

Enhanced Bimodal PE makes the impossible possible

Steven Sheu

Borouge Pte Ltd.

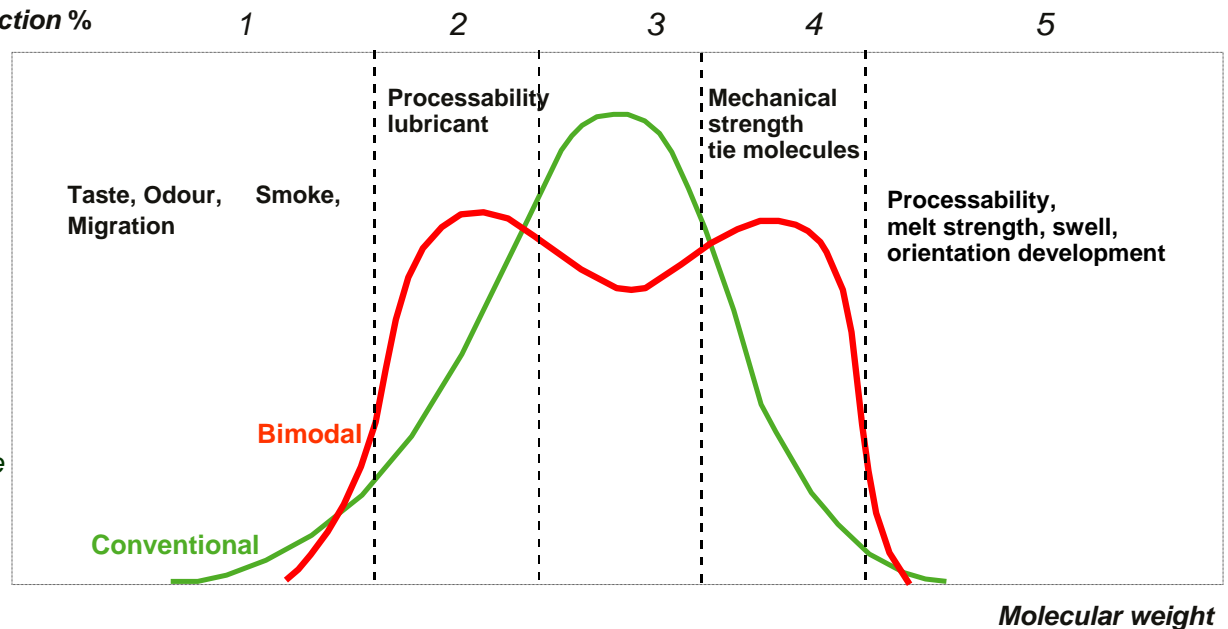
Oct. 2006, Shanghai



SHAPING *the* FUTURE *with* PLASTICS

Borstar Technology

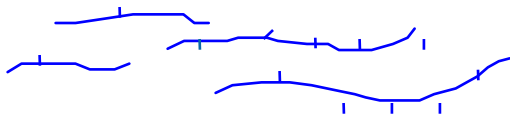
- Dual reactor, bimodal process
- Broad molecular weight distribution
 - *Combines good processability and good mechanical strength*
- Tailored comonomer addition
 - *Low taste & odour*
 - *Improved low temperature properties*
- Wide range of MFR and densities achievable



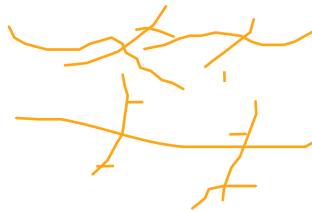
1. To be avoided
2. Necessary to bring down pro-cessing forces (extrusion) and to protect fraction (4) from being degraded. To avoid melt fracture (poor surface properties). This fraction is, however, mechanically weak and has to be reinforced by (4).
4. Necessary to get high enough tie chain concentrations for toughness and strength.
5. Impact melt strength and modify rheological behaviour of the polymer melt.

What is Different?

Enhanced Bimodal PE



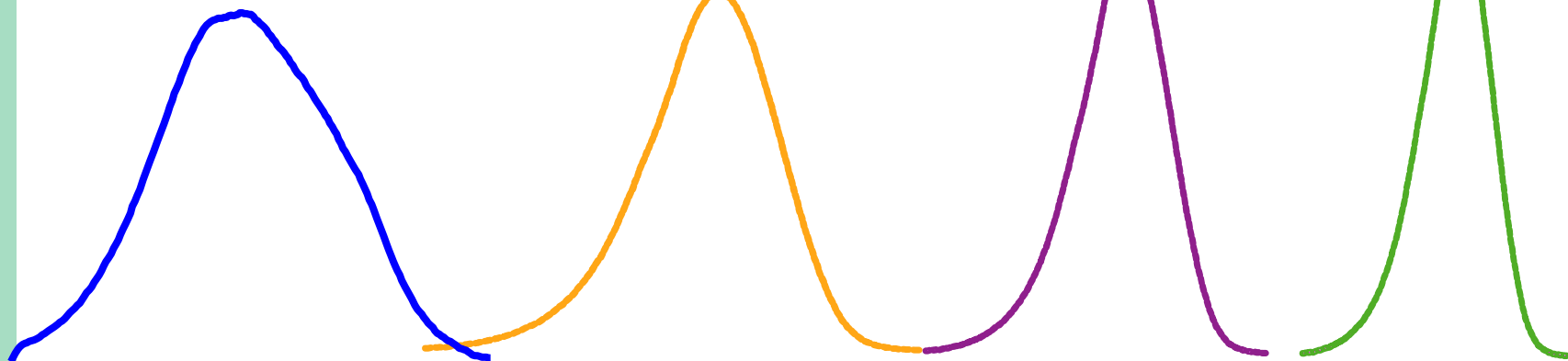
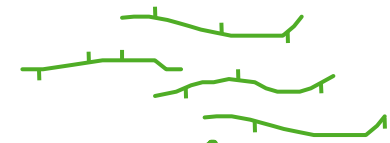
LDPE



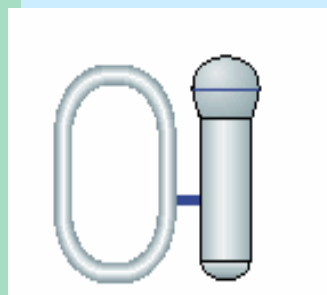
LLDPE



m-LLDPE

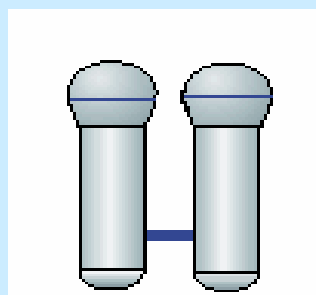


Bimodal PE Process Technologies



**Loop - GP
solution**
* **Borstar**

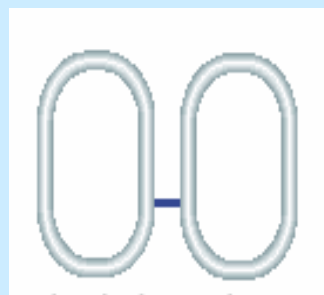
- whole density range accessible
- short transition times



GP - GP

- * **Unipol II**
- * **Evolve**
- * **Spherilene**

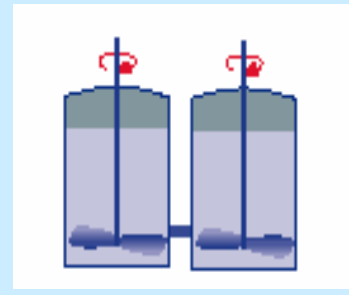
- whole density range accessible
- long transition times



Double slurry loop

- * **Atofina**
- * **Solvay**
- * **Showa Denko**

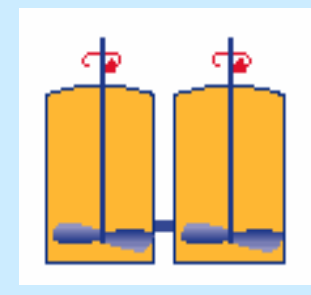
- no LLDPE
- Limited product design possibilities



Dual/triple slurry tank

- * **Hostalen**
- * **Mitsui CX**
- * **Equistar-Maruzen** (Nissan)
- * **JPE** (Nippon)

- no LLDPE
- higher costs
- outdated technology



Dual/triple

- * **Dowlex**
- * **Adv. Sclairtech**
- * **Equistar**
(= old DuPont)

- no high MW products
- higher costs



101 Enhanced Bimodal PE applications

Air filled bags, Aprons, Asparagus, Bag liners, Bag-in-box liners, Bag-on-the roll, Banana interleaving, Barrier films, Big bag liners, Bin liners, Boil-in-bags, Box liner, Boutique carriers, Bread bags, Bun wrap, Bundle wrap, Canal liners, Car protection films, Car seat covers, Carcass bags, Card box liner, Carrier bags, Cereal box liners, Chemical drum liner, Cheese packs, Chicken bag, Cocoa powder liner, Coffee packaging, Coin bags, Collation shrink film, Compost bags, Compression packaging, Cosmetic tubes, Courier envelopes, Cream liners, Cross laminated films, Detergent bags, Detonation cord, Diaper packs, Disposable gloves, Drum liners, Dry food packaging, Edible oil pouches, Electronic packaging, Explosive bags, Fabric softener pouches, Fashion carriers, Fertilizer bags, FFS shipping sacks, Fluming tapes, Food grain covers, Frozen meat and fish liners, Frozen food film, Fruit tree covers, Garbage Bags, Geo-membranes, Grape covers, Green houses, Heavy Duty Shipping Sacks, Hospital bags, Household freezer bags, IBC liners, Ice bags, Industrial liners, Insulation packs, Interleaving film, Irrigation liners, Irrigation tubes, Juice packs, Lamination films, Laminated tubes, Land fill liners, Lid film, Liquid detergent bags, Loose tea bags, Magazine wrap, Marking tapes, Masking film, Meat packaging, Milk pouches, Mining film, Mozzarella packs, Mulching film, Nursery bags, Oil pouches, Palm oil liners, Paper bag liners, Pet food bags, Pistachios pouch, Planter bags, Pond liners, Potting mix packs, Pouches, Protection film, Refuse bags, Resin sacks, Rice bags, Rubbish bags, Sack packaging, Sack liners, Salt bags, Sandwich bags, Security bags, Shopping bags, Shrink films, Soap sachets, Spay guards, Spiral liners, Stand-up pouches, Sugar pouches, Swing bin liners, Tarpaulins, Textile liners, Thin wall tubes, Timber wrap, Toilet paper packs, Tooth paste tubes, Tyre thread wrapping, Valve sacks, Water pouches, Wheat flour bags, Woven bags,



What is impossible?

- It is difficult to make commercial LLDPE film products in existing film production machines, without any major restrictions or modifications.
In one moment produce >250 micron film product and in the next make 15 micron film products!



It is possible!

- With the use of Enhanced PE from Borouge
 - ★ FB2230
 - ★ FB2310



Enhanced PE has unique properties that makes it possible

- ... to downgauge 20 to 30% or more and still maintain or improve mechanical properties compared with traditional LDPE and LDPE/ LLDPE blends.
- ... for our customers to improve their profit by simplifying the production, reduce logistic costs and improve production regularity.
- ... with Enhanced PE products to produce most film applications with existing production equipment.

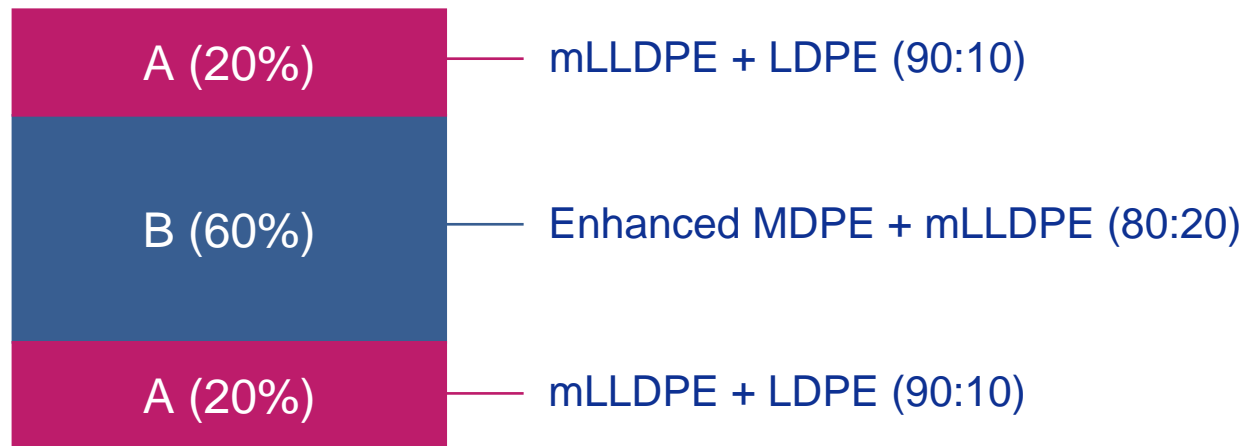


What is impossible?

- It is difficult to produce a wide range of high quality films with high clarity and excellent mechanical properties films in conventional blown film lines.

It is possible!

- by use of Enhanced MDPE in the core layer and mLLDPE + LDPE in the skin layers.



*Haze = 6,7% *Gloss = >100 *Dart drop = 200 g * MD- tear = 1,6 N *1% Sec. Modulus = 310 MPa * Hot-tack = 3,4 N



What is impossible?

- ... to make a FFS shipping sack with balanced properties, like film stiffness, creep resistance, excellent heat sealing, correct friction, high film impact, high fold impact and acceptable tear resistance and to be able meet all requirements by further downgauging.



It is possible !

- **With Enhanced MDPE and mLLDPE**

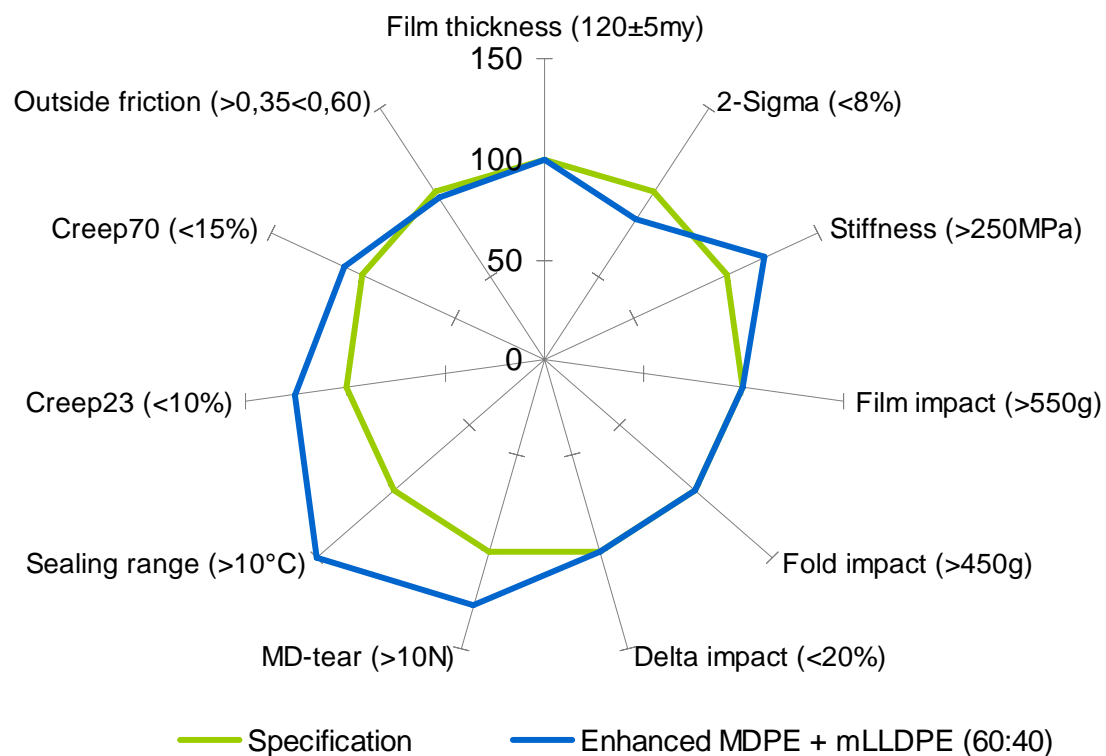
Enhanced MDPE + mLLDPE is an excellent concept combination for HDSS



Mono blend:

60% Enhanced MDPE + 40% mLLDPE

Enhanced MDPE + mLLDPE is an excellent combination for HDSS



Enhanced MDPE + mLLDPE is an excellent combination for HDSS



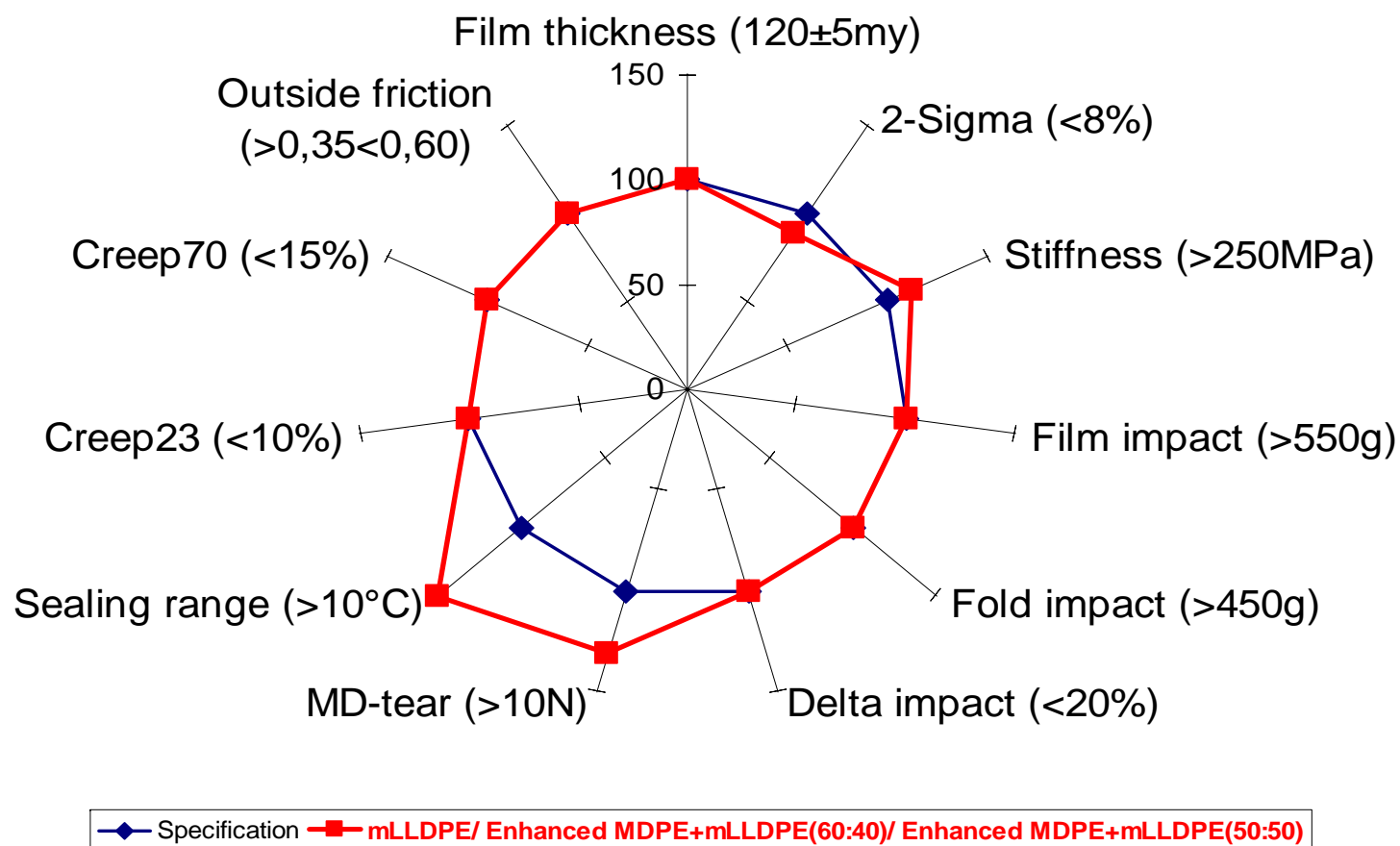
ABC/ Coex.

A: mLLDPE

B: 60% Enhanced MDPE + 40% mLLDPE

C: 50% Enhanced MDPE + 50% mLLDPE

Enhanced MDPE + mLLDPE is an excellent concept for HDSS





What is impossible?

- ... to make compression packaging films for insulation materials (rockwool and glasswool) with optimal balance in film stiffness (1% Sec modulus), creep resistance, heat sealing (Hot-tack), impact, puncture and MD- tear resistance!



It is possible!

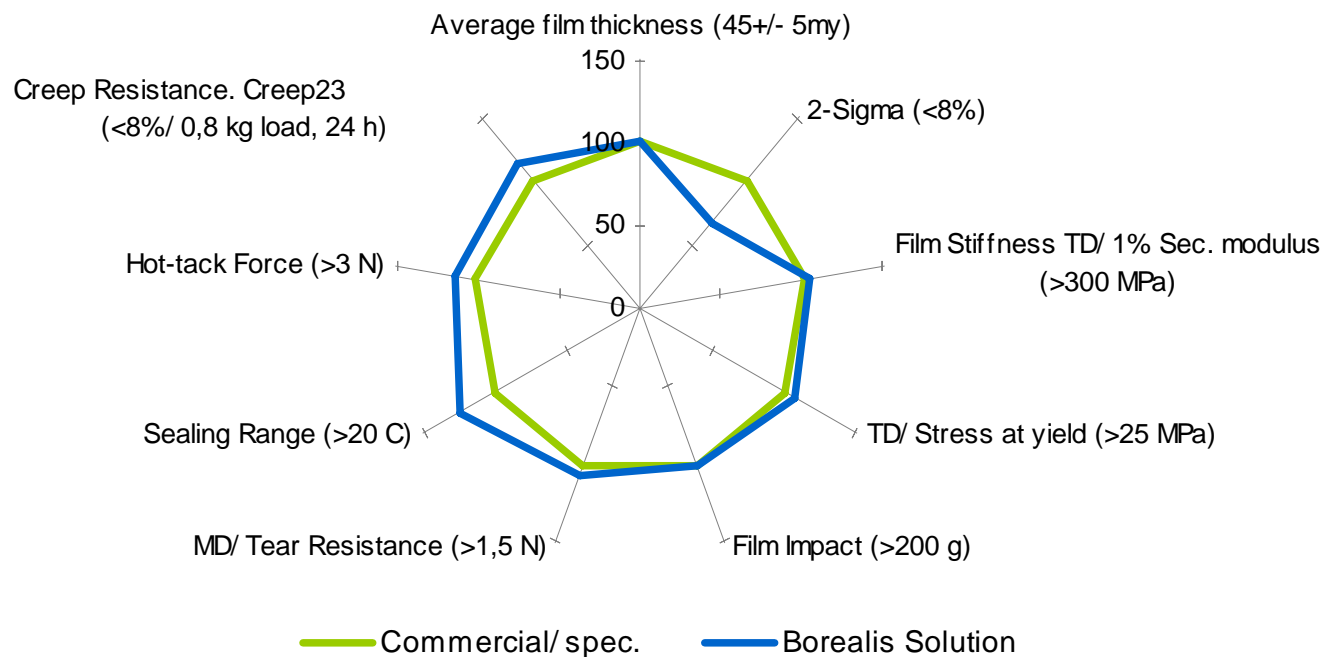
- **With Enhanced Bimodal MDPE/HDPE, mLLDPE and EBA**

Enhanced MDPE + mLLDPE and EBA a unique combination



**Coex mLLDPE / Enhanced MDPE /
EBA (MI = 0.3, BA = 3%)**

Enhanced MDPE + mLLDPE and EBA a unique combination



*Haze = 6,7% *Gloss = >100 *Dart drop = 200 g * MD- tear = 1,6 N *1% Sec. Modulus = 310 MPa * Hot-tack = 3,4 N

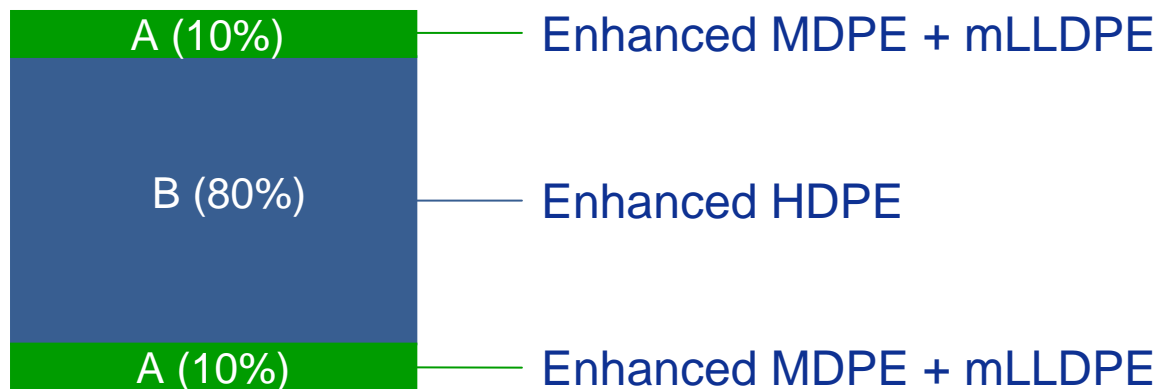


What is impossible?

- It is difficult to produce moisture barrier Polyethylene film with balanced properties like film stiffness, moisture barrier, heat sealing, film impact, fold impact, MD- tear resistance and friction and to substitute PE/Al – laminates for FFS packaging of moisture sensitive materials.

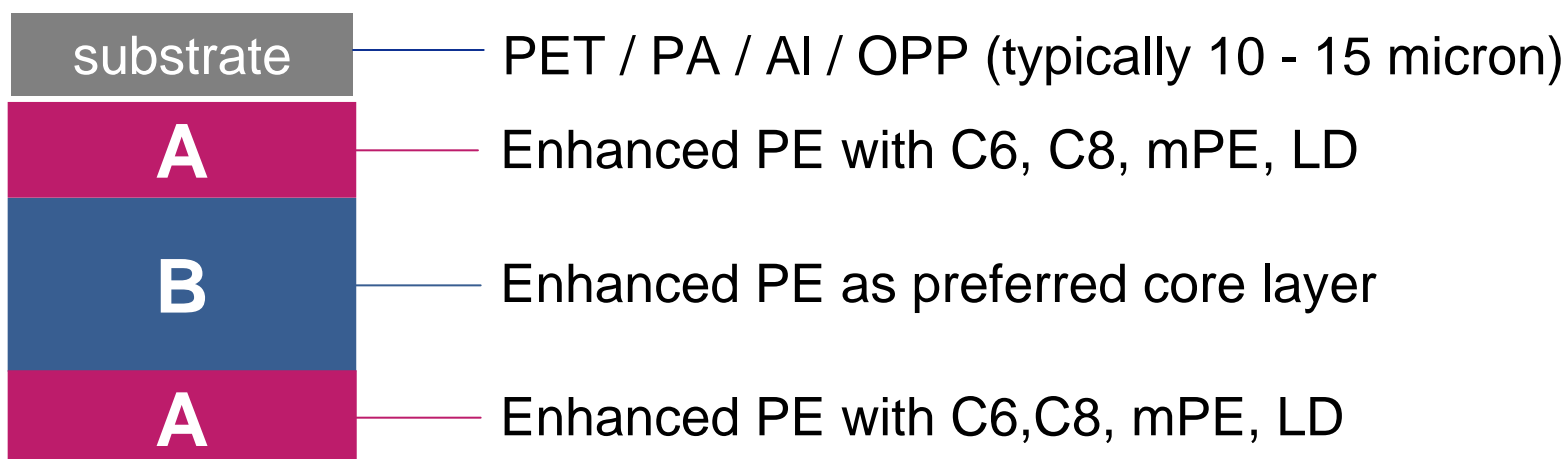
It is possible !

- ... this Enhanced PE combination will meet the requirements for moisture barrier $< 0,8 \text{ g H}_2\text{O/ m}^2, 24\text{h}, 38^\circ\text{C}, 90\% \text{ RH}$.



250 my FFS film

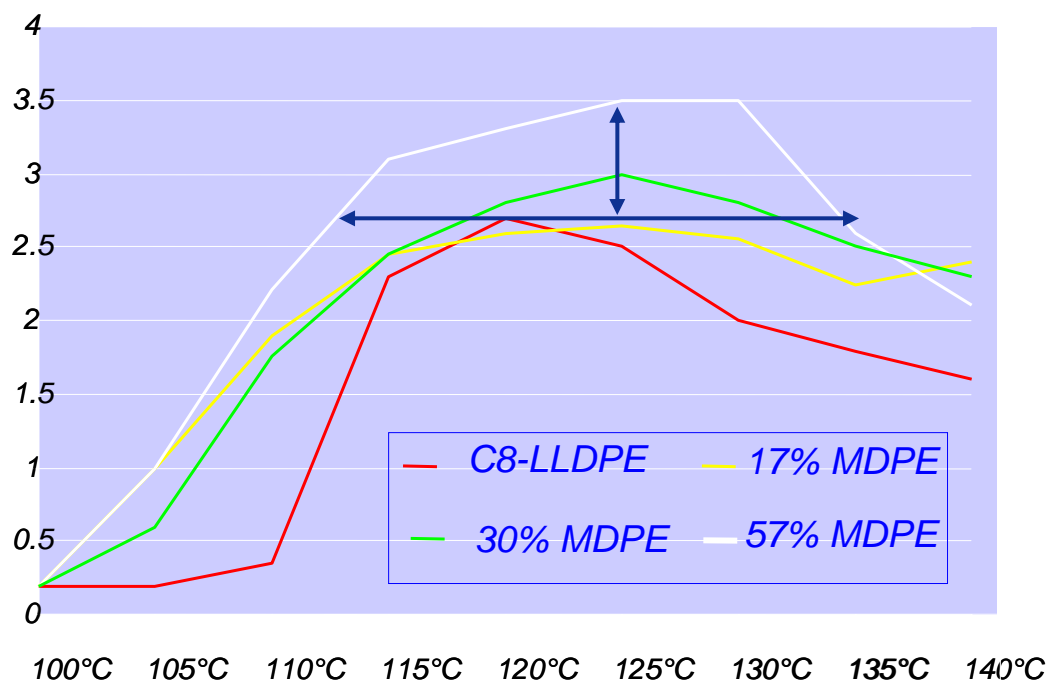
Enhanced PE as main component in 3 layer coextruded lamination film



- Enhanced PE backbone for strength and stiffness with tailored surface layers to fit requirements
- High clarity and Gloss achievable in coextrusion
- Extrusion of mPE rich films with excellent bubble stability
- Lower seal initiation temperatures & high strength sealing
- Outstanding mechanical properties
- Stiffness (for FFS packaging and stand up pouches)

Enhanced MDPE brings sealing advantages

- All Films in chart (right)
 - Same sealing layer composition of C8/LDPE
 - Variable content of FB2310 in other layers
- With higher % Enhanced MDPE:
 - Broader sealing window
 - Higher hot tack force
 - Seal strength.
 - Faster conversion with no seal breaks
 - Low gel count to avoid seal leakage
- Cost reduction through less usage of expensive sealing materials
 - Enhanced MDPE enhances properties of other thin heat seal layers eg C8, mPE



Due to Enhanced MDPE melt strength – supports sealing layer and avoids deformation

Enhanced MDPE total content

Hot tack strength, N @ 125 deg C

Sealing “window” at 2.5 N, °C

0%	17%	30%	57%
2.5	2.7	3.0	3.5
118-125	115-130	115-135	110-135

Performance

Productivity

Versatility

SHAPING the FUTURE with PLASTICS

Coextruded Collation Shrink Films

- **Film thickness = 40 - 45 μ**
- **Film structure**
 - Outer layer = LDPE (0.8MI)
 - Core layer = Enhanced MDPE
 - Inner layer = LDPE (0.8MI)
- Thickness Ratio = 1:2:1
- **Functional Requirement**
 - Good collation and holding force
 - Good film strength and stiffness
- **Why Enhanced MDPE fits**
 - Good processability
 - Good shrink properties
 - Good film strength and stiffness



A	B	C
LDPE	Enhanced MDPE	LDPE
25%	50%	25%

Typical Monolayer Shrink Films

Heinz in NZ (with bottom tray)

- **Film structure : Monolayer 40 μ m (used to be 55 μ m)**

Blend: 60% LDPE (MFR 0.3)
 30% Enhanced MDPE
 10% HDPE

Requirements

- Shrinkage MD 70%
 TD 10%
- Good Retention / High Cold Shrink Force
- Balance of strength, toughness and stiffness

- **Key advantages with Enhanced MDPE**

- Down gauging , better performance with thinner film
- Improved retention / very high cold shrink force
- Low hot shrink force, No hole burning
- Freedom to tailor the shrinkage properties with Enhanced MDPE rich blends



Enhanced PE in lamination: Pet Food Bags



- Enhanced PE Benefits
 - broader sealing range
 - higher film stiffness
 - improved mechanical properties
 - cost saving and gauge reduction without compromising package integrity
 - Stand up performance
 - Runnability on FFS machine

- Enhanced MDPE used in core layer to improve film stiffness and mechanical properties

- Typically the core layer represents 40-60% of the total film thickness

A	B	C
mPE	Enhanced MDPE	Enhanced LLDPE
LDPE		mPE
85/15%		60/40%

27

Enhanced PE in lamination: Large size detergent bags

A	B	C
Enhanced LLDPE	Enhanced MDPE	Enhanced LLDPE
mPE		mPE
75/25%		75/25%

- Increased stiffness
=> Rigidity and handling
- High ESCR
=> Shelf life and no breakage
- Toughness/seal strength
=> Less product spoilage
- Matt surface
=> Ease of conversion and filling
- Low migration and additive level
=> Low taste and odour
=> Compliance to food packaging
- Runnability FFS machine
- Drop test



Enhanced PE in lamination: Wheat Flour Packaging (10kg)

- Film Structure: PE/PET (100 μ / 12 μ)
- PE Film Structure
 - Outer layer = C8LLDPE + LDPE (90:10)
 - Core layer = Enhanced LLDPE
 - Inner layer = mLLDPE + LDPE (90:10)
 - Thickness Ratio = 1:1:1
- Requirement
 - Good impact strength
 - Excellent seal strength
 - High clarity
- Other similar applications
 - Packaging of rice
 - White cement



Enhanced PE in lamination: Salt Packaging (1kg)

- Film Structure : PE/PET (39 μ / 10 μ)
- PE Film Structure
 - Outer layer = mLLDPE + LDPE (85:15)
 - Core layer = Enhanced LLDPE
 - Inner layer = mLLDPE + LDPE (85:15)
 - Thickness Ratio = 1:1:1
- Requirement
 - Excellent seal strength
 - High clarity
- Other similar applications
 - Packaging of detergent powder

