Actafoam® and Celogen® Chemical Foaming Agents

General Properties Guide

Introduction

Celogen® and Actafoam® foaming agents are used in most major processes for polymeric foams. These products may be used to obtain more parts per pound of raw material; lighter-weight finished products, improved resilience and shock absorption and improved thermal and acoustical properties. These products are also used in a wide variety of non-polymer applications where their ability to generate gas and porosity provides customers with some interesting product and process design alternatives.
### Product Selection
Recommended foaming agent types for use in various resins by processing technique.

#### Chemical Foaming Agents Selector Guide

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- ○ Primary Recommendation
- △ Secondary Recommendation
- ▲ Primary Recommendation w/ Activation
- • Secondary Recommendation w/ Activation

AJD rev. 25-May-2010
Actafoam® AZ

An Efficient General Purpose Chemical Foaming Agent for Thermoset and Thermoplastic Polymers

Features
- Operating temperature 390-500°F (199-260°C); from 330°F (166°C) with activation
- Actafoam AZ and its decomposition residue impart no odor to the finished product
- The off-white decomposition residues of Actafoam AZ do not impart significant color to the finished product
- All Actafoam AZ grades can be activated by metal oxides, metal organic salts, bases, and acids to reduce its decomposition temperature to as low as 330°F (166°C)
- Actafoam AZ is the most efficient Chemical Foaming Agent on a cost performance basis

Properties
- Appearance: Pale yellow to yellow-orange powder
- Chemical Composition: Azodicarbonamide
- Decomposition Temperature: 401-415°F (205-213°C)
- Bulk Density: 31-38 lbs/ft³ (497-609 kg/m³)
- Specific Gravity: 1.65
- Gas Composition: N₂, CO, CO₂, NH₃
- Gas Evolution at STP: 210-220 mL/g
- Molecular Weight: 116
- Decomposition Residues: Biurea, cyanuric acid, urazole, urea, cyamelide
- Shelf Life: 36 months

Particle Size Grades (check for availability)
- AZ-120: 4 to 6 microns (flow treated)
- AZ-130: 6 to 8 microns (flow treated)
- AZ-150: 8 to 10 microns
- AZ-9370: 10 to 12 microns
- AZ-1901: 12 to 15 microns
- AZ-2500: 18 to 27 microns

Solubility
Actafoam® AZ is moderately soluble in dimethylsulfoxide (DMSO) and dimethylformamide (DMF). It is soluble with decomposition in aqueous bases to form the corresponding azodicarboxylate salt with the evolution of ammonia. It is slightly soluble in water and polyalkylene glycols. It is insoluble in benzene, methanol, acetone, and ethylene dichloride.

Handling Precautions
This product is dusty, and good local exhaust ventilation in mixing and handling areas is highly recommended. A dust mask and protective clothing must be worn by anyone handling this product. Actafoam AZ is a known pulmonary sensitizer and some individuals may develop asthma-like symptoms when exposed to the dust from this material. Should this occur, remove the individual from the area immediately. Wash thoroughly after handling.

Storage
The storage stability of Actafoam AZ is excellent under normal conditions. A storage temperature less than 167°F (75°C) is recommended. Containers not in use should be kept closed. The product should be stored in a cool, dry area away from any sources of heat, spark, open flames, or direct sunlight. Actafoam AZ is not hygroscopic.

Please refer to the Actafoam AZ Material Safety Data Sheet for additional information on handling, storage and properties.
FDA Approvals

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Description</th>
<th>Limitation</th>
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</thead>
<tbody>
<tr>
<td>21CFR172.806</td>
<td>Azodicarbonamide (flour maturing agent)</td>
<td>Not to Exceed 45 ppm in Flour</td>
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<tr>
<td>21CFR175.300</td>
<td>Resinous and Polymeric Coatings (can end cements)</td>
<td>Not to Exceed the Amount Required to Achieve the Desired Effect</td>
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<tr>
<td>21CFR177.1210</td>
<td>Closures with Sealing Gaskets for Food Containers</td>
<td>Not to Exceed 2 Weight Percent of Gasket Composition</td>
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<tr>
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<td>As a Foaming Agent in the Manufacture of Polyethylene Complying with 21CFR177.1520 (c), Not to</td>
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<td>Exceed 5 Weight Percent of Gasket Composition</td>
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<td>21CFR177.2600</td>
<td>Rubber Articles Intended for Repeated Use</td>
<td>Not to Exceed 5 Weight Percent of Rubber Product</td>
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<td>21CFR178.3010</td>
<td>Adjuvant Substances Used in the Manufacture of Foam Plastics</td>
<td>For Use As a Foaming Agent in Polyethylene Complying with Item 2.1 in 29CFR1520 (c) of this chapter at a Level Not to Exceed 5 Weight Percent of Finished Foam Polyethylene</td>
</tr>
</tbody>
</table>

Decomposition Mechanisms

There are several mechanistic pathways that have been outlined for the thermal decomposition of Azodicarbonamide and its derivatives. Several of them have been outlined in the schematics below:

\[
\begin{align*}
H_2N-C=N-N-C=NH_2 & \xrightarrow{\Delta} H_2N-C=NH_2 + N_2 + CO \\
\text{Azodicarbonamide} & \\
H_2N-C-N-C-N-C=NH_2 + NH_3 & \xrightarrow{\Delta} H_2N-C=NH_2 + H_2N-C=NH_2 \\
\text{Hydrazodicarbonamide (Biurea)} & \text{Semicarbazide or aminourea} \quad \text{Urea}
\end{align*}
\]
Decomposition Mechanisms

**Azodicarbonamide**

\[
\text{H}_2\text{N-C-N-N-C-NH}_2 \xrightarrow{\Delta} \text{N}_2 + \text{CO} + \text{NH}_3 + \text{HNCO}
\]

Nitrogen + Carbon monoxide + Ammonia + Isocyanic acid

**Hydrazodicarbonamide (Biurea)**

\[
2\text{H}_2\text{N-C=N-C-NH}_2 \xrightarrow{\Delta} \text{H}_2\text{N-C=N-C-NH}_2 + \text{N}_2 + 2\text{HNCO}
\]

**Semicarbazide or aminourea**

\[
\text{H}_2\text{N-C-N-N-C-NH}_2 \xrightarrow{\text{H}_2\text{O}} \text{HN-NH} \xrightarrow{\Delta} \text{HN} + \text{CO}_2 + \text{NH}_3
\]

**Urazole**

Cyanate

\[
\text{HO-C} = \text{C} = \text{OH}
\]

Cyanuric acid

Isocyanate

\[
\text{HN} = \text{C} = \text{NH}
\]

Cyamelide
Actafoam® and Celogen®
Chemical Foaming Agents

Specialty and Pre-activated Actafoam AZ- Blends

Actafoam® AZ-760-A
A Nonplateout Azodicarbonamide for Use in Applications Where Foaming Agent Mold Plateout, Die Blockage and Screw Build-Up Create Problems

Features
- Operating temperature 390-500°F (199-260°C); from 330°F (166°C) with activation
- Eliminates the plateout (typically cyanuric acid) occasionally associated with Azodicarbonamide decomposition products
- Helps to reduce downtime for cleaning operations by eliminating problems associated with foaming agent residue plateout (die and vent blockage, screw build-up)
- An excellent foaming agent for the extrusion and injection molding of materials such as HDPE, PP, HIPS, ABS, PPO, PPE, Acetal, TPRs, TPU, TPEs, TPVs and others
- Especially recommended for HDPE and PP foamed wire & cable insulation
- A free-flowing product with excellent flow characteristics that may be automatically introduced into blending operations
- Can be activated to lower temperatures using traditional materials such as zinc oxide, zinc stearate, zinc octoate, urea, and various PVC stabilizers

Properties
- Appearance ......................... Free-flowing yellow powder
- Chemical Composition .............. Azodicarbonamide (60%), hydrated silica (40%)
- Decomposition Temperature ........ 392-401°F (200-205°C)
- Bulk Density .......................... 15-20 lbs/ft³ (240-320 kg/m³)
- Specific Gravity ....................... 2.0
- Gas Composition .................... N₂, CO₂, NH₃, CO
- Gas Evolution at STP ................ 160-180 mL/g
- Shelf Life .............................. 36 months

FDA Approvals
See Actafoam AZ Section.

*Please refer to the MSDS for additional information on handling, storage and properties.*
Actafoam® 780
A Pre-activated Azodicarbonamide for Polymers Processed at 285°F (140°C) and Higher

Features
- A one-pack formulation containing Actafoam AZ-130 with a proprietary activator system
- Provides the fastest rate of gas release of all Actafoam products
- Suitable for use in low-temperature polymer systems including acrylics, epoxies, and automotive sound-deadening and space-filler materials

Properties
- Appearance: Yellow powder
- Chemical Composition: Azodicarbonamide with activators
- Decomposition Temperature: 285-302°F (140-150°C)
- Bulk Density: 28 lbs/ft³ (448 kg/m³)
- Specific Gravity: 1.78
- Gas Composition: N₂, CO, CO₂, NH₃
- Gas Evolution at STP: 160-180 mL/g
- Shelf Life: 24 months

Please refer to the MSDS for additional information on handling, storage and properties.

Actafoam 765-A
A Pre-activated Azodicarbonamide for Polymers Processed at 300°F (149°C) and Higher

Features
- A one-pack formulation containing CELOGEN AZ-130 with a proprietary activator system
- Provides a faster rate of gas release compared to Celogen 754-A
- May be a more cost-effective substitute for CELOGEN OT

PROPERTIES
- Appearance: Yellow powder
- Chemical Composition: Azodicarbonamide with activators
- Decomposition Temperature: 306-320°F (152-160°C)
- Bulk Density: 29 lbs/ft³ (464 kg/m³)
- Specific Gravity: 1.78
- Gas Composition: N₂, CO, CO₂, NH₃
- Gas Evolution at STP: 160-180 mL/g
- Shelf Life: 24 months

Please refer to the MSDS for additional information on handling, storage and properties.
Actafoam® 754A  
*A Pre-activated Azodicarbonamide for Polymers Processed at 329°F (165°C) and Higher*

**Features**
- A one-pack formulation containing *Actafoam AZ-130* with a proprietary activator system
- Highly recommended for Ca-Zn stabilized flexible PVC formulations for molding and extrusion applications
- Suitable for use with other polymers such as HYTREL®, KRATON®, TPR®, SANTOPRENE®, SARLINK® and metallocene polyolefins

**Properties**
- **Appearance**: Yellow powder
- **Chemical Composition**: Azodicarbonamide with activators
- **Decomposition Temperature**: 329-256°F (165-180°C)
- **Bulk Density**: 25 lbs/ft³ (400 kg/m³)
- **Specific Gravity**: 1.68
- **Gas Composition**: N₂, CO, CO₂, NH₃
- **Gas Evolution at STP**: 160-180 mL/g
- **Shelf Life**: 24 months

*Please refer to the MSDS for additional information on handling, storage and properties.*

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Actafoam AZRV  
*An Azodicarbonamide Blend Designed Specifically for Rigid PVC Processed at 380°F (193°C) or Higher*

**Features**
- Designed specifically for rigid PVC formulations containing calcium stearate
- Relies on calcium stearate for activation
- Compatible with all traditional rigid PVC compounding ingredients
- Nonplateout

**Properties**
- **Appearance**: Yellow powder
- **Chemical Composition**: Azodicarbonamide blend
- **Decomposition Temperature**: 392-410°F (190-210°C) with CaSt, 360-380°F (182-193°C) without CaSt
- **Bulk Density**: 29 lbs/ft³ (465 kg/m³)
- **Gas Composition**: N₂, CO, CO₂, NH₃
- **Gas Evolution at STP**: ~200 mL/g
- **Shelf Life**: 36 months

*Please refer to the MSDS for additional information on handling, storage and properties.*
Celogen® OT
A Sulfonilhydrazide Chemical Foaming Agent for Use with Polymers Processed in the 300-350°F (149-177°C) Range

Features
- Lower operating temperature range
- Does not generate ammonia
- Decomposition residue is non-polar and does not affect electrical properties
- An excellent choice for white foams where appropriate
- Highly recommended for epoxies and vinyl ‘puff’ inks

Properties
- Appearance: White powder
- Chemical Composition: p,p'-oxybis(benzenesulfonylhydrazide), oil
- Decomposition Temperature: 316-320°F (158-160°C)
- Bulk Density: 30 lbs/ft$^3$ (480 kg/m$^3$)
- Specific Gravity: 1.55
- Gas Composition: N$_2$, H$_2$O
- Decomposition Residue: A polythiosulphonate
- Gas Evolution at STP: 125 mL/g
- Molecular Weight: 358
- Shelf Life: 24 months

Solubility
Celogen® OT is soluble, with reaction, in ketones to form the corresponding hydrazone. It is very soluble in dimethylsulfoxide (DMSO) and dimethylformamide (DMF). It is moderately soluble in ethanol, bases, and polyalkylene glycols. It is insoluble in benzene, ethylene dichloride and water.

Handling Precautions
This product is dusty, and good local exhaust ventilation in mixing and handling areas is highly recommended. A dust mask and protective clothing must be worn by anyone handling this product.

Sources of heat such as sparks from static electricity or welding operations, open flames, metal-on-metal frictional heat, and hot pipes will cause Celogen® OT to decompose with the evolution of heat and large volumes of smoke.

All equipment that will be in contact with Celogen® OT, including weighing and mixing equipment, should be continuously grounded.

Storage
The storage stability of Celogen® OT is excellent under normal conditions. A maximum storage temperature of 113°F (45°C) is recommended. Containers not in use should be kept closed. The product should be stored in a cool, dry area away from any sources of heat, spark, open flames, or direct sunlight.

Celogen® OT is a flammable solid that will continue to burn once it is ignited. Intense heat and large volumes of smoke will be given off.

DO NOT attempt manual firefighting.

Please refer to the Celogen® OT Material Safety Data sheet for additional information on handling, storage and properties.
Actafoam® and Celogen®
Chemical Foaming Agents

FDA Approvals

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<th>Description</th>
<th>Limitations</th>
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<tbody>
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<td>21CFR175.300</td>
<td>Resinous and Polymeric Coatings (can end cements)</td>
<td>Not to Exceed 0.5 Weight Percent of the Composition</td>
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<tr>
<td>21CFR177.1210</td>
<td>Closures with Sealing Gaskets for Food Containers</td>
<td>Not to Exceed 0.5 Weight Percent of the Gasket Composition</td>
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<tr>
<td>21CFR177.2600</td>
<td>Rubber Articles Intended for Repeated Use</td>
<td>Not to Exceed 5 Weight Percent of Rubber Product</td>
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Decomposition Mechanisms

p,p'-oxybis(benzenesulfonylhydrazide) or CELOGEN® OT

\[
\begin{align*}
\text{H}_2\text{N}-\text{N} & \quad \text{O} \\
\text{S} & \quad \text{O} \\
\text{O} & \quad \text{H} \\
\text{N} & \quad \text{NH}_2 \\
\end{align*}
\]

\[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{O} & \quad \text{H} \\
\text{S} & \quad \text{N} \\
\text{N} & \quad \text{NH}_2
\end{align*}
\]

\[
\begin{align*}
\text{HOS} & \quad \text{O} \\
\text{O} & \quad \text{SOH}
\end{align*}
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\[
\begin{align*}
\text{HOS} & \quad \text{O} & \quad \text{S} & \quad \text{SS} & \quad \text{O} & \quad \text{S} \\
\text{O} & \quad \text{O}
\end{align*}
\]

\[
\begin{align*}
2\text{N}_2 & \quad + & \quad 2\text{H}_2\text{O} \\
\end{align*}
\]

\[
\begin{align*}
\text{A polythiosulfonate}
\end{align*}
\]
Factors affecting Chemical Foaming Agent Performance

Effect of Temperature and Time on Decomposition Rate
The decomposition rate of Actafoam® and Celogen® chemical foaming agents will vary with temperature and time. Lower temperatures will require longer times for complete decomposition.

Effect of Activators on Decomposition Rate
Activators (catalysts) may be added to chemical foaming agents to reduce their normal temperatures of decomposition. For Actafoam AZ and related blends, heavy metal oxides and their organic salts are typically used. This group includes compounds of zinc, lead, chromium, cadmium, barium and calcium in order of decreasing activity. When added, these materials will reduce decomposition temperature and increase or speed up the rate of decomposition of the foaming agent. Activator levels can vary from 1% of the foaming agent level up to equal to the foaming agent level, depending on the desired effect. It is always advisable to preblend the foaming agent and activator before addition to the polymer system to insure maximum effect.

Note that other additives in polymers may also act as activators for chemical foaming agents.

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<th>Materials</th>
<th>Celogen® OT</th>
<th>Actafoam® AZ</th>
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<tr>
<td>Barium stearate</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>BIK®-OT (urea)</td>
<td>VS</td>
<td>VS</td>
</tr>
<tr>
<td>Cadmium stearate</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Calcium stearate</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>Calcium sulfate</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Carbon black</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Citric acid</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>Dibasic lead phosphate</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Dibasic lead phthalate</td>
<td>S</td>
<td>VS</td>
</tr>
<tr>
<td>Dibasic lead stearate</td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>Dibutyltin bis(isooctylthioglycolate)</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Dibutyltin dilaurate</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>Dioctyl adipate</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Dioctyl phthalate</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Lead stearate</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td>W</td>
<td>N</td>
</tr>
<tr>
<td>Paraffin oil</td>
<td>N</td>
<td>W</td>
</tr>
<tr>
<td>Stannous stearate</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>W</td>
<td>N</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>W</td>
<td>N</td>
</tr>
<tr>
<td>Triethanol amine</td>
<td>VS</td>
<td>W</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>M</td>
<td>VS</td>
</tr>
<tr>
<td>Zinc stearate</td>
<td>W</td>
<td>S</td>
</tr>
</tbody>
</table>

N = None; W = Weak; M = Moderate; S = Strong; VS = Very strong
Effect of Particle Size on Decomposition Rate

Generally, foaming agent particle size may be used to control the speed of decomposition only when activators for the foaming agent are present in the polymer. A smaller particle size foaming agent (and activator) will provide a faster rate of decomposition and gas evolution. In polymer systems where cure or fusion is involved, especially at atmospheric pressure, rate of gas evolution from the foaming agent must be balanced with the viscosity of the polymer system. If gas is generated when polymer viscosity is too low, much of the gas will escape resulting in little to no density reduction and a larger and more irregular cell structure. If gas is generated when the polymer viscosity is too high, less expansion may take place and cracking will occur in extreme cases. Although foaming agent particle size and activator type and level may be varied to achieve this balance, it is sometimes necessary to modify the cure or fusion behavior of the polymer system as well.

Solubility in Various Liquids

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Celogen® OT</th>
<th>Actafoam® AZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>Reacts</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Benzene</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Dimethylformamide (DMF)</td>
<td>Very soluble</td>
<td>5.0 g/ml</td>
</tr>
<tr>
<td>Dimethylsulfoxide (DMSO)</td>
<td>Very soluble</td>
<td>4.3 g/ml</td>
</tr>
<tr>
<td>Divinyl benzene</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Moderately soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Ethylene dichloride</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Methanol</td>
<td>Moderately soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Methyl ethyl ketone (MEK)</td>
<td>Reacts</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Pentane</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>Low</td>
<td>Soluble with reaction</td>
</tr>
<tr>
<td>Toluene</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
<tr>
<td>Water</td>
<td>Practically insoluble</td>
<td>Practically insoluble</td>
</tr>
<tr>
<td>Xylene</td>
<td>Not soluble</td>
<td>Not soluble</td>
</tr>
</tbody>
</table>