



HDPE Barrier Extrusion Coating & Lamination for Flexible Packaging Structures

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Presentation Agenda

- Background
- Market/Applications
- Initial Findings
- Experiment
- Results
- Conclusions



Background

- Current Market: Foils/metallized films and HDPE extrusion coatings
- Barrier Films:
 - Polymer properties: MWD, MI, density, crystallinity & orientation, polydispersity
 - Processing: temperature, shear rate, residence time, gauge
- Proposition: Extrusion coat various HDPE based structures to gain the following benefits:
 - Reduced use of foils & metallized films
 - Weight and energy savings
 - Decrease processing steps
 - Improved WVTR & OTR compared to LD extrusion coated films



Extrusion Lamination Market/Applications

- Flexible Packaging
 - Snack wraps (chips, peanuts)
 - Dry food goods (instant potatoes, hot chocolate)
- Paper/Paper Board Packaging
 - Folding cartons (frozen foods, bulk packaging)
 - Liquid cartons (orange juice)



Initial Findings*

- Initial Study: Extrusion lamination of high barrier HDPE films to provide comparable WVTR
- Initial Results:
 - Lamination of a monolayer HDPE film provides comparable moisture barrier to industry standard
 - Optimization of laminating film can balance WVTR, OTR and sealing characteristics

**Please Reference "HDPE Barrier Extrusion Lamination for Flexible Packaging" given at TAPPI FlexPack PLACE Conference 2022*

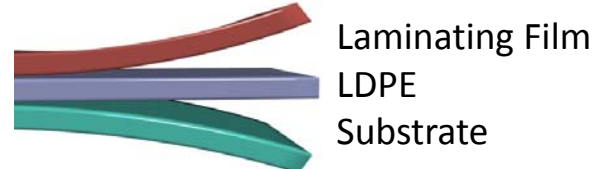


Extrusion Coating Structures

- Current Structures



- Initial Study: lamination of blown films



- Current Study: Extrusion coating of barrier layer





Experiment

- Experimental Outline:
 - Vary processing conditions while extrusion coating a HDPE structure to monitor changes in WVTR
 - Compare to laminated structure from initial study
- Processing Conditions:
 - 615°C Melt temperature
 - 500 ft/min line speed



Experiment

- Variables Altered:
 - HDPE
 -  HD1 H6012: 12 g/10min, 0.960 g/cc
 -  HD2 M6080: 7.9 g/10min, 0.960 g/cc
 - Resonance time (air gap)
 - 7 inch
 - 11 inch
 - Amount of Shear/Decreased Drawdown (die gap)
 - 20 mil
 - 30 mil
- Consistent Variables:
 - LDPE skins
 - NA217: 5.6 g/10min, 0.923 g/cc
 - Nucleated HDPE
 - Polyester film substrate
 - 2 mil thickness (~28 lb/ream)



Samples – 30 mil die gap

7 in air gap, 30 mil die, 30% core			
Thickness (mil)	0.7	0.6	0.7
Sample 1	LDPE	HD1	LDPE
Sample 3	LDPE	HD2	LDPE

11 in air gap, 30 mil die, 30% core			
Thickness (mil)	0.7	0.6	0.7
Sample 2	LDPE	HD1	LDPE
Sample 4	LDPE	HD2	LDPE

7 in air gap, 30 mil die, 50% core			
Thickness (mil)	0.5	1.0	0.5
Sample 5	LDPE	HD1	LDPE
Sample 7	LDPE	HD2	LDPE

11 in air gap, 30 mil die, 50% core			
Thickness (mil)	0.5	1.0	0.5
Sample 6	LDPE	HD1	LDPE
Sample 8	LDPE	HD2	LDPE



Samples – 20 mil die gap

7 in air gap, 20 mil die, 30% core

Thickness (mil)	0.7	0.6	0.7
Sample 11	LDPE	HD1	LDPE
Sample 13	LDPE	HD2	LDPE

7 in air gap, 20 mil die, 50% core

Thickness (mil)	0.5	1.0	0.5
Sample 15	LDPE	HD1	LDPE
Sample 17	LDPE	HD2	LDPE

11 in air gap, 20 mil die, 30% core

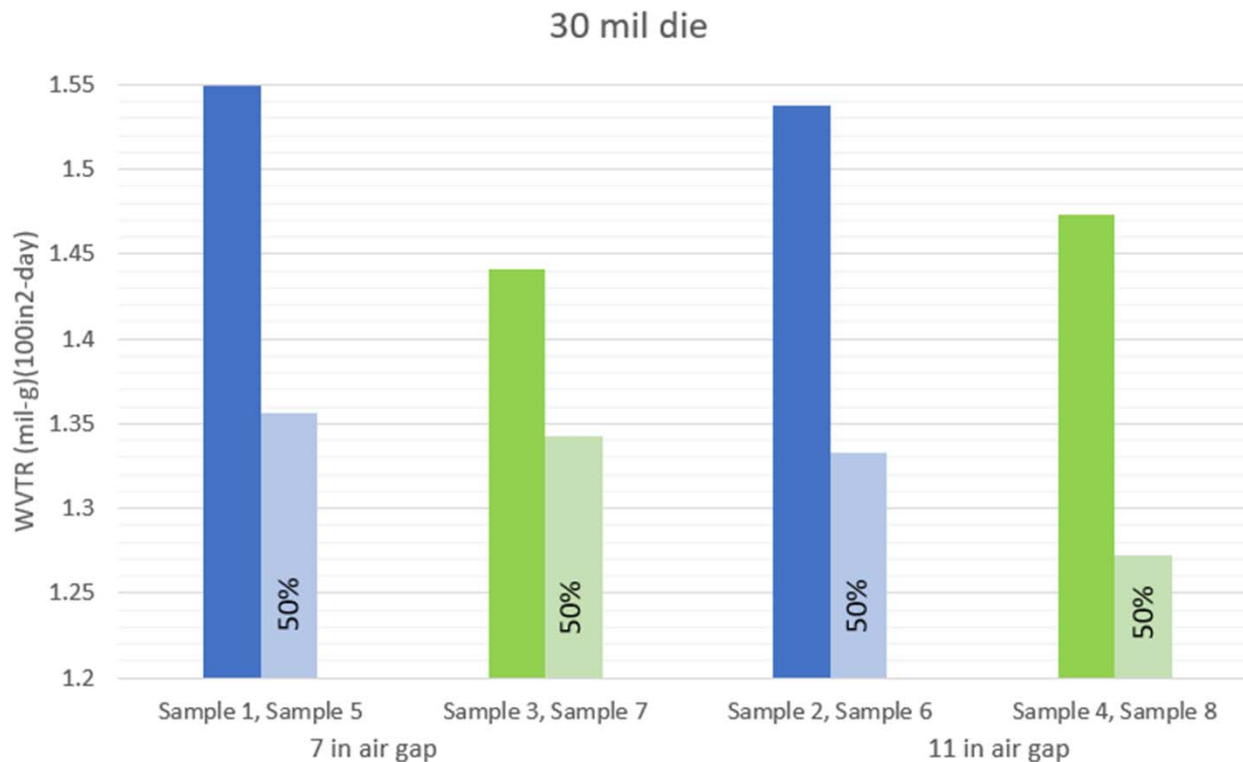
Thickness (mil)	0.7	0.6	0.7
Sample 12	LDPE	HD1	LDPE
Sample 14	LDPE	HD2	LDPE

11 in air gap, 20 mil die, 50% core

Thickness (mil)	0.5	1.0	0.5
Sample 16	LDPE	HD1	LDPE
Sample 18	LDPE	HD2	LDPE



Results – WVTR, 30 mil die



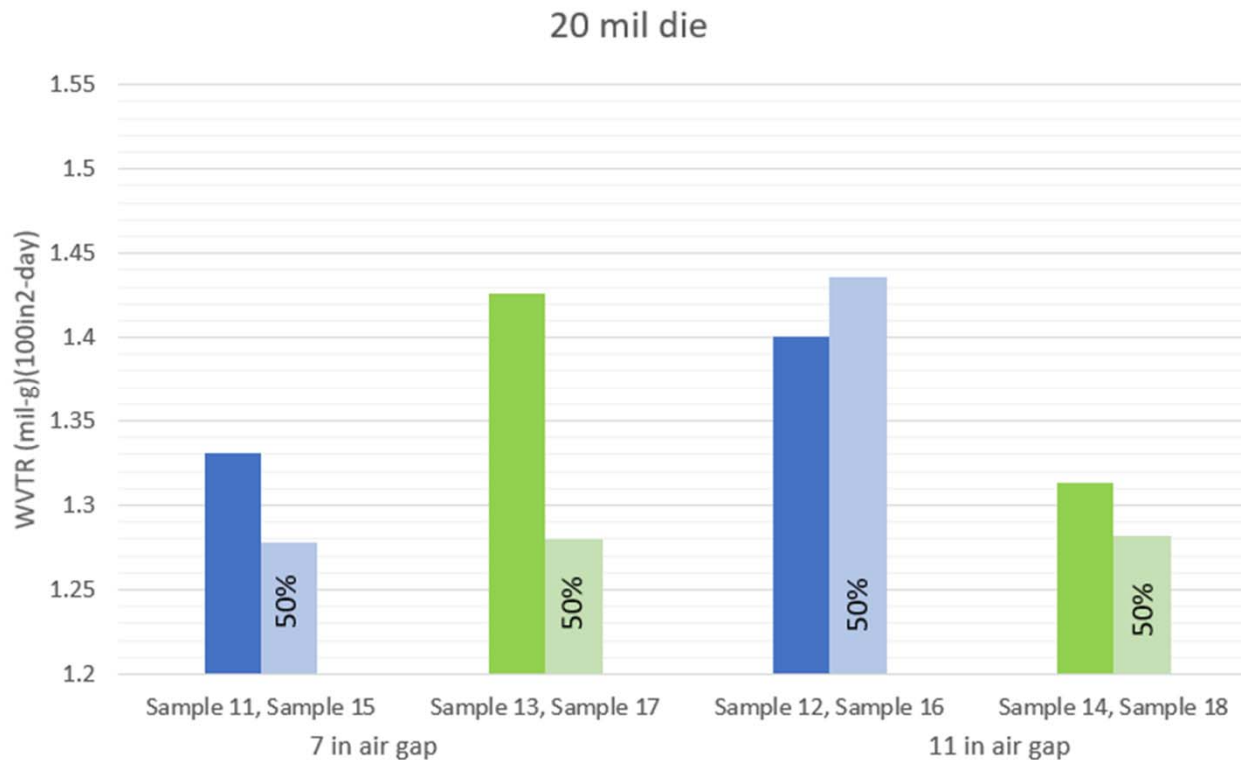
- HD2 gave consistently improved moisture barrier over HD1
- Increasing the HD core percentage significantly improved the moisture barrier as well
- Overall, raising the air gap and increasing the resonance time allowed for some improvement in WVTR

• *Note: WVTR values are normalized to one mil*





Results – WVTR, 20 mil die



- HD2 gave consistently improved moisture barrier over HD1
- Increasing the HD core percentage significantly improved the moisture barrier as well
- Raising the air gap did not have as big of an impact as the tighter die gap (50% core)

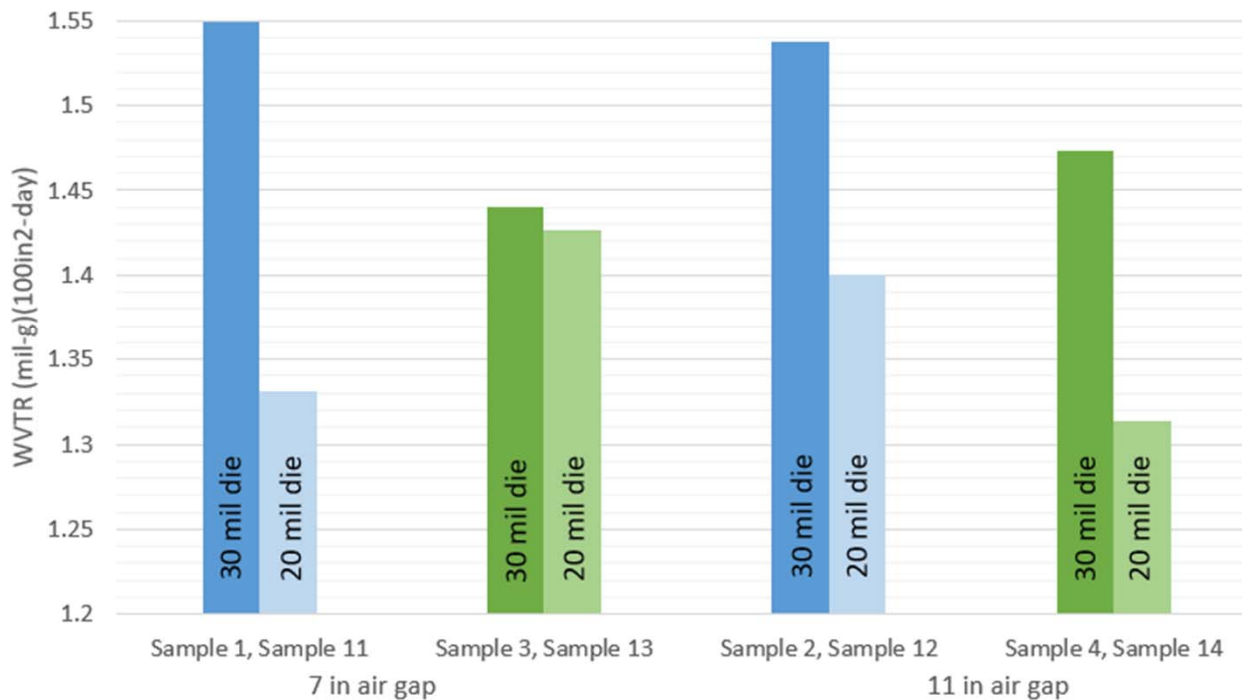
• Note: WVTR values are normalized to one mil

HD1
HD2



Results – WVTR

30% HDPE Core



- Tightening the die, or increasing the shear rate applied to the polymer, assisted in improving the overall moisture barrier

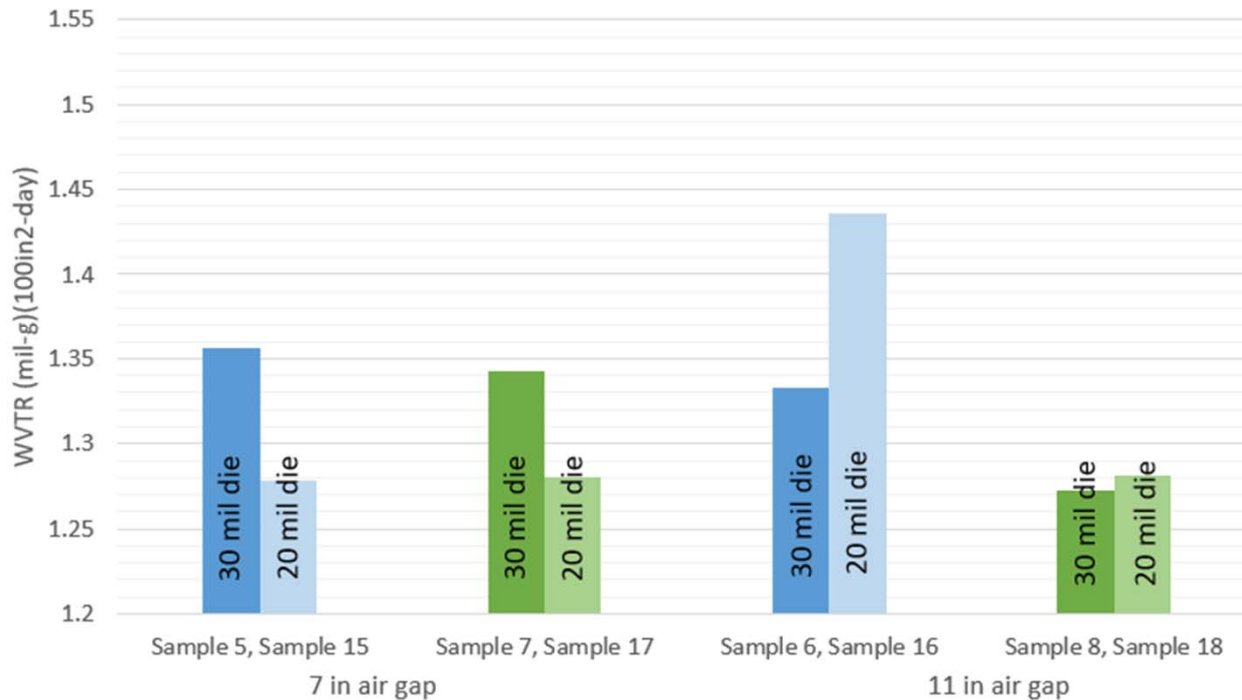
• Note: WVTR values are normalized to one mil





Results – WVTR

50% HDPE Core



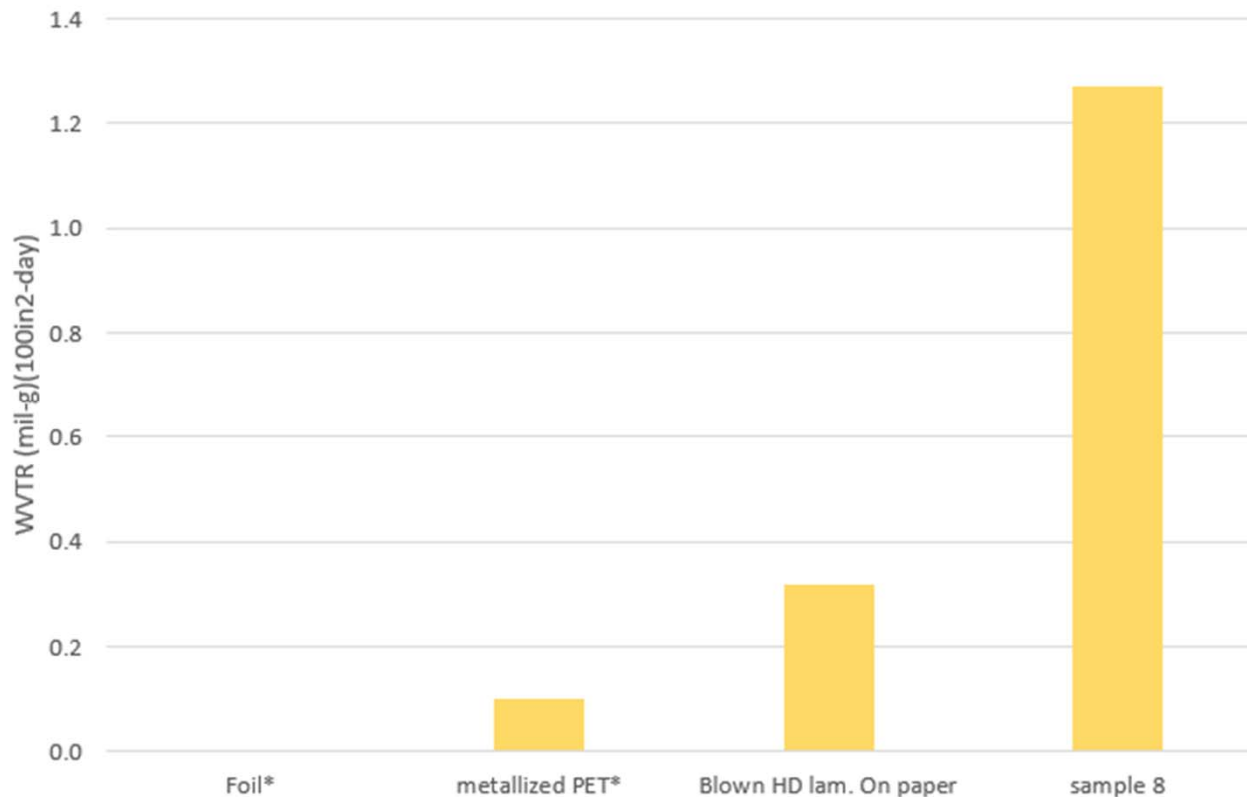
- Tightening the die, or increasing the shear rate applied to the polymer, assisted in improving the overall moisture barrier
- *Two outliers – further investigation needed*

• *Note: WVTR values are normalized to one mil*





Results – WVTR: Laminated vs. Ext. Coated



- Lamination still gives the best comparative barrier performance to foils and metallized films

- *Note: WVTR values are normalized to one mil*
- **Industry standard barrier values*



Conclusions

- Lowering the MI of the HD core consistently gave improved barrier
- Increasing the amount of HD (core layer percentage) also improved the barrier
- Increasing the resonance time of the molten curtain assisted in improving the moisture barrier but not as much at tighter die gaps
- Increasing shear rate applied to the polymer resulted in better WVTR
- Lamination still gives the best comparative barrier performance to foils and metallized films, but there is more work to be done
- Next steps:
 - Alternative WVTR/OTR resins geared towards extrusion coating
 - Other properties to fine tune that could affect barrier while still in the realm of processability
- Continuing Goal: Discover potential ways to reduce the use of foil & metallized films for more sustainable packaging

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Questions?





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Thank You

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