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Modified Atmosphere Packaging and Material Gas Permeability

Abstract: This article outlines the packaging principle, preservative gas and application of Modified Atmosphere Packaging (MAP). It also presents detailed reasons why gases have different permeability on the same material.
Keywords: packaging , MAP , modified air packaging , preservative gas , permeability and dynamic diameter

1. MAP

Modified Atmosphere Packaging (MAP) is a kind of preservative packaging developed on the basis of vacuum and nitrogen-filled packaging and it is mainly used for food preservation.

The packaging principle of MAP is to replace air in packaging bags and boxes with modified preservative gas (mixture of 2~4 gases according to food property), so as to change the internal environment of packed food, restrain bacilli growth as well as slow down the metabolic rate and extend the freshness or shelf life of the food. Take fruit and vegetable preservative as an example, fresh fruit and vegetable still respire after pick. They consume oxygen and produce carbon dioxide, which would result in increase of carbon dioxide content and decline of oxygen concentration. With high permeability film, oxygen could be supplied and carbon dioxide be vented through exchanging packaging gas with atmosphere. When the gas permeability rate equals to respiratory rate of fruit and vegetable, certain gas equilibrium concentration in the package is achieved. Then, fruit and vegetable could maintain weak respiratory rate without anaerobic respiration. Thereby, the maturation of fruit and vegetable is delayed and freshness is preserved. MAP could ensure food taste, nutritional ingredient and freshness period without applying preservative and additive.

MAP preservative gas mainly consists of carbon dioxide, nitrogen, oxygen and other special gases such as nitrogen dioxide, sulfur dioxide, and argon. Their functions are as follows: carbon dioxide, the main preservative gas, could restrain growth of most putrid bacilli and fungus; oxygen could restrain the propagation of most anaerobic bacilli and keep meat color and fruit and vegetable freshness. Nitrogen, inert gas, does not react with food, nor is absorbed by food. It is used as filling gas to prevent package slump caused by gas escaping such as carbon dioxide. Different food and fruit have different preservative gas ingredient and proportion. For crop MAP, it is critical that oxygen permeability rate should be matched with respiratory rate.

MAP has a complete application in the packaging of snacks, coffee, and meat. Nowadays, it has also been adopted more and more in the fields of cold stored and pretreated convenience foods, especially for the packaging of fresh sliced farm products, choice cheese, and pre-packed sandwich.

2. Different gas permeability

Many factors should be taken into consideration in designing MAP system, among which, relative percentage of carbon dioxide and oxygen in the packages are most important; and which are mainly determined by gas concentration in packaging and material gas permeability, i.e. precision of MAP preservative gas proportion and gas exchangeability rate of material. Different from vacuum packaging and nitrogen-filled packaging, most MAP

materials are low barrier materials with high permeability rate.

Gas permeability is related with coherent status of material macromolecule (crystallinity), influences of polymer structure on diffusibility and solubility as well as the influences brought forward by additives. However, different gases have different permeability for the same materials which is determined by gas molecule dimensions (dynamic diameter, see table 1) and gas molecule shape. For the same material, nitrogen has the smallest permeability rate; oxygen has larger while carbon dioxide has the biggest. The smaller dynamic diameter, the easier the diffusion is and the bigger diffusion coefficient molecule has. However, gas molecule dimension is not the only determining factor since gas diffusibility is also involved. In addition, molecule shape also affects permeability. Some research shows that long strip molecule has the strongest diffusibility and permeability, and the tiny change of molecule shape would produce great influence on permeability.

Table 1 Gas Molecule Dimension

Gas	He	H_2	NO	CO_2	Ar	O_2
Dynamic Diameter/nm	0.26	0.289	0.317	0.33	0.34	0.346
Gas	N_2	CO	CH_4	C_2H_4	Xe	C_3H_8
Dynamic Diameter/nm	0.364	0.376	0.38	0.39	0.396	0.43

3. How to Choose Appropriate MAP Material

There is no doubt that MAP material should be selected appropriately according to its gas permeability. The commonly used gas for MAP is a mixture of oxygen, carbon dioxide, nitrogen or mixture of oxygen and carbon dioxide. Therefore, gas permeability of oxygen and nitrogen should be tested accurately and respectively. Permeability of other gases should not be calculated simply by converting oxygen transmission rate (O2TR) according to experience. It can be imagined that index testing mistakes or inappropriate MAP material selection caused by incomplete gas permeability testing would not only cause great loss to enterprises but also waste the resource as well.

At present, the commonly used methods for gas permeability test are different pressure method and equal pressure method. Equal pressure method instrument has limited testing objects. It can only test oxygen permeability (as Labthink TOY-C1 Oxygen Permeability Tester) and carbon dioxide permeability. Nitrogen permeability testing instrument has not been developed by any enterprises. However, different pressure method instrument could test common gases such as oxygen, nitrogen, carbon dioxide and it has low cost and can provide self-control testing temperature (Labthink VAC-V1 Gas Permeability Tester). With the support of film theory, vacuum instrument of different pressure method can test common gas permeability as well as specimen diffusion coefficient and solubility coefficient. Compared with equal pressure method instrument, permeability testing instrument of different pressure method is more suitable for research institution and enterprises to have a comprehensive testing and analysis of MAP material.