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Blending of Cyclic Olefins in single site LLDPE (sLLDPE) for Improved Bubble Stability and Output Rates on Blown Film Extrusion Processes

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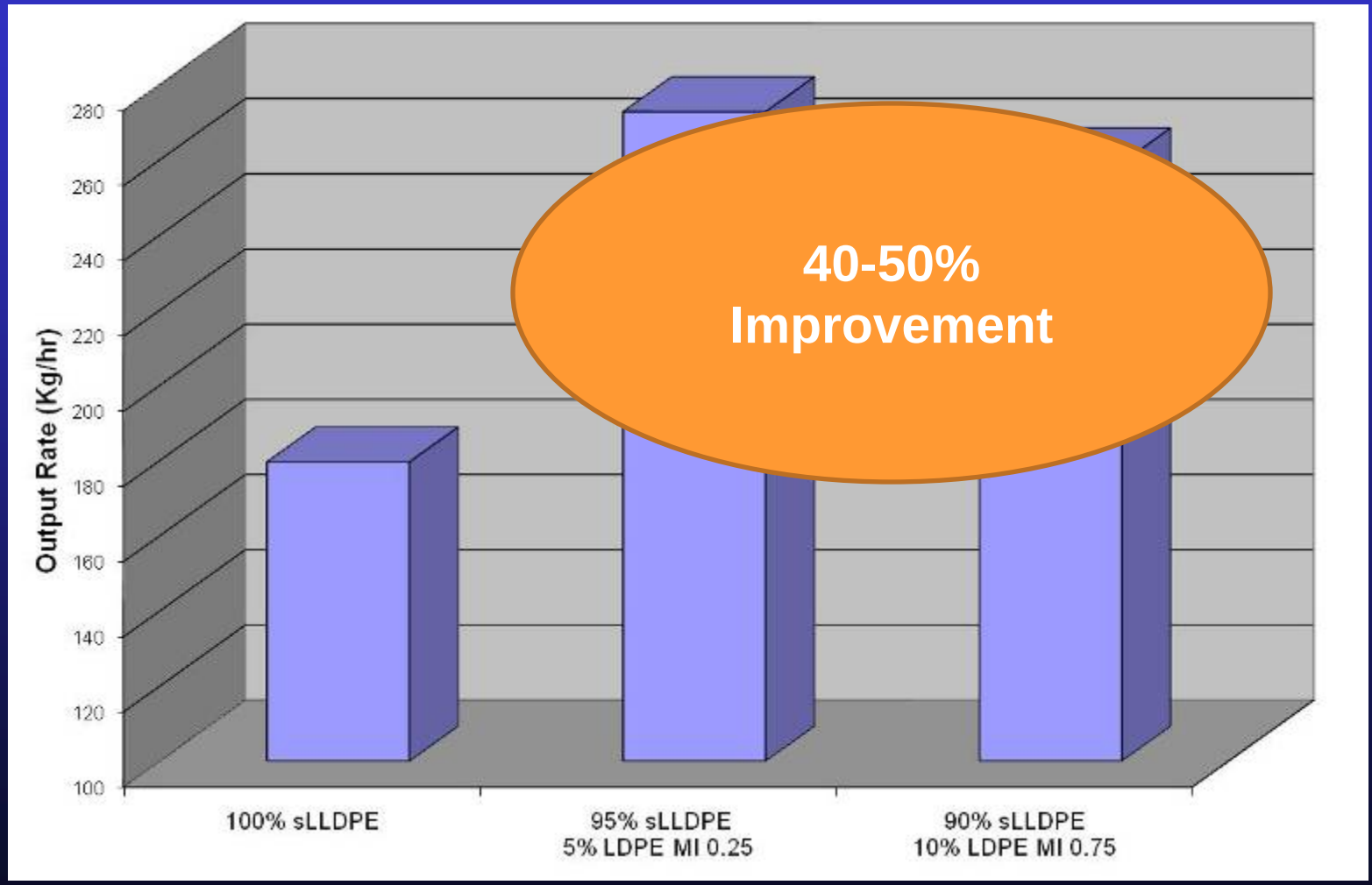
NOVA Chemicals®

TOPAS Advanced Polymers

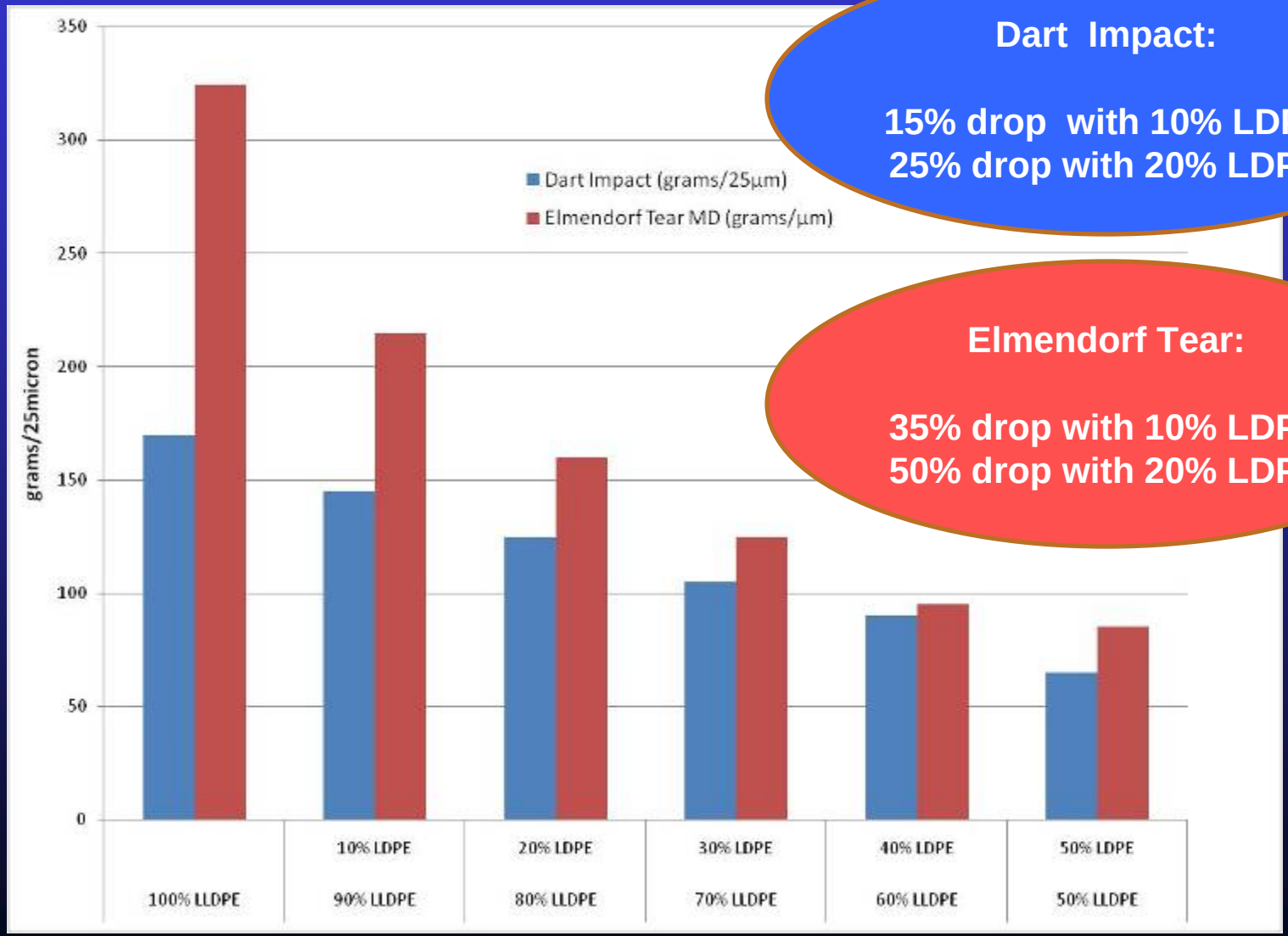
Outline

- Background
- Idea
- Materials
- Experiment - Part 1
- Experiment - Part 2
- Conclusions
- Acknowledgements

Why Blend LDPE into LLDPE or sLLDPE?



Film Toughness Properties



Dart Impact:

15% drop with 10% LDPE
25% drop with 20% LDPE

Elmendorf Tear:

35% drop with 10% LDPE
50% drop with 20% LDPE

Idea / Concept

- Cyclic olefin copolymers are utilized in polyethylene to enhance thermoforming properties

- Could COCs improve bubble stability and maximum output rate?

Materials

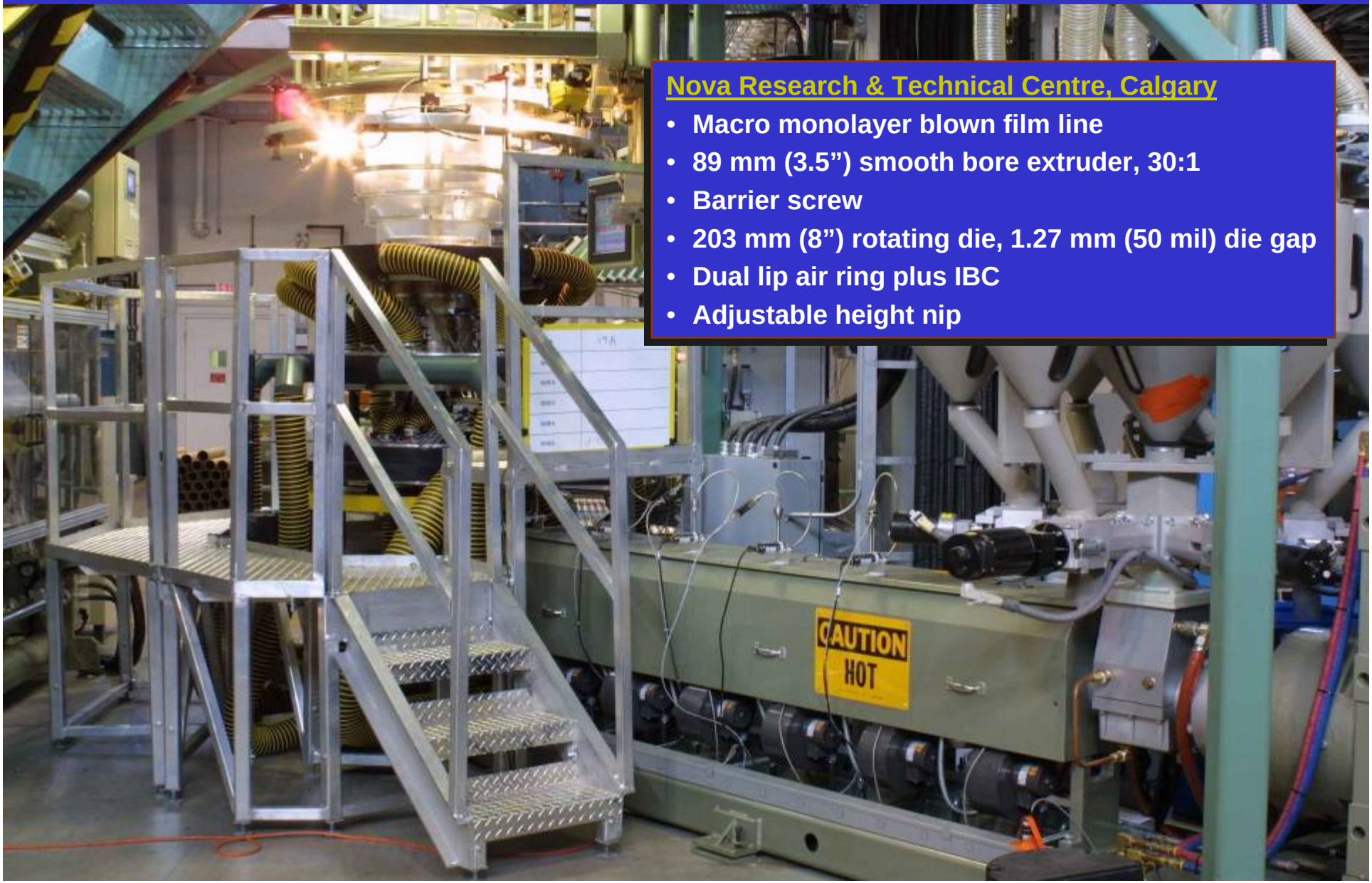
Polyethylene

	Grade	Melt Index (dg/min, 190C)	Density (g/cm^3)	Catalyst Type
sLLDPE	SURPASS® FPs117-C	1.0	0.917	SSC
LDPE-1	NOVAPOL® LF-Y819-A	0.75	0.919	-

Cyclic Olefin Copolymer

	Grade	Tg, ºC	MFI (dg/min, 230C)
COC-1	TOPAS® 5013X14	136	8
COC-2	TOPAS® 9506X5	68	5.5

Equipment



Nova Research & Technical Centre, Calgary

- Macro monolayer blown film line
- 89 mm (3.5”) smooth bore extruder, 30:1
- Barrier screw
- 203 mm (8”) rotating die, 1.27 mm (50 mil) die gap
- Dual lip air ring plus IBC
- Adjustable height nip

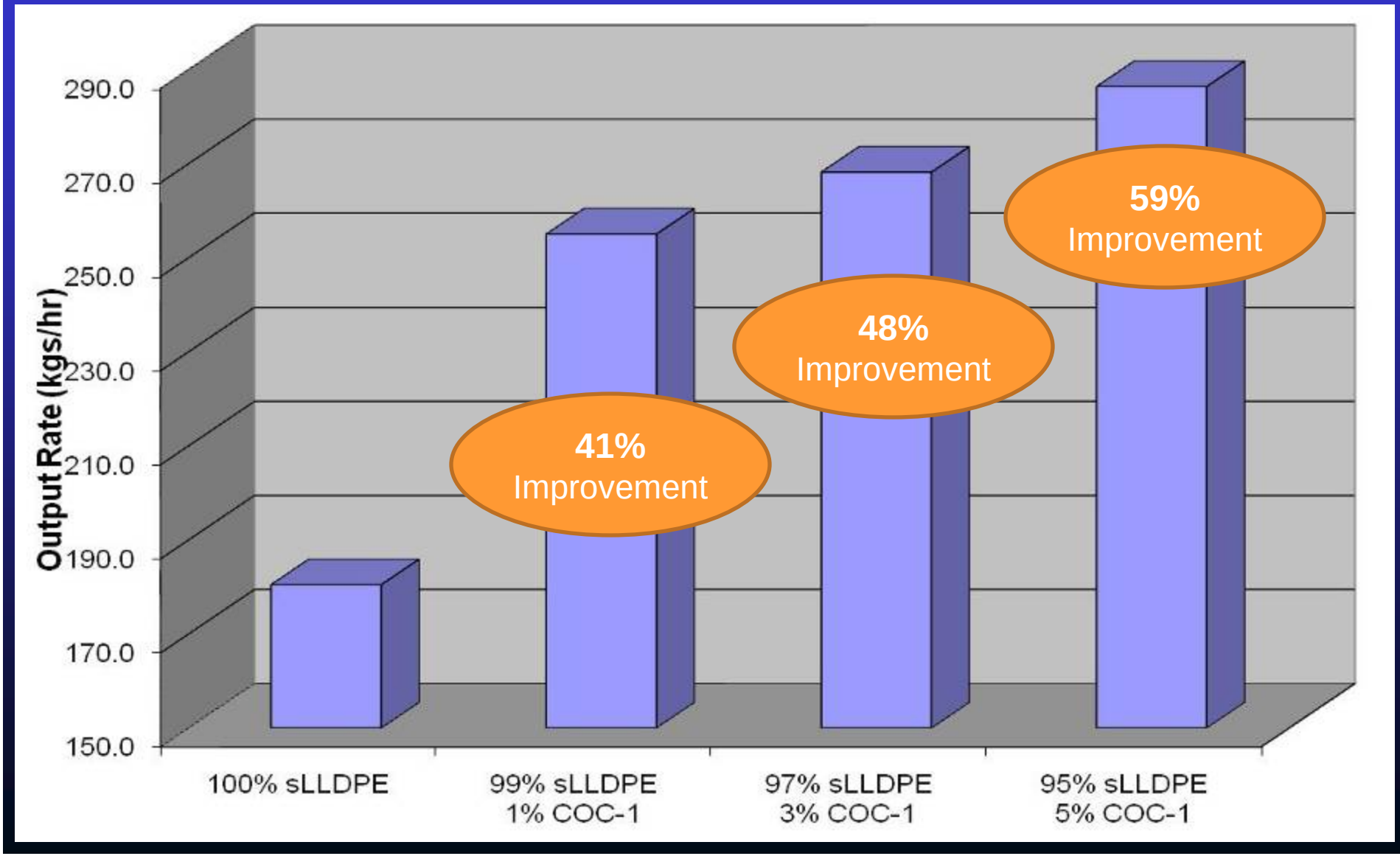
Determination of Maximum Output Rate

- Maximum output rate on blown film equipment is often limited by bubble stability
- As output rate is increased bubble will oscillate or move, correlating with poor or reduced film quality (i.e. increased gauge variation, layflat variation, movement of frostline height)
- Criteria for determining maximum output rate:
  - Stability of bubble (limited oscillations result in little or no variation in layflat width)
  - Gauge variability (maintained within +/-10% when measured around bubble)

Part 1: Blends

- 100% sLLDPE control
- Blends of sLLDPE with:
  - 1% COC-1
  - 3% COC-1
  - 5% COC-1

Part 1: Maximum Output Rate



Part 1: Processing Information

	100% sLLDPE	99% sLLDPE 1% COC-1	97% sLLDPE 3% COC-1	95% sLLDPE 5% COC-1
Output Rate (kg/hr)	180.5	255	268	286.5
Screw Speed (rpm)	53	72	75	85
Drive Amps	13.7	15.7	16.2	16.5
Head Pressure (MPa)	18.5	24.4	25.6	28.7
Melt Temperature (ºC)	234	243	246	241

- No surprises – RPM, amps, pressure, temperature increase as rate rises

Part 1: Key Film Properties

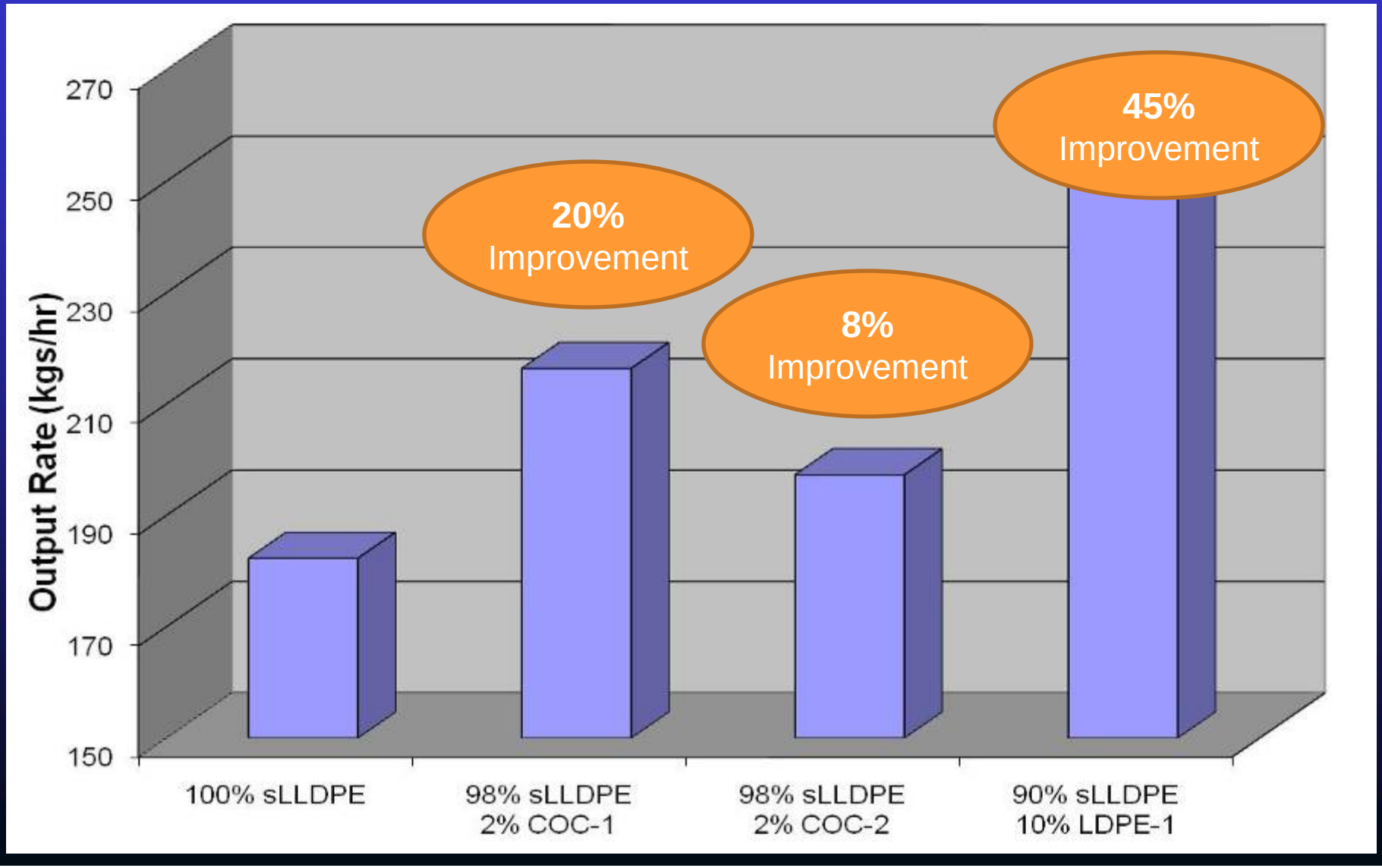
Properties	100% sLLDPE	99% sLLDPE 1% COC-1	97% sLLDPE 3% COC-1	95% sLLDPE 5% COC-1
45º Gloss	36	46	46	42
Haze (%)	18.2	13.3	14	17
Dart Impact F_{50} (g/25µm)	400	450	415	365
Elmendorf Tear MD (g/25µm)	315	225	300	205
Elmendorf Tear TD (g/25µm)	580	525	630	505
1% Secant Modulus MD (MPa)	135	180	185	225

- High toughness of sLLDPE retained in COC blends
- Stiffness also improved, as is typical with COC
- Film had small defects due to extrusion below recommended COC temperature

Experiment: Stage 2

- Melt compound sLLDPE/COC formulations
  - Performed on a single screw extruder
- Investigate a second COC material
- Include a reference blend
  - sLLDPE and LDPE

Stage 2: Maximum Output Rate



Stage 2: Processing Information

	100% sLLDPE	98% sLLDPE 2% COC-1	98% sLLDPE 2% COC-2	90% sLLDPE 10% LDPE-1
Output Rate (kg/hr)	181	216	197	264
Screw Speed (rpm)	57	67	63	87
Drive Amps	16.6	17.3	16.5	17.3
Head Pressure (MPa)	28.4	29.5	28.5	30.2
Melt Temperature (ºC)	233	240	234.5	250
Frost line Height (cm)	75	>100	87	>100

- No surprises except slightly easier processing with COC-2

Stage 2: Key Film Properties

	100% sLLDPE	98% sLLDPE 2% COC-1	98% sLLDPE 2% COC-2	90% sLLDPE 10% LDPE-1
45º Gloss	29.1	61.3	34.8	68.9
Haze (%)	15.7	11	16.9	6.2
Dart Impact F_{50} (g/25 µm)	395	405	380	150
Elmendorf Tear MD (g/25 µm)	330	315	280	175
Elmendorf Tear TD (g/25 µm)	510	480	475	700
ASTM Puncture Energy (J/mm)	155	165	155	75
Tensile Yield Strength MD (MPa)	10	10.1	10	12.4
Tensile Ultimate Strength MD (MPa)	51	46	48	49
Tensile Elongation MD (%)	480	500	470	525
1% Secant Modulus MD (MPa)	135	150	135	155
Thickness Profile Average (µm)	39.1	39.6	39.1	40.9
Thickness Profile (min - max) (µm)	35.0-44.7	34.8-44.5	34.5-47.2	37.3-44.2

Toughness retained

Conclusions

- Blending low levels of COC-1 offers an interesting combination of improved output rate and retention of film toughness properties
- Selection of COC material important as not all COC materials offered significant improvement in maximum output rate

Acknowledgements

- Nova Chemicals
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