered as a possible variable.

INJECTION RATE

The mold cavity needs to be filled at high speed to maintain a high pressure until the end-of-fill and ensure that the dispersed gas bubbles create the necessary expansion after the pressure drop at the end of the injection process.

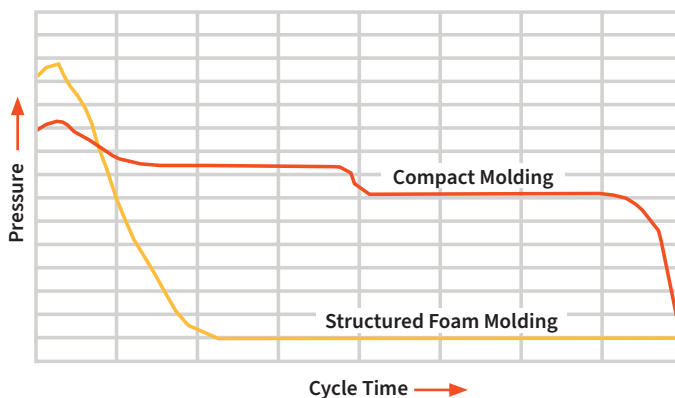
The injection pressure presses the melt against the comparatively cold wall of the mold, creating the typical foam structure, which includes solid skin and cellular core. The gas expansion pressure supports the foam core structure formation while reducing the appearance of sink marks, as it expands from within.

INJECTION PRESSURE

The injection pressure must be set high enough to obtain a high injection rate (Figure 3).

This way, an early expansion of the dissolved gas out of the melt can be avoided. In some cases it is recommended to use an accumulator. Minimal to no holding pressure is applied for foam injection molding to avoid cell compression, except when thicker outer skins are desired.

PRESSURE PROFILE



Properties of foamed injection molded parts

The main reason for the use of Hydrocerol Chemical Foaming Agents is to achieve weight reduction of plastic parts, which in turn saves material costs and supports a more sustainable profile to the molded part. The weight reduction that can be achieved greatly depends on the geometry of the part. It is obvious that thicker walls favor the formation of foam. Typically, a weight reduction of 10–25% is achieved in parts with wall thicknesses >4 mm and short flow paths. Under certain conditions, weight reductions of more than 30% are possible.

Sink marks and warpage are caused by material shrinkage in thick or asymmetric areas during cooling. They often appear in parts with ribs and bosses. A small amount of specially formulated Hydrocerol concentrates will reduce these blemishes significantly.

Hydrocerol Chemical Foaming Agents can be used in low pressure and high pressure processes. Both



Sink-mark



With chemical foaming, no sink-marks

processes lead to an integral foam, but the cell structure looks different in each process. The low pressure method leads to uniform round shaped cells. The high pressure process leads to larger and stretched cells with higher density reductions.

SPECIAL FOAMING PROCESSES

A number of specific processes have been developed to achieve special properties of the foamed parts. The most important processes are:

- CBE process (Core-Back Expansion)
- Gas counterpressure process
- Co-injection molding (sandwich method)
- Dynamic tool heating
- IMD process (In-Mold Decoration)

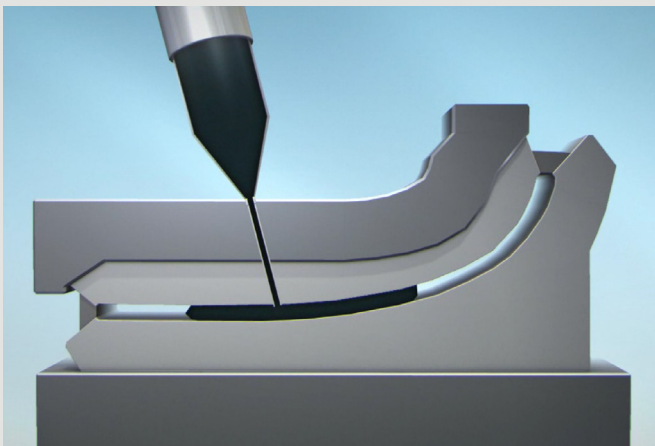
In all these processes, Hydrocerol Chemical Foaming Agents provide excellent results. Gas counterpressure and dynamic tool heating can be used for foaming visible parts with Class-A surface. As CBE is a widely spread process, it will be explained further in the next paragraph.

Core-Back Expansion (CBE) molding principle

Core-Back Expansion molding allows greater density reductions than typical injection molding. The sliding back of the mold cavity at the end of fill allows a greater pressure drop and herewith more expansion. In typical injection, there is a higher final pressure on the melt, limiting the ultimate gas expansion.

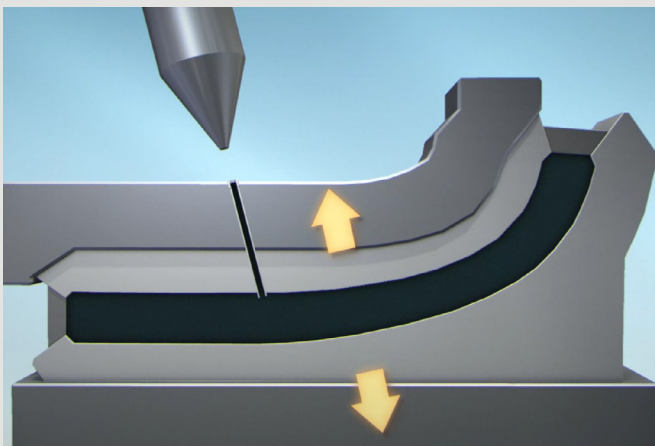
The CBE process allows a smooth, strong surface (as in automotive Class A) while still having a highly foamed interior. This is especially evident in molding systems, which utilize gas counterpressure systems on the mold, to keep maximum pressure on the melt front during the filling stage.

THERE ARE 3 PHASES IN THE CORE-BACK EXPANSION MOLDING



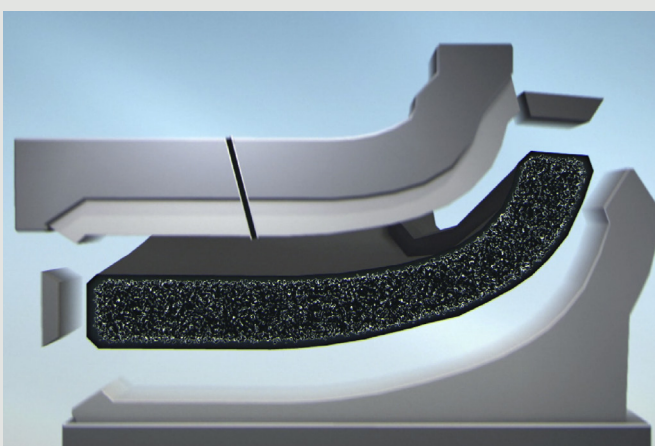
PHASE 1: MIXING AND ACTIVATING

The CFA is mixed into the melt for maximum distribution and then activated in the barrel, to release the gases. The foaming system typically employs shut-off nozzles and/or valve gates to keep pressure on the melt and keep the gas solubilized.



PHASE 2: FILLING AND EXPANDING

In this stage, either a rapid injection is used to keep pressure on the melt, or a slower injection (to minimize turbulence) if a gas counterpressure system is utilized. Once the cavity is filled, the mold opens, or one of the sides has a slide, to allow the expansion of the gas-loaded compound.



PHASE 3: COOLING AND DISMANTLING

During the cooling process, a final low-density, integral foam cell microstructure is created. Compared to conventional thermoplastic foam injection molding (TFIM) without mold expansion, CBE creates a lower-density foam with an increased stiffness-to-weight ratio.

The information contained herein is intended to provide general information about the use of chemical foaming agents in injection molding. It is not advice for any

particular use or process. It is the responsibility of the manufacturer to determine the appropriate processes and additives in the manufacture of its products.



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