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Antimicrobial Packaging Technologies and Testing Emphases

Abstract: this article briefs the advantages of antimicrobial package, its working principle and the testing importance for it. The permeability testing method for gaseous state antimicrobial agent against antimicrobial packaging material is also introduced, and the importance of such permeability testing is testified with data.

Key words: permeability, antimicrobial package, gaseous state, antimicrobial agent, organic gas

The antimicrobial and anticorrosive requirements for food are stricter than those of pharmaceuticals, daily chemistry and electronic products; this is because food is composed of perishable components. The common antimicrobial and anticorrosive method is to add anticorrosive agent into food, yet, the safety of this method is still under dispute. The introduction of antimicrobial package has greatly relieved the dependence on food anticorrosive agent, and has become an effective means to improve food preserving quality and reduce the amount of additives.

1. The Limitations of Anticorrosive Agent

The traditional antimicrobial and anticorrosive method for food is to add anticorrosive agent inside it. However, there exist several remarkable issues for this method. Firstly, the addition of anticorrosive agent to food would influence food safety. Though some anticorrosive agent has been applied for years, the potential safety hazard has been exposed with the deep-going researches. For example, benzoic acid, which has been widely applied, has led to the reports of several accumulating toxication. Secondly, from the viewpoint of the customers, though anticorrosive agent has been widely used, the acceptance of food with such elements is inferior to those without them. Thirdly, there would be a period of time, relating to the amount of anticorrosive agent inside, for such agent to release to the food surface and bring the antimicrobial and anticorrosive functions into full play. Therefore, even if the anticorrosive agent is added inside food, there would be a high requirement for the environment.

2. Antimicrobial Package

The principle of antimicrobial package is different from anticorrosive agent. The antimicrobial function is realized through adding antimicrobial agents inside or on the surface of the packaging materials. Those antimicrobial agents would scarcely permeate the antimicrobial elements into the food, and thus, the food is safer. In this way, antimicrobial package provides a way for the reduction of anticorrosive agent's amount. The antimicrobial package can be used individually, or with anticorrosive agent(s).

The antimicrobial package is not required to instantly kill hazardous microbes, but required to restrain the growth and reproduction of those microbes in the long term so as to protect the food. To achieve this aim, controlled-release technology should be applied in antimicrobial package designing, so as to release the antimicrobial agent in the proper 'speed' that matches with the growth kinetics. Antimicrobial agent is the core of antimicrobial packaging system. Such agent has its specific antimicrobial activity, and the suitable agent should be chosen according to the activity of the target microbe. Antimicrobial chemical elements fit for food packaging include

organic acid and salt, sulphurous acid, nitrous acid, antibiotics and ethanol, etc. Those elements are categorized into three states: solid state, solute state and gaseous state. Comparing with solid and solute antimicrobial agents, gaseous antimicrobial agent has remarkable advantages. They can evaporate and permeate into the places where the non-gaseous agents can not reach. Meanwhile, gaseous antimicrobial agent is in the headspace and has no direct contact with food. It's not easy for such antimicrobial agent to permeate into the food so that the food safety is guaranteed.

The inner environment of the package is directly influenced by the antimicrobial materials and their characteristics, and thus, the antimicrobial effects would be influenced. The hydrophilic property of the antimicrobial agent is usually better than the film materials. At the same time, the pores inside the materials would be filled with antimicrobial agents. So, the adding of antimicrobial agent would lead to slight changes to materials' mechanical and processing properties as tensile strength and burst strength, etc., as well as gas and water vapor permeability, hygroscopic property, oil resistivity and glossiness, etc. The functioning of some antimicrobial agents has close relationship with the characteristics of the packaging materials. For example, utilizing anti-oxidant to create a non-oxygen environment to limit the mildew growth and the subsequent deterioration brings high requirements for the permeability of the packaging materials. When using gaseous antimicrobial agents, the oxygen and water vapor barrier properties of packaging materials, and the permeability of gaseous antimicrobial agent itself against the packaging materials should be considered. For example, ethanol's permeability against the packaging materials needs to be considered for gaseous ethanol antimicrobial packages, and ethanol permeability test against the packaging materials is a necessity to avoid failure of the antimicrobial packaging system.

3. Permeability Testing Demands for Antimicrobial Packages

The influence of antimicrobial agent to materials relates to additive amount and type of the antimicrobial agent. Therefore, a complete and comprehensive performance testing for antimicrobial packaging material is a must, so as to avoid losses caused by the decreasing material strength. As to antimicrobial packages with gaseous antimicrobial agents, the permeability of such agent should be especially noticed.

The gas permeability of flammable, explosive or poisonous gases like chlorine dioxide or ozone, etc., can be tested by differential-pressure method, a method for common gas permeability testing. However, such instruments should be customized, and structural adjustment should be made according to characteristics of the corresponding testing gases. Labthink has provided customers with several customized differential-pressure method permeability instruments for specialty gas testing. There have been great differences between the testing methods for organic gases and inorganic gases. Organic vapors, such as ethanol, may lead to swelling of the film, and subsequently, remarkable changes to the permeability. Globally, the research of this field is still at the developing stage. Now, Labthink has newly introduced PERME™ 2/410 Organic Gas Transmission Rate Test System, which applies the balancing-method to test the organic gas permeability. This instrument has patent structural design, and is composed of permeability cell, organic gas generating device, timed sampling valve, separation chamber and FID (fire ionized device), etc. It's easy to control, and it's the most automatic organic gas permeability testing instruments in the market.

Fig. 1 PERME™ 2/410 Organic Gas Transmission Rate Test System

Now, Labthink Lab has accomplished organic gas permeability testing against several common flexible packaging films. Those organic gases include ethanol, acetone and toluene, etc. Some of the data can be seen in Chart 1.

Chart 1. Ethanol Transmission/Permeability Rate through Common Materials

Material	Ethanol Transmission /Permeability Rate（$g/m^2 \cdot 24h$）
PC（125um）	0.21
AL（100um）	0
PET（19um）	0.02
PE（40um）	7.17

Comparing the ethanol transmission/permeability rate with oxygen and water vapor transmission/permeability rate through the above-mentioned packaging materials, it's easy to find out that there is no rule of coincidence or similarity between the transmission rates of organic gases and oxygen as well as water vapor. Though the permeability the packaging materials is the determinant factor for organic gas transmission, types of the organic matter and the characteristics of the materials would influence the final data. Therefore, it would be an important cause of failure, if the organic gas permeability is inferred by the common gas transmission/permeability rate (GTR) or water vapor transmission/permeability rate (WVTR) with inevitable errors.

4. Conclusions

With the growing packaging requirements and increasing focus on food safety, antimicrobial package has been widely used in food packaging. Yet, antimicrobial package is not simply a combination of antimicrobial agent and package; the two sides are interacted and mutually restricted. The most appropriate balancing point between the two sides is to be achieved with the help of material testing. More and more testing items has evaluated from qualitative testing to quantitative testing with the progress of testing technologies. The development of those testing technologies would eventually promote the progress and development of antimicrobial packages.