



Prevent fogging of your transparent food packaging

Effective solutions exist to keep your packaging fog-free, and recent developments make it easier than ever



INTRODUCTION

Fog formation on food packaging films frustrates consumers, can lead to product spoilage, and ultimately hinders sales. Fortunately there are ways to minimize fogging. There is now also a new development that not only helps minimize fogging but also makes it easier for consumers to open packaging.

Tremendous effort goes into the production and preparation of fresh foods, but unfortunately much of that effort goes to waste. Estimates vary, but industry experts generally acknowledge that about 40–50% of all food meant for humans is wasted worldwide—thrown away before being consumed. Food packaging helps limit that waste by providing protection for food so that it remains safe to eat, and packaging also serves a significant role by increasing attractiveness, making it more likely customers will purchase a specific food.

Processors and converters of flexible thermoplastic film often do an excellent job of meeting the requirements for food protection and attractive marketing. But they still can be challenged when it comes to minimizing condensation, or fogging, and frustrating consumers either at the point of sale or later after storage but before use. This paper discusses the reasons fogging occurs, tools to minimize it, and also a new development that can both limit fogging and support development of easy-to-open packaging.

WHAT IS FOGGING AND HOW CAN WE PREVENT IT?

What is fog? In the classical sense, fog is the result of tiny water droplets suspended in the air. The meteorological office will tell you that the thickest fogs occur where there are the most particles on which these water droplets can form. Fogging on

THE PROBLEM WITH FOG

Why be concerned with fogging on food packaging films? Fogging poses aesthetic and hygiene challenges which can hurt sales.

- Consumers perceive the packaged food as poor in quality
- Moisture accumulation can lead to spoilage
- Consumers are unlikely to purchase foods they cannot see

Consumers want to see what they are buying, and that is especially true for fresh foods.

plastics films is really not all that different than the fog that forms outside; it's just that, on a plastic film, fog forms on a convenient hydrophobic surface—namely, the film. But the reasons for fog forming on packaging and agricultural films are just the same as those in the San Francisco Bay area.

Water vapor in the form of tiny droplets condenses on a plastic film's surface when an enclosed mass of air cools to a temperature at its dew point. The extent of the phenomenon depends on the relative humidity of the enclosed air mass and the temperature of the plastic film enclosing that air mass.

Fogging in food packaging is most frequently seen on packaging films around fresh products in refrigerators and chiller cabinets. Here the temperature is low enough to initiate condensation if the relative humidity is high enough. Fogging on



THE FOG THREAT: WHERE WILL IT STRIKE?

Fog formation is a challenge for many fresh foods and packaging types, including:

- Fresh and processed meats and fish
- Lidding barrier films on rigid or semi-rigid containers
- Stretch films
- Fruits and vegetables
- Stretch or shrink films
- Biaxially Oriented Polypropylene (BOPP) films

Food packaging is not only a problem of aesthetics, but also hygiene. And depending on the product, fog may lead to an actual reduction in quality and to spoilage.

The root cause of water droplet formation is the difference in surface tension between the film and the water. Most films used in food packaging are either totally olefinic (polyethylene or polypropylene) or have multilayer structures in which the inner polymer surface is olefinic. Polyolefins are non-polar and highly hydrophobic, with surface energies much lower than that of water (which has a surface energy of 0.072 J/m²). As a result, water condenses on a polyolefin film's surface in discrete droplets with high contact angles. When water condenses on a film made out of polar (hydrophilic) polymer with a higher surface energy, the droplets have lower contact angles. These droplets tend to accumulate and form a very thin transparent film of water, reducing or even

eliminating the fogging effect. Another example of the difference between higher and lower contact angles is an automobile which has a wax finish and the beading of water after a rain shower. The higher contact angles lead to beading and separation of the water drops from each other.

There are two ways to improve anti-fog properties in polyolefin films:

1. Treat the film and then spray a coating onto its surface after extrusion.
2. Incorporate a specialty additive concentrate during extrusion of a film.

Spraying a coating on a film's surface requires an investment in capital equipment and use of a secondary process in a film manufacturing line. In contrast, a specialty additive concentrate can be added at the film extrusion machine, in concentrations formulated to support manufacturing of different types of films. Whether a surface coating or an additive concentrate is selected, the anti-fogging system balances the differences in surface energies by increasing that of the film to meet that of the water. The increased surface energy of the film results in a lower contact angle of the water droplets, allowing adjoining water droplets to merge and eventually spread out into a thin continuous layer of water on the film. With a nearly constant layer of water, translucency approaching the transparency of the film returns, and no single droplet is so large as to fall from the film onto the food in that enclosed air mass within the package.

KEEP FRESH FOOD FRESH

Film packaging performs several important roles. It protects and preserves the contents, and it makes them look good. Film materials and processing technologies have come a long way



in recent years, and it is now possible to create films with outstanding mechanical properties, gas barrier properties, and optical qualities. But with fresh food packaging in particular, we are talking about a highly dynamic environment. Fruit and vegetables continue toward equilibrium with their surroundings after they have been picked, for example, which is why sometimes it is important for the film to present only a partial barrier to gases, to prevent product deterioration because of an enclosed air mass which is too humid or too arid for sustaining freshness of the food. Additionally, packaging can benefit from oxygen and acetaldehydes scavengers.

It is also important to remember that a very high proportion of any fruit or vegetable is water. An apple is 84% water; only 4% of a cucumber is not water. The amount of naturally occurring water present in meat is around 60–70%. All these fresh foods have porous surfaces, so it is inevitable that some of that water is going to equilibrate with its environment while the product is in its package. Unless the packaging film has a very low barrier to water vapor, or unless there is some sort of water absorber contained in the package, there is a high likelihood that water will accumulate in the enclosed air space and, at a specific temperature and relative humidity, condense in droplets on the inner surface of the package, most noticeably on the transparent film meant to display the food

GOOD PACKAGING ALSO PROTECTS YOUR BRAND

Product brand identity is the sum of many factors, including the quality of packaging used. That's because packaging, when it is done well:

- Protects and preserves food from external factors
- Ensures a fresh product with a long shelf life
- Provides convenience for use (if it is easy to open and possibly also reclosable)
- Enhances shelf-appeal

without opening the package. And unless the film has an anti-fogging surface under those temperature and humidity conditions, a fog will form, and the visible display aspect of the contents will be significantly affected.

This fog can form at any one of the various stages in the transport and storage of the product, from the moment it is put in the pack, to the time that it is put on the shelf or in the refrigerator at home.

GREAT LOOKS AND A SIMPLER PROCESS

The addition of just a small amount of a relatively low-cost additive during the film production process can make the difference between a product ending up in the shopping cart, or staying on the shelf—possibly until it has to be thrown away.

In 2010, Avient introduced the first anti-fog additive for polypropylene films that enabled anti-fog sealant film conversion without the need for surface treatment. It simplified production of anti-fog films for the flexible food packaging industry, and improved production efficiencies for both cast and blown film producers.

It also was one of the few anti-fog additives available with both EC and FDA food contact compliance, which meant that film producers can use the same anti-fogging product across multiple geographic regions.



By eliminating the need for surface treatment using anti-fog coatings, these additives remove the risk of orientation error because they are not a surface treatment. They also save time and energy by reducing the number of separate steps needed to arrive at a finished film. In addition, laboratory tests indicate that these additives produce anti-fog properties at a slightly faster rate than other additive solutions.

These additives are offered globally as a masterbatch or as a component of a specialty formulation, and development has continued to make them even more efficient and easier to add to processing lines.

BEHAVIOR OF ANTI-FOG CONCENTRATES IN LAMINATED BARRIER FILMS

Different anti-fog masterbatch concentrates can be formulated for different types of packaging film. In order to create the most appropriate anti-fog additives for different types of films, research was commissioned into potential interactions between anti-fog additives in polyethylene (BOPE) films and the bi-component adhesives used in the lamination of biaxially-oriented polyethylene terephthalate (BOPET) to a PE film.

Following a broad screening of potential anti-fog candidates, production began on a series of polyethylene films containing the different types selected, and then laminates were produced with BOPET using bi-component adhesives. Some of these adhesives contained solvents, and some were solvent-free. Evaluation was made of the films before and after lamination—in both cases over a period of six months.

The various films were then subjected to a cold fog test, simulating conditions in the type of refrigerator used in food packaging systems.

Tap water was put in a beaker, the top of the beaker was covered with a sample of the test film, and the beaker was put in a refrigerator at 4°C (39°F). The appearance of the film was observed after one hour and then after four hours, and visibility through the film is given a rating from A (zero visibility due to fogging of the inside surface of the film) to E (completely transparent).



Results showed that the type of adhesive used could negatively affect the performance of the anti-fog agent, with solvent-free adhesives having a greater effect. But some anti-fogs performed better than others, no matter the adhesive used. As a result of this testing, new anti-fog additives were developed and marketed. These additives do not interact with two-component polyurethane adhesives, maintain their properties after lamination of films, and maintain the sealability of the laminate. In addition, there is no restriction on their use in food contact applications, because no Specific Migration Limit (SML) applies to them.



ATTRACT CONSUMERS, BUT DON'T THEN FRUSTRATE THEM: ANTI-FOGGING WITH EASY-PEEL

Anti-fogging additives can be combined with other functional features in films to increase the overall customer-friendliness of a complete package. But plastics material systems are dynamic too. Film processors need to be aware that incorporation of an additive to create or enhance one property or set of properties may also have an unwanted adverse effect on other properties, either inherent in the polymer or created by another additive.

One of the most tantalizing aspects of modern packaging is this: it provides such good protection for the contents, that sometimes it is almost impossible to break into it! This is why so much effort is put into developing films for lidding that provide an excellent seal while the product is on the shelf or in transit, but which allow the lid to be peeled back easily when the consumer wants to open the package.

Today, thanks to a development cooperation between a leading global supplier of additive and colorant masterbatches and a major producer of polyolefin thermoplastics, packaging film producers have the opportunity to select film-grade polypropylene for sealing layers that are highly transparent, can be efficiently processed and converted, and yield film that provides an excellent seal and yet still enables easy opening. In addition, these films contain an anti-fogging additive specially formulated not to compromise any of this easy-peel functionality. Typical applications are fresh and processed meat, fish, ready-to-eat meals, and fresh produce.

There were several key challenges that had to be met in the development of this specialty

formulation. Firstly, the additive had to be compatible with the polymer system, but at the same time it needed to be able to migrate to the surface of the film over time, in order to provide a consistent and long-lasting anti-fogging effect.

Secondly, the additive must not interfere with the principal role of the polymer, which is to provide high levels of film sealability and peelability. It must not affect the integrity of the overall film structure, avoiding any chance of delamination. It must not affect the optical properties of the film.

Thirdly, the additive must meet all relevant food contact approvals. This includes meeting any Specific Migration Limits (SML) that apply.

EASY-PEEL + ANTI-FOG: A WIN FOR CONSUMERS AND MANUFACTURERS

The combination of easy-peel and anti-fog in a complete system has important advantages for film processors, particularly when it comes to costs:

- Ready-to-process grades simplify logistics and ease processing
- Broad sealing window for fast and flexible processing
- No need for an extra processing step to bring peel & anti-fog effects
- No need for corona treatment of the packaging



YOUR NEXT STEP?

Anti-fog additives are a cost-efficient means of maintaining the high optical qualities of polyolefin films used to pack perishable fresh foods. This, in turn, keeps food attractive to consumers for longer durations, and can also help maintain food quality by minimizing spoilage. Various anti-fog additives are available, and their careful selection depends on the construction of the film in which they are used, as well as the specific conditions of the application. Collaborating with an experienced supplier able to offer a wide variety of these additive concentrates, globally, can help film manufacturers play their part in limiting food waste and keeping consumers happy.

For more information from Avient on anti-fog solutions for transparent food packaging, visit www.avient.com.

