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FLAIR FLEXIBLE PACKAGING WHITE PAPER

Water Vapor Transmission Rate (WVTR)

INTRODUCTION

Controlling moisture migration is crucial to maintaining the quality of packaged food products. Dairy, meat, seafood, and wet pet food products require moisture retention, while dry products such as gourmet snacks, coffee, grains, dry pet foods, and non-food products require a moisture-free environment to avoid undesirable changes in texture, taste, and microbial stability.

PRODUCT	POTENTIAL ADVERSE EFFECTS OF MOISTURE
Bakery Products	Loss of softness (dehydration)
Baked/Fried Snacks	Loss of crispiness (hydration)
Confectionery (Sugar)	Textural changes (hydration for uncrystallized, dehydration for crystallized)
Chocolate	Bloom (hydration)

A packaging film's ability to serve as a barrier to moisture is expressed as its "water vapor transmission rate," or WVTR. Sometimes referred to as "moisture vapor transmission rate" (MVTR), WVTR is the standard indicator of the ease or difficulty with which moisture can pass through a film. Lower WVTR indicates greater resistance to permeation and, as a result, stronger barrier to moisture.

WVTR's at 38°C and 95% Relative Humidity

Polymer	Transmission Rate (g mm $m^{-2} day^{-1}$) x 10^{-2}
Polypropylene (PP)	7.8-15.7
High density polyethylene (HDPE)	0.1-0.2
Poly(vinyl chloride) (PVC)	19.7-31.5
Low density polyethylene (LDPE)	31.5-59
Poly(ethylene terephthalate) (PET)	31.5-59
Ethylene-vinyl alcohol copolymer (EVOH)	546
Nylon 6	634-863

Source: From Robertson, G., Food Packaging Principles and Practice, 2nd ed., CRC Press, 2006.

FACTORS AFFECTING WVTR

As with oxygen transmission rate (OTR), WVTR is affected by structural elements of films. Permeation theory, based on Henry's and Fick's laws, tells us the movement of a gas through a film is actually a three-step process: adsorption – by which the gas dissolves in the film matrix at the higher concentration side, diffusion of the gas through the film, and desorption or evaporation of the gas from the opposite side of the film.[1]

Crystallinity, the amount of amorphous vs. solid state regions in a film, will also affect WVTR by affecting the rigidity and space through which water vapor can pass. For example, high density polyethylene (HDPE) with up to 85% crystallinity exhibits a lower WVTR than low density polyethylene (LDPE) and linear low density polyethylene (LLDPE) with crystallinities of 30-55%.

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Polarity of a polymer is affected by the types of functional groups associated with the main polymer chains. With no functional groups, polyethylene and polypropylene are non-polar. The presence of a hydroxyl (OH) group makes polyvinyl alcohol polar. Non-polar materials are better barriers to polar molecules including water.[2]

Extrusion methods, cast and blown, and the parameters therein will affect WVTR values. Cast films are cooled more rapidly than blown films, the latter providing more time for development of larger and more random crystals, yielding lower WVTR's (improved water barrier properties). Looking to both processes, increasing biaxial orientation through higher blow-up rates (BUR) and lower drawdown rates (DDR) which also results in improved moisture barrier properties.[3] WVTR can also be effected by processing parameters including die gap and frostline height, as well as resin properties such as density, molecular weight distribution, and melt index.

WVTR can be reduced dramatically through metallization, coating a flexible film with a vaporized metal. While typically aluminum and silicon, other coating metals have included tin, copper, nickel, zinc, silver, and gold. While barrier effect can be improved by increasing the amount of metal applied, there is potential for cracking and/or melting of the film during coating. Conversely, very thin coatings can be susceptible to pinholes.[4]

Material	Magnitude of Water Vaper Barrier Improvement With Metallization
Polyester	98.5%
PVdC Copolymer-Coated Polyester	95.5%
Cast Polypropylene	93.4%
Biaxially Oriented Polypropylene	75.0%
Low Density Polyethylene	95.3%

Source: From Robertson, G., Food Packaging Principles and Practice, 2nd ed., CRC Press, 2006.

When choosing a packaging film, WVTR requirements should be assessed in conjunction with OTR to provide the most appropriately balanced barrier characteristics for the product's storage/shelf-life needs.

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[1] Siracusa, Valentina. "Food Packaging Permeability Behaviour: A Report," *International Journal of Polymer Science*, Article ID 302029, 2012.

[2] Romero, Anna. "Evaluation of the change on water vapor transmission rate of different polypropylene films in contact with dLimoneme and the effect such changes have on the shelf life of confectionary products," Rochester Institute of Technology, 2002.

[3] Frey, K. "*Polyethylene & Polypropylene in Flexible Barrier Packaging*," Consumer Packaging Solutions for Barrier Performance Course, 2009.

[4] Robertson, G. *Food Packaging Principles and Practice*, 2nd Edition, CRC Press, 2006.