PACKALL

PackAlliance:
European alliance for innovation training
& collaboration towards future packaging

Linking Academy to Industry.

Training program: modules

- New materials and biomaterials
- **Eco-design & novel manufacturing processing**
- Citizen and Consumer Engagement
- Residue management and valorisation

Co-funded by the
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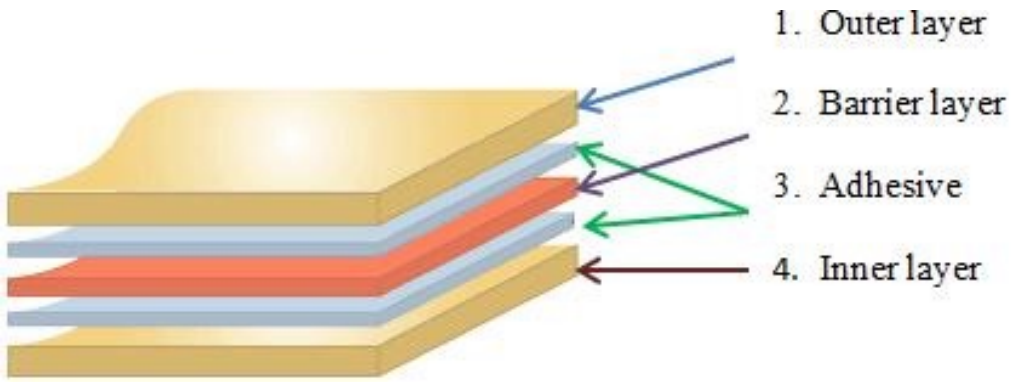
MULTILAYER FILMS

Multilayer films are produced by combining several resins with different properties to produce products with combined features that are not feasible using a single resin. Multilayer films are mainly used in food packaging, where specific resins with attributes such as

- moisture resistance
- oxygen barrier
- film for toughness
- improved heat sealability
- improved appearance



are combined to produce an **improved product at lower cost**.

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TYPICAL RESINS USED IN MULTILAYER FILMS

STRUCTURES ARE GENERATED BASED ON THE FOLLOWING REQUIREMENTS:

- Polymer in contact with food
- Oxygen and moisture barrier requirements
- Food flavor change
- Package sealing
- Transparency
- Printability on the outer surface

PC	Optical transparency, temperature resistance, surface gloss, impact, puncture resistance, high cost
PET	Puncture resistance, transparency, inexpensive high temperature resin
Polyvinylidene Chloride (PVDC)	Inexpensive, oxygen barrier, clear, tough, clings to container in use
EVOH	Oxygen barrier, clear, reasonable moisture resistance, numerous ethylene contents available, flavor retention

Polymer	Attributes
LDPE	Processability, transparency, moisture resistance, low cost, readily available, numerous types, weldable
LLDPE	Readily available, inexpensive, transparency, strength, weldable
HDPE	Strength, rigidity, toughness, large number of flow grades, higher processing temperature than LDPE
EVA	Puncture resistance, weldable, use as a tie layer, good adhesion to PP
Ionomer	Puncture resistance, weldable, good adhesion to polymide
PP	High stiffness, wide processing window, many grades, tough, readily available, good moisture resistance
Polyamide	Flavor and aroma barrier, good chemical resistance, higher temperature

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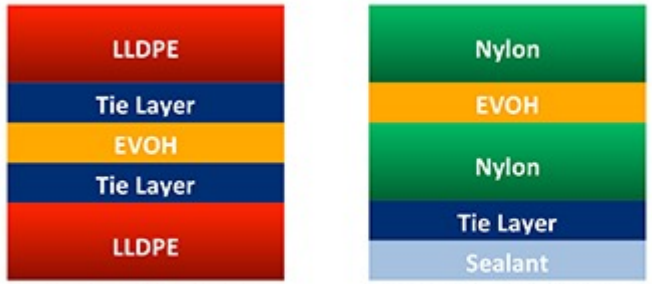
RESIN COMPATIBILITY

Since some of the resins systems that provide the unique properties are not compatible, **tie layers** or **adhesive layers** between non-compatible resins are necessary to tie the structures together.

Material	LDPE	LLDPE	HDPE	Ionomer	EVA	PP	PA6	PET	PC	EVOH	PS
LDPE	GA										
LLDPE	GA	GA									
HDPE	GA	GA	GA								
Ionomer	V	V	V	GA							
EVA	GA	GA	GA	TL	GA						
PP	TL	TL	TL	TL	GA	GA					
PA 6	TL	TL	TL	TL	TL	TL	GA				
PET	TL	TL	TL	TL	TL	TL	TL	GA			
PC	TL	TL	TL		TL	TLTL	TL	TL	GA		
EVOH	TL	TL	TL	TL	TL	TL	GA	TL	TL	GA	
PS	TL	TL	TL	V	TL	TL	TL	TL	TL	TL	GA

In general, polar resins adhere to polar resins and nonpolar resins adhere to nonpolar resins.

GA = Good Adhesion
TL = Need for Tie Layer or Adhesive to Provide Bonding
V = Variable Adhesion Depends on Resin Type



MATERIALS USED AS TIE LAYERS INCLUDE:

- ✓ EVA, Anhydride modified EVA, Acid acrylate modified EVA
- ✓ Maleic anhydride modified LDPE (or HDPE, LLDPE, PP)
- ✓ Acid modified ethylene acrylate
- ✓ Maleic anhydride modified ethylene acrylate
- ✓ Ethylene methyl acrylate
- ✓ Ethylene ethyl acrylate

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ADHESION BETWEEN THE RESINS AND TIE LAYER

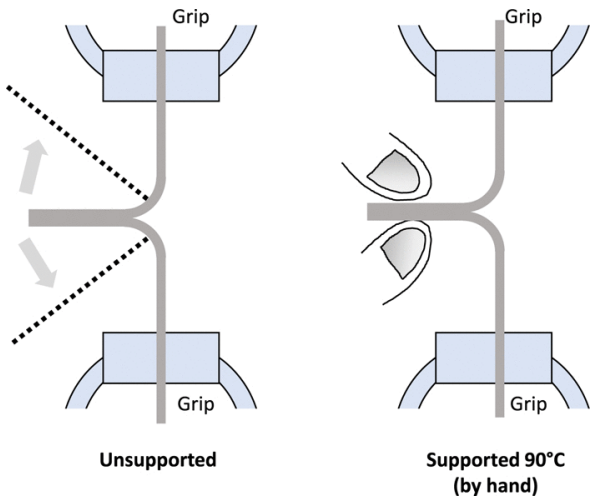
ADHESION BETWEEN THE RESINS AND THE TIE LAYER CAN OCCUR THROUGH:

- molecular chain entanglement in the melt phase,
- co-crystallization,
- covalent bond or hydrogen bond,
- Van der Waal forces or dipole-dipole interaction

IN COEXTRUSION PROCESSES, THE ADHESION LEVEL IS AFFECTED BY:

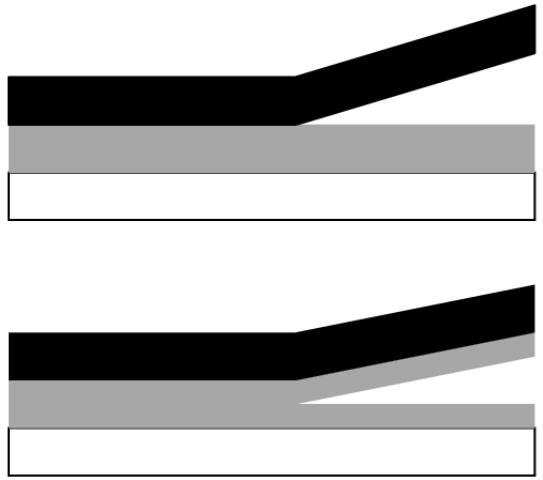
- Tie layer thickness
- Increased functionality in the tie layer
- Melt temperature
- Contact time

The strength of the adhesive bond between different layers in a multilayer structure is measured using a **T-peel test.** The strength required to pull the layers apart using a universal stress-strain tester is measured. Two different tie layer failure mechanisms are **adhesive failure** and **cohesive failure**.



Unsupported

Supported 90°C (by hand)



ADHESIVE FAILURE

COHESIVE FAILURE

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BARRIER RESINS

Oxygen Transmission Rates at 0% Relative Humidity

Material	5°C[1]	23°C[1]	35°C[1]	50°C[1]
EVOH – 27% ethylene	0.022	0.095	0.231	0.637
EVOH – 38% ethylene	0.090	0.395	0.946	2.600
EVOH – 48% ethylene	1.034	1.800	2.700	6.110
PVDC[3] – Saran MA	0.093	1.240	4.464	19.80
AN[4] – Barrex 210	2.325	12.40	31.00	95.00
MXD6 nylon	0.670	2.325	4.430	14.26
Oriented PA6	7.590	25.59	51.15	
Non-Oriented PA6	22.30	78.74	154.9	
Oriented PET	10.23	35.64	79.04	260.0
HDPE		2325	4448	
LDPE		8586	11547	
Oriented PP		2526	3146	
PS		4030		

1. Units = cc. 25µ/m2 * 24hr * atm

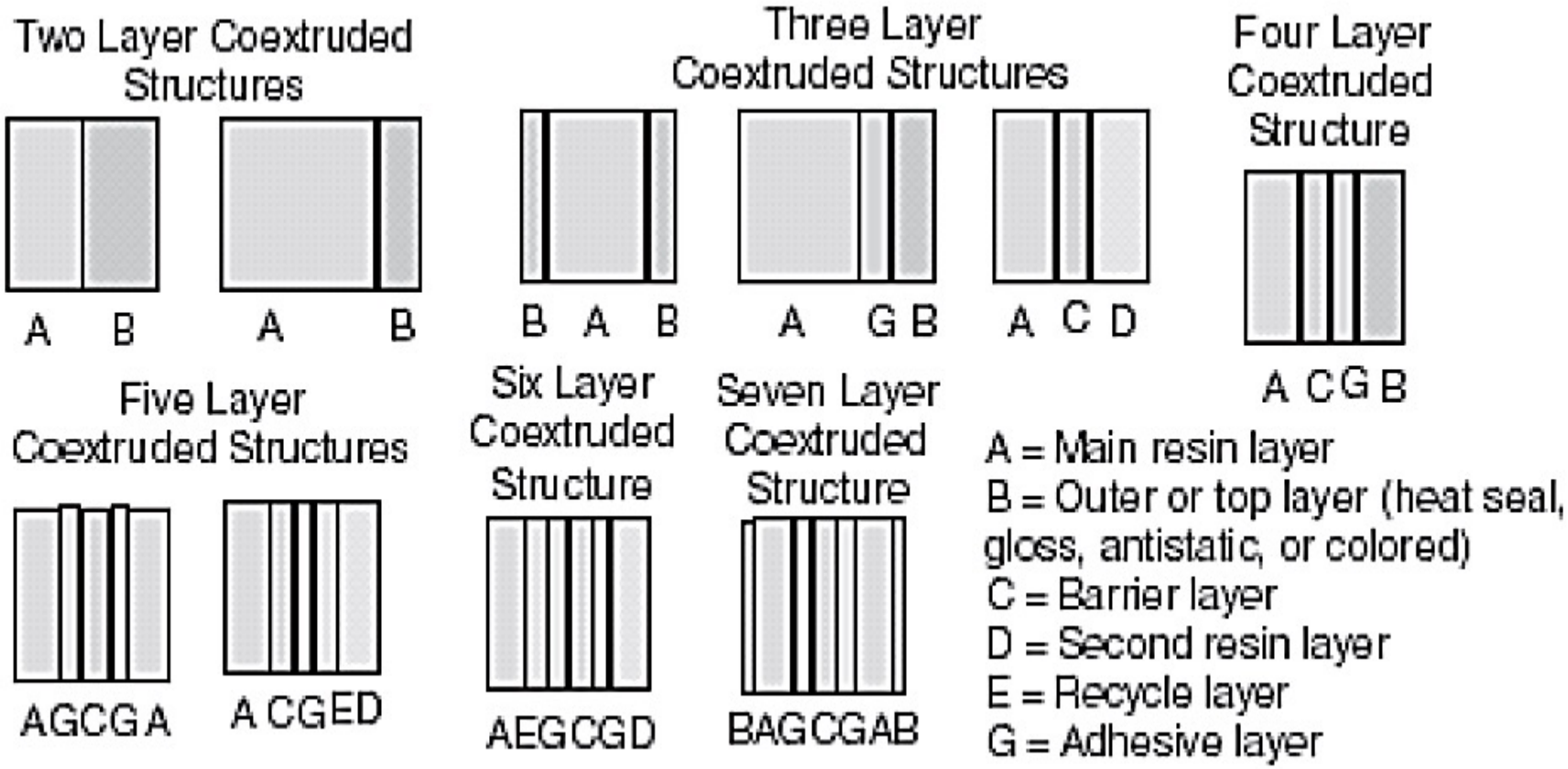
Water Vapour Transmission Rates

Material	g 25µ/m²/24 hrs
BOPP[1]	5.9
HDPE	5.9
PP	10.7
LDPE	17.7
PET	20.2
UPVC[2]	46.5
PS	131.8
PC	170.5
EVOH 38% ethylene	32.6
PVDC	3.4
AN – Barex®[3]	94.6
MXD6 nylon	50

Barrier resins are normally incorporated in the middle of packaging film structures to provide resistance to oxygen (O_2), moisture (H_2O), carbon dioxide (CO_2), or nitrogen (N_2) penetration from outside the package to the inside or inside the package out.

- ✓ Oxygen penetrating food packaging from the outside can cause food to spoil, degrade, lose flavor, and in some instances change color.
- ✓ Permeation of gases from inside packaging structures to the outside can allow carbonated soft drinks to go flat
- ✓ High moisture vapor transmission rates can cause ingredients in a package to dry out or, conversely, allow the ingredients to pick up moisture and become soggy.

POTENTIAL MULTILAYER STRUCTURES



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