

Food-grade Recycled PET Production

Consume, Collect and Convert Locally.



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The 'What' of Recycling

Produce Virgin PET

Energy Consumption
79 MJ/kg

Produce
Food-grade
Packaging

Energy Consumption
8-30 MJ/kg

Convert Flake to
Food-grade rPET

Recover
Packaging

Sort, Grind, Wash
to Clean Flake

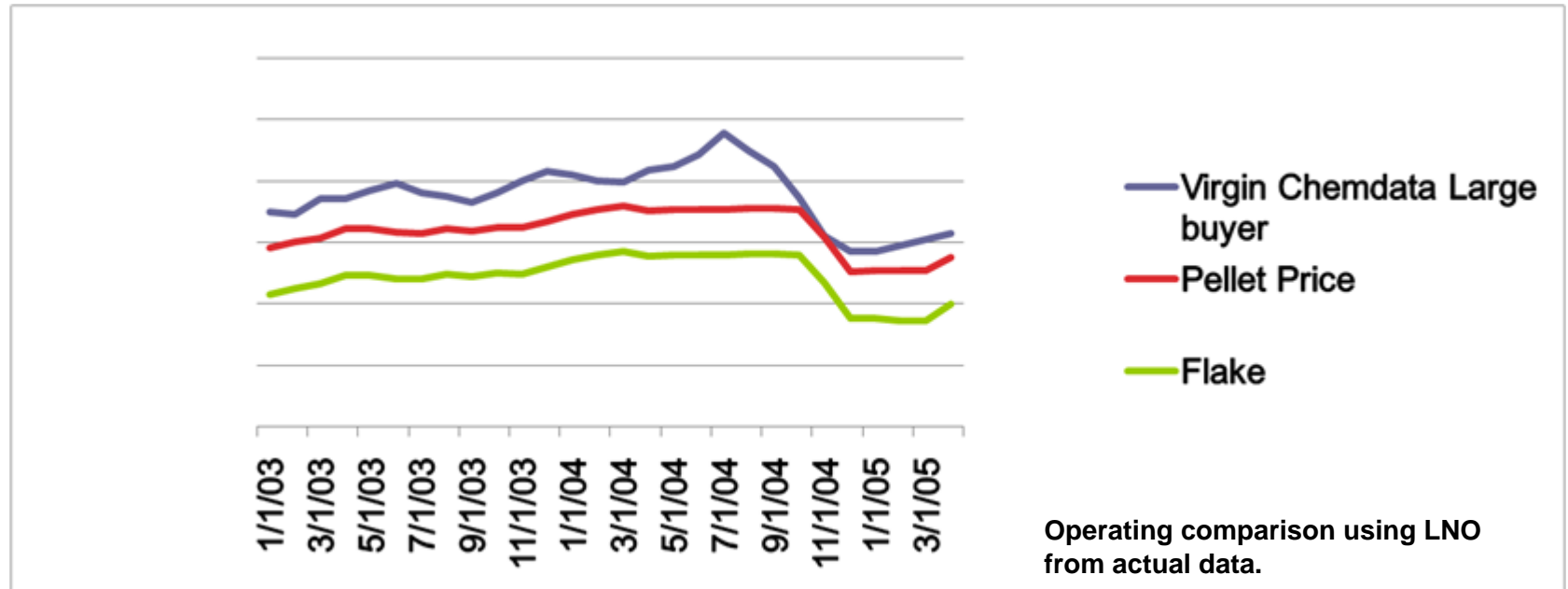
WRAP Report, 2006, www.wrap.org.uk

The 'Who' of Recycling

- Virgin PET Producers¹
 - Source is from Oil Distillates
 - Plant is large Capital Expenditure
 - Carbon and Hydrogen Footprint is large
- Flake Producers²
 - Source is from post-consumption recovered material
 - Plant is moderate Capital Expenditure
 - Carbon Footprint is moderate, Hydrogen is substantial
- rPET Processors³
 - Source is from Flake Producers
 - Plant is small to large Capital Expenditure
 - Carbon & Hydrogen Footprint extremely variable



The 'Why' of Recycling



- In times of stable prices, rPET is consistently profitable.
- In time of volatile prices, rPET profitability depends on:
 - Operating Costs
 - Flake Price



Why focus on PET?

- PET is supremely stable with strong recycling attributes
- Avoids the chemical issues inherent in other polymers
- PET is used globally for food-grade with properties that allow its use across many product types:
 - Low Acid
 - Carbonated
 - High Acid



Recycling Concerns

- Source of Raw Materials
 - Many industries compete for post-consumer PET
 - Cleaning, sorting, and selling is a separate business (i.e., scrap metal, paper, PVC and other plastics)
- Increasing environmental concerns
 - Carbon-equivalent emissions (energy consumption)
 - Hydrogen cycle (water use, reclamation, re-use)
 - Hazardous Material Release



PET Recycling Summary

- Natural flow of material
 - Post-consumer Collector
 - Sort, Grind, Clean Flake Producer
 - Clean Flake Processor
 - Converter into new packaging
- Historical price advantage over Virgin PET
- A need for:
 - Environmentally Friendly System
 - A System sized to supply of Clean Flake



Recycling Methods

According to Waste & Resources Action Programme (WRAP), U.K.

- Chemical Recycling
- Caustic Recycling
- Vacuum Decontamination with Melt Filter
- LNO™c

*Method Descriptions are from WRAP Project Number: PLA0032,
ISBN: 1-84405-274-5 except for the LNO™c Method*



Chemical Recycling

- “Chemical recycling involves breaking the PET down to the base chemicals and adding them to the polymerisation process.”
- “The capital investment for these plants is typically in excess of US \$10m and the plants need to be located adjacent to polymerisation operations.”

WRAP Project Number: PLA0032, ISBN: 1-84405-274-5



Caustic Recycling

- “... involve a prewash of bottles followed by bottle sorting and grinding to 10 to 14 mm flake and then a hot (>80 °C) wash using caustic soda and low foaming detergents.”
- “At the next stage, there is a decontamination process either before or after extrusion, which involves exposure to a number of hours at 200 ° C with the application of vacuum or within an inert atmosphere such as nitrogen.”

WRAP Project Number: PLA0032, ISBN: 1-84405-274-5



Vacuum Decontamination

- Caustic recycling followed by....
- “extrusion and melt filtration through ...[a] two stage vacuum treatment system...”

WRAP Project Number: PLA0032, ISBN: 1-84405-274-5



The LNO™ Process

- In 1999, Phoenix Technologies became the first company to receive a *Letter of No Objection* from the FDA for the use of curbside collected material at 100% inclusion rates.
- Food Contact Approval from Australian and New Zealand Food Authority (ANZFA)
- Canadian Health Ministry
- Since that time, the LNO™ process has been *continually improved*.

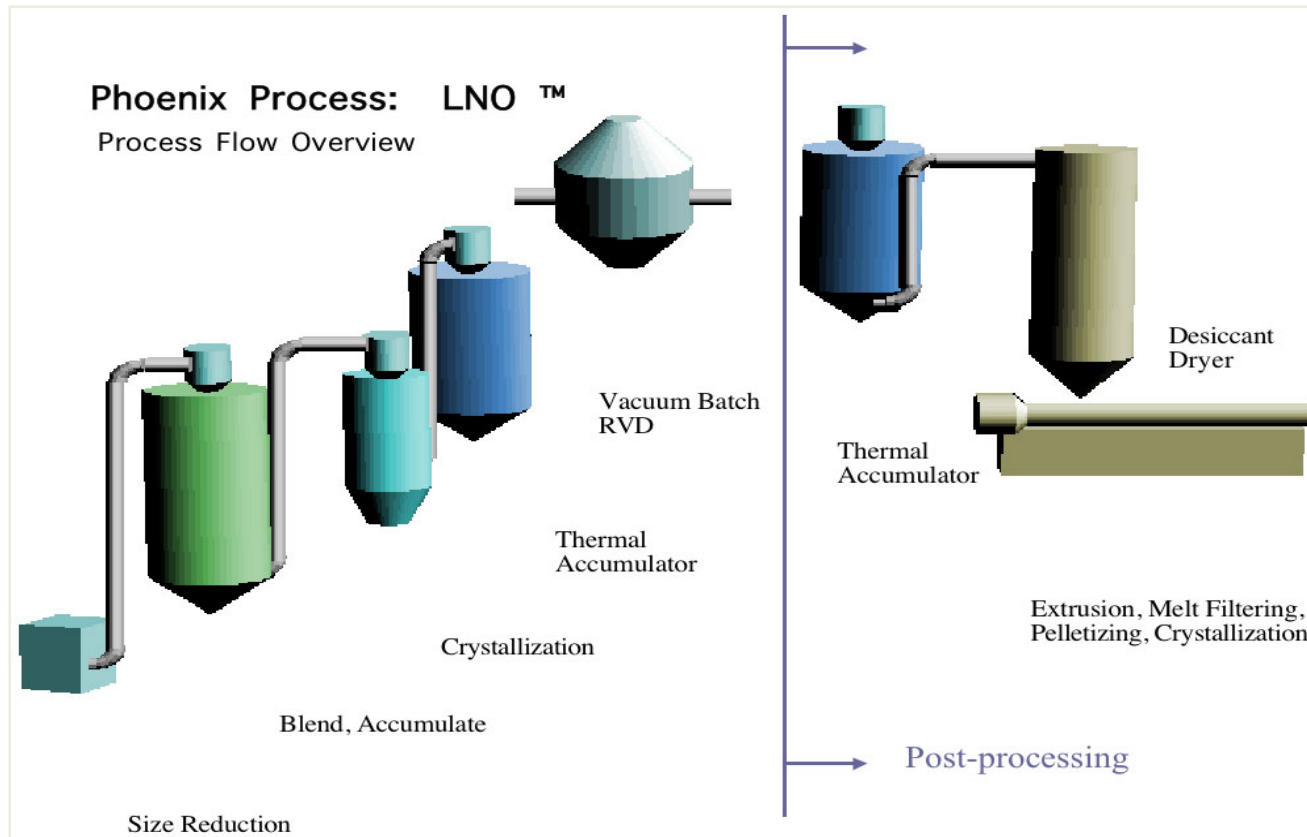


LNO™ Process History

- First Food Grade Line started in 2000
- Using 4 mm flake
 - Processing conditions were established at 4 hours at temperature and vacuum, with a total cycle time of ~ 7 hrs
 - Process about 16M lbs of material per batch which calculates to about 4M lbs per hour in our rotary vacuum decontamination (RVD) chamber.
- The process used to decontaminate flake is precisely the same as a batch solid stating unit
- One of the synergies found
 - Decontamination increases the IV and, because of the reduced particle size, the IV build rate is increased.



LNO™ Vacuum Decontamination



This is the LNO™ p process still in use today!

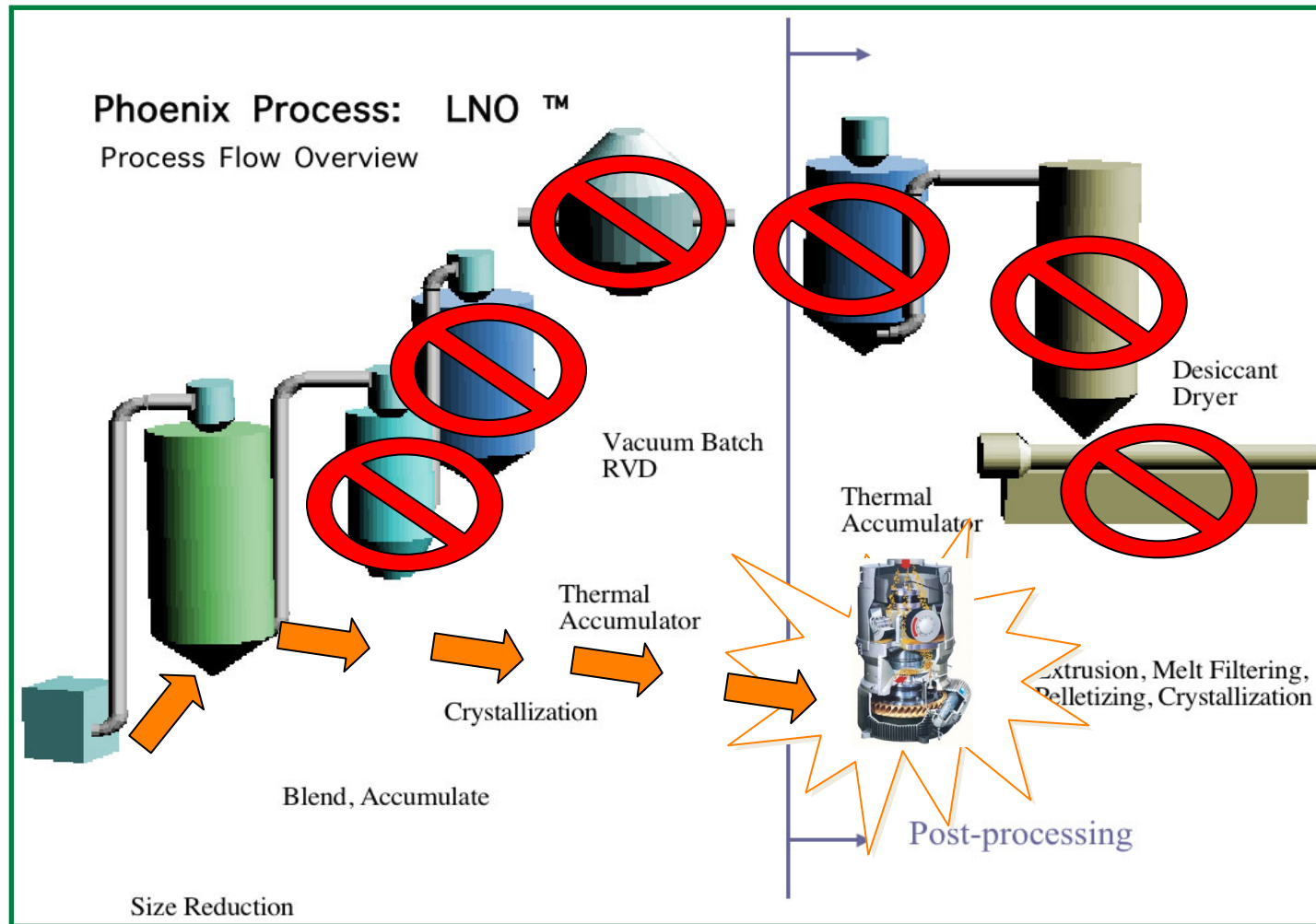
LNO™c : The Next Evolution

The next step in the constant improvement of the LNO™ Process is **LNO™c**:

- High Quality & High IV
- Unrestricted Feedstock Source
 - Deposit
 - Single Stream Curbside
 - Viable with any wash technology
- Patented Technologies
 - Based on LNO™F, LNO™p Resins.
Food-grade powder (ESPS) research



Reduction in Size & Cost



rPET vs. Virgin PET

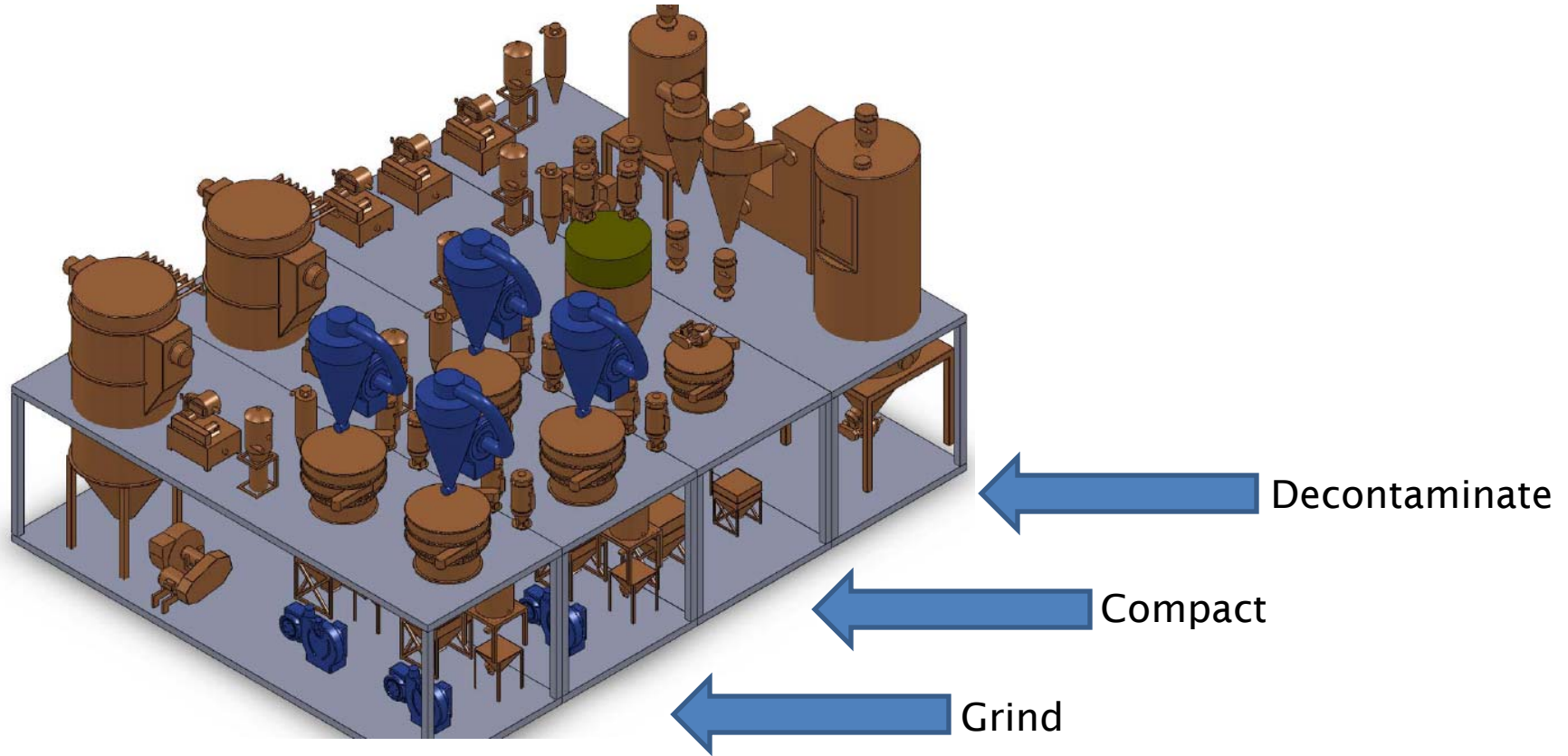
Attribute	Units	ITW	Cleanaway	Virgin PET (example)	LNO™ c
		K04013	GKO-21	Dupont Laser+	
Intrinsic Viscosity- solution technique	dL/gm	0.79	0.75 +/-0.04	0.84 +/-0.02	0.77 ± 0.03
Melting	°C	250	250		246 + 3
Density – solid	g/cm3	1.33	1.33	1.33 Amorp >1.39 Cryst	1.33
Crystallinity	%	>30	>30	>48	>30
Colour	L	79.59	76.9		79.0 Min.
CIE	a	-2.84	-2.18		-1.5 + 0.5
(L,a,b)	b	3.08	4.84	2.0 Max	3.50 Max
	Y	4.32	8.47		
Pellet Size	mm	2.5	2.5		3mm Dia
Major Diam max.	mm	3.0	3.0		
Residual Acetaldehyde	ppm	<1	<1	<1	<1
Guaranteed Acetaldehyde	ppm	<1	<1.5		<1
Fines <0.5mm (max)	%		>0.1		
Metal, Black Specs	>100µm	0	0	0	
Foreign Matter-PVC, Metals, Polyolefins, Paper	ppm	<1	<1		
Moisture Content	Max %	0.4	0.14	0.2	.2
Bulk Density (Target)	Kg/m3	700	770	840	480-560
GC/MS (Free of foreign residues)		<15ppb of Limonene			

Note 1: ITW data is from Erema Process and Cleanaway data is from URRC Process

Note 2: Bold border table is from WRAP Project Number: PLA0032, ISBN: 1-84405-274-5



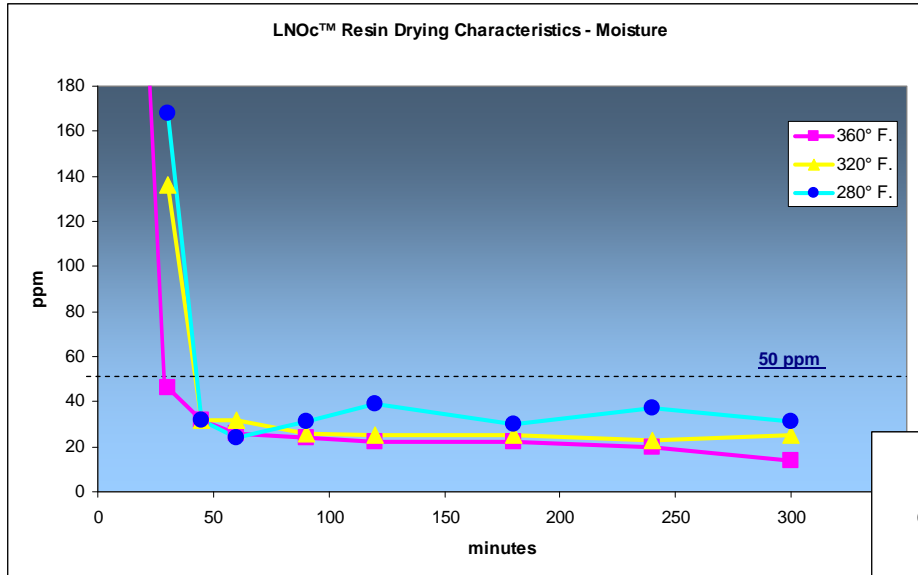
The LNO™c System



- Recommended footprint is 260m² with vertical clearance of 12m high
- Modular design starts with 4.5k T/year that can double to 9k T/year

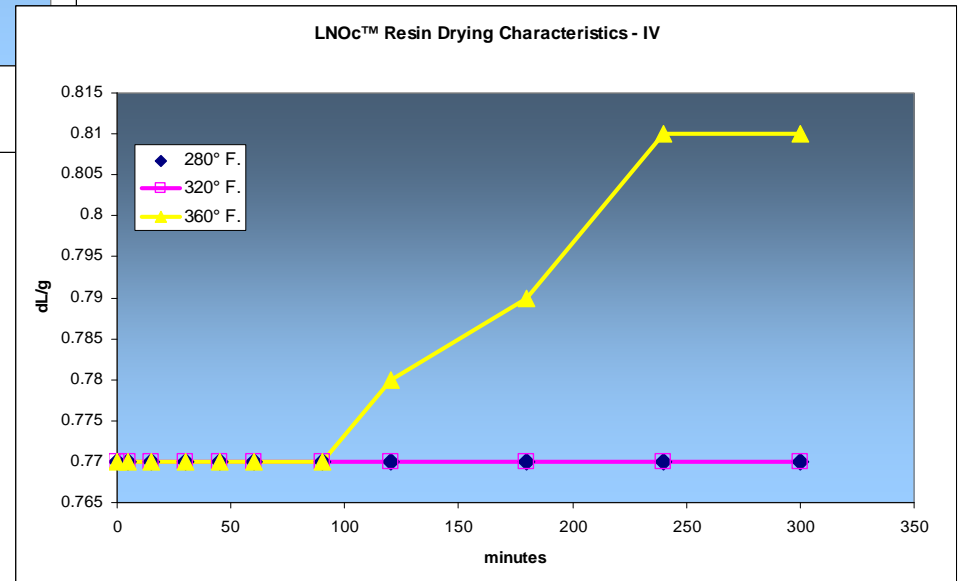


LNOTMc Drying Characteristics

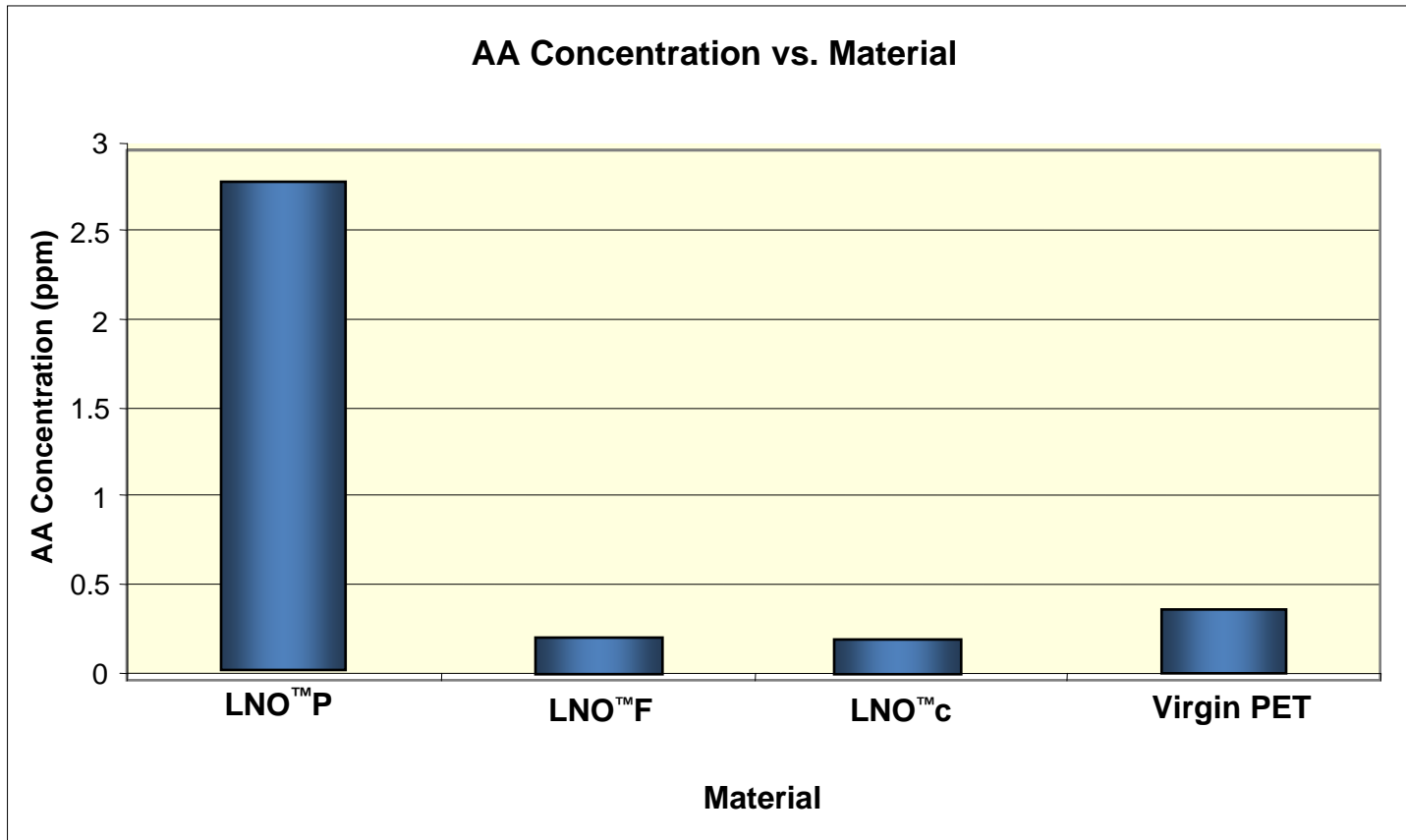


Moisture

IV Build



LNO™c AA Advantages



Packaging Converter Value

- Blends of PET and rPET produce cost savings
- In countries with Greenhouse Gas Emission controls:
 - Use of rPET – PET blends reduce Carbon footprints in a stable and predictable manner
 - Converters can apply for VERs carbon credits through the consistent use of low carbon-hydrogen footprint rPET technologies
- Converter purchase of a plant reduces rPET price volatility (raw material cost)



Procurement Considerations

- Modular system
- Ships in standard shipping containers
- Purchase includes:
 - Two-step system acceptance (Pre-ship & Operating)
 - System training
 - 1 Year Warranty and Technical Support
 - Recommended Spares Kit
- Optional Support contract past first year



LNOTMc Process Advantages

- Reduction of ~ 40% in energy usage
- No water consumption (only re-circulated chiller water)
- Improved yields (>95%)
- Small footprint <300m²
- Simple to operate – 1 person



Health, Safety & Environment

- No effluent filled waste water
- No hazardous material containment
- Industrial hygiene testing completed:
 - Conducted by Ohio Bureau of Workers Compensation
 - All items below permissible exposures or not detected at all



Operating Advantage

- Can be married to any wash technology
 - **Allows for maximization of each process step depending on feed stream requirements**
- Increased control over processing costs
- Increased value of feed stock
 - **Internal and external re-use programs**
 - **Regeneration of fines and regrind providing more value**
 - **Improves yields throughout the facility**
- Small volume processing line increases:
 - **Logistics savings – either at collection/wash site or converter site**
 - **Operating savings – low staffing, “light switch” start-stop**
 - **Spares & Maintenance savings – no extrusion, no melt filter screens**



Summary

- Modular System sized for:
 - Processors' need (4.5k Tonnes expandable to 9k Tonnes per year)
 - Available Clean Flake Supplies
- Higher Yield at Lower Cost
 - One Operator
 - Minimal Consumables
- Safe & Environmentally Friendly
 - No constant water usage
 - 40% Energy Reduction



To learn how PTI Recycling Systems can help you expand into food-grade PET recycling, contact us at: info@ptirecyclingsystems.com

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