vercet™

ADHESIVES

CREATING PERFORMANCE THROUGH CHEMISTRY

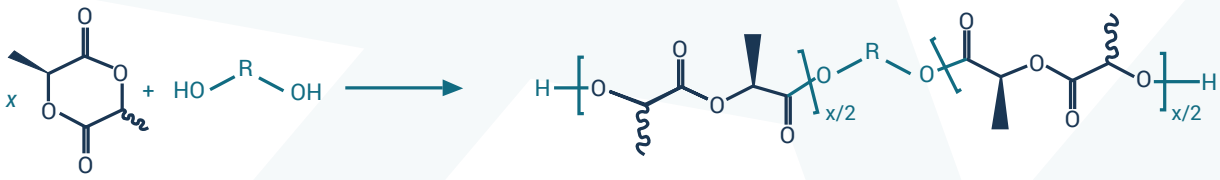
Building upon decades spent advancing materials chemistry innovation, NatureWorks offers solutions based on lactides and lactide intermediates that help innovators within the coatings, adhesives, sealants, and elastomers (C.A.S.E.), toner and surfactant industries realize:

Significant, measurable product performance benefits

Move through the R&D process more efficiently and with minimal risk

Decrease systems costs via an optimized supply chain

VERSATILE VERCET LACTIDE CHEMISTRY

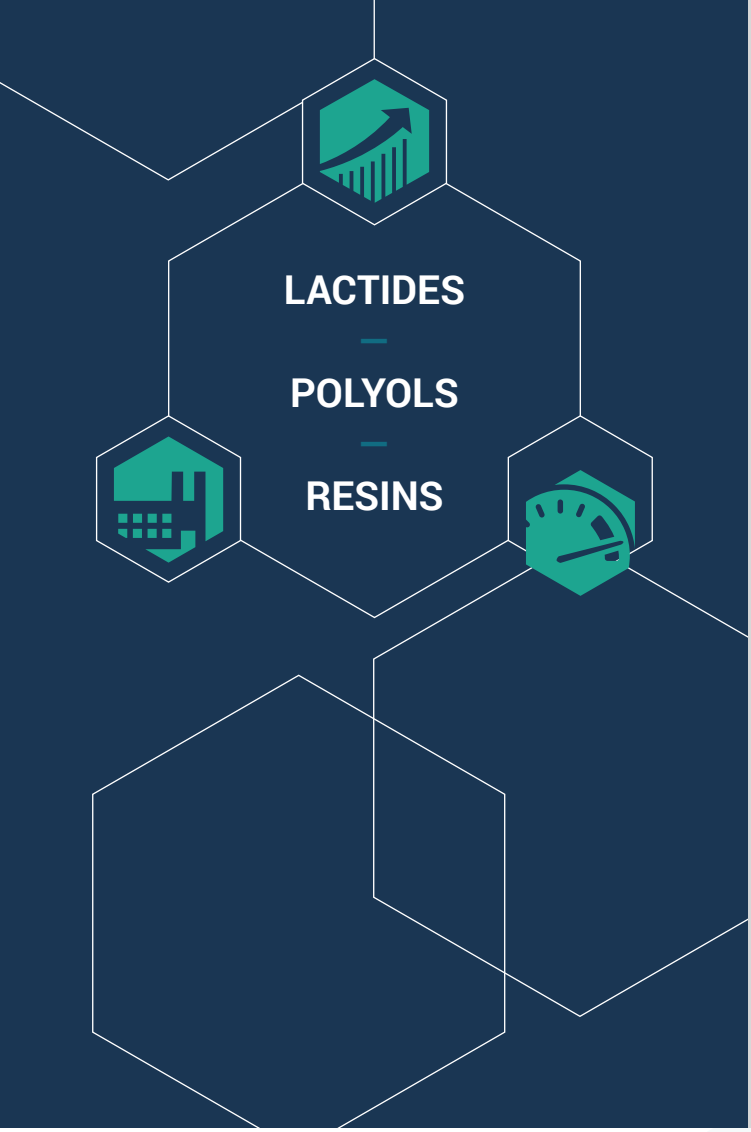


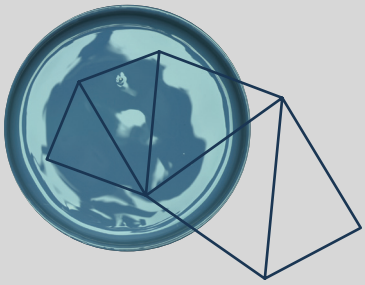
LACTIDE

- Reacts readily with alcohols, amines, glycols
- 100% solids
- No water loss
- Sustainably sourced

LACTIDE POLYOLS

- Tg ranges ~ 0 - 60°C
- Hydroxyl values 12-112 mg-KOH/g
- Secondary hydroxyl functionality
- Readily reacts with isocyanates
- Readily soluble in esters and ketones
- Renewably-sourced biobased polyols and resins





We achieve this by coupling tunable Vercet™ lactide-based chemistries with the knowledge of scientists and engineers who understand how to dial in the full capabilities of this versatile product line.

POLYOLS + RESINS

CUSTOM SOLUTIONS FOR ADHESIVES

Vercet lactide-based chemistry enables formulation flexibility in adhesives when trying to achieve new or enhanced performance properties not found with incumbent chemistries.

	VERCET POLYOLS FOR URETHANE ADHESIVES	VERCET RESINS FOR ADHESIVES
SUBSTRATES	Wood & wood laminates Plastics Film Metal Glass Dissimilar substrates	Wood & wood laminates Paper Metals Plastics
DELIVERY MECHANISMS	100% solids - liquid 100% solids - reactive Hot melt	Solvent-borne Hot melt
MARKETS	Furniture & flooring Nonwovens / hygiene Durable assembly Recreation / transportation Electronics Packaging- rigid & flexible	Flexible packaging Packaging - carton and case seal 3D printing Edge banding
PERFORMANCE BENEFITS	Tailored open times and pot life Compatible with common polyols Adhesion to polar substrates Excellent chemical and solvent resistance Overlap shear strength Renewably-sourced building block	Tunable viscosity and set time (seconds to minutes) Improved green strength Low dispensing temperatures Adhesion to polar substrates Renewably-sourced building block

POLYOLS FOR URETHANE ADHESIVES

Vercet polyols show compatibility with a variety of polyols such as 2000 molecular weight adipate-based polyols.

Vercet Grade	*f*	Tg (˚C)	Viscosity @100˚C (Pa*s)	OHV[1] [mg-KOH/g]	Performance Features
P1025X	1	15	1.3	25	Chain stopper
P2025X	2	40	11.3	25	High modulus & hardness. Oil & grease resistance.
P2056X	2	25	2.1	56	
P20112X	2	5	<1.0	112	
P2225X	2	35	13	25	High modulus & hardness. Oil & grease resistance. Improves flexibility & toughness.
P2256X	2	21	2	56	
P22112X	2	-1	<1.0	112	
P3025X	3	40	19.1	25	Crosslinker

1. OHV-Hydroxyl Value as determined by ASTM E1899

PROPERTIES

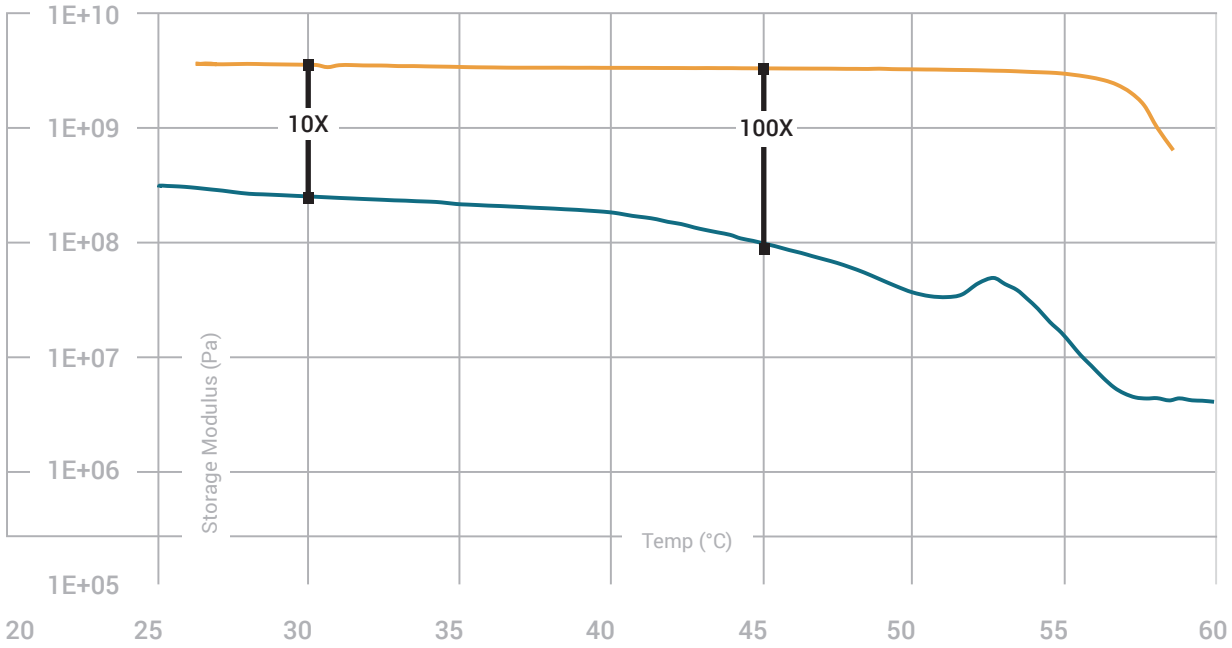
POLYURETHANES FORMULATED WITH VERCET POLYOLS

Polyurethane with Polyol	Vercet P2025X	Control (Based on AA-HDO)[8]
Wt% - Polyol / MDI[6] /1,2 PDO[7]	85.3/12.5/0.8	86.6/11.6/0.8
Polyol OHV[1] [mg-KOH/g]	30	29
Gel Time [sec] 120°C	158	60
Hardness[2] [Shore A / D]	84/71	70/33
Tg/Tm[3]	Tg 51-55˚C	Tm peak 55˚C
Resiliency[4]	17	23
Water Pickup[5]	0.9%	0.6%

1. OHV – Hydroxyl Value as determined by ASTM E1899
2. Hardness as determined by ASTM 2240, 4 weeks
3. DSC mid-point, 20°C/min, 2nd heat
4. Resiliency as determined by ASTM D2632
5. Immersion testing, 8 days at 25°C
6. 4,4' - Methylene diphenyl diisocyanate
7. 1,2 - Propanediol
8. 1,6 - Hexanediol adipate

POLYURETHANE PERFORMANCE

HIGHER MODULUS CREATES HIGHER STRENGTH OVER EXTENDED TEMPERATURE RANGE

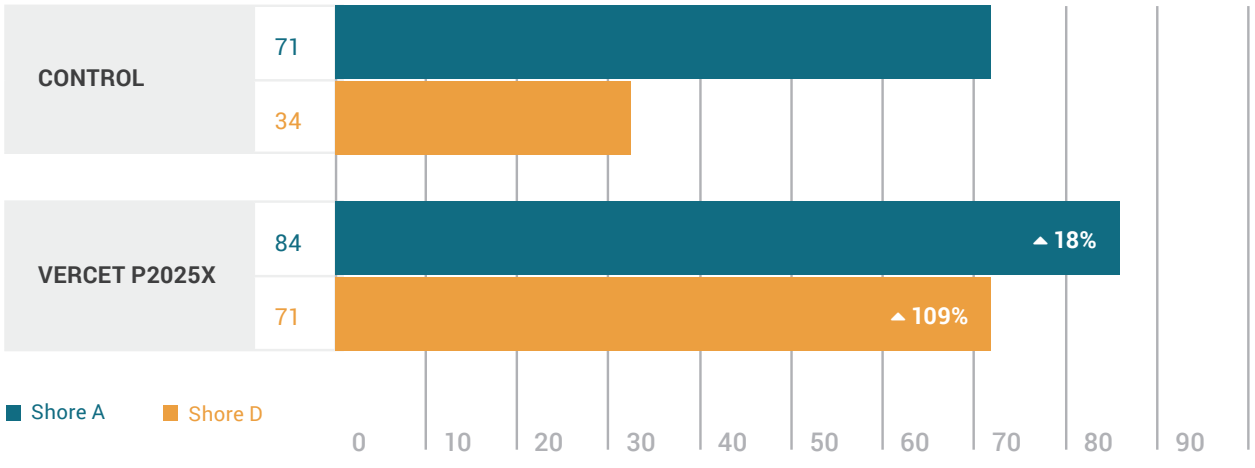


	Tg (°C, DSC)	Tg (°C, DMA)	E' (MPa, 30°C)	E' (MPa, 35°C)	E' (MPa, 45°C)	E' (MPa, 50°C)
CONTROL TPU	41-44 Tm (onset)		24	21	8.8	3.0
VERCET P2025X	49-52	56	347	331	321	315

ASTM Method D790. 3 point bend fixture heated 3°C per minute.

POLYURETHANE PERFORMANCE

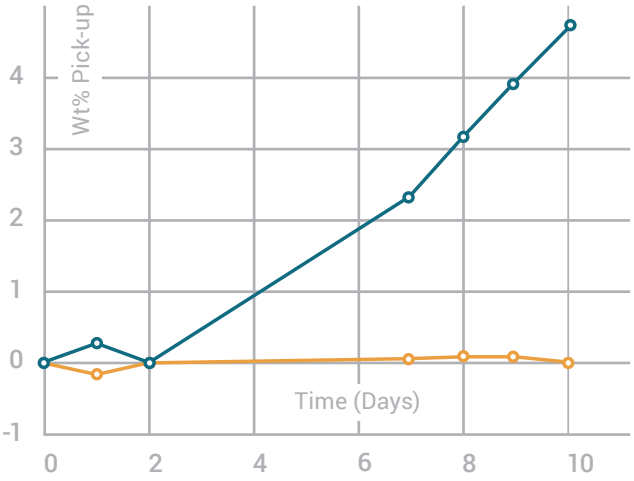
EXCELLENT HARDNESS AT LOW MDI CONTENT USES LESS ISOCYANATE



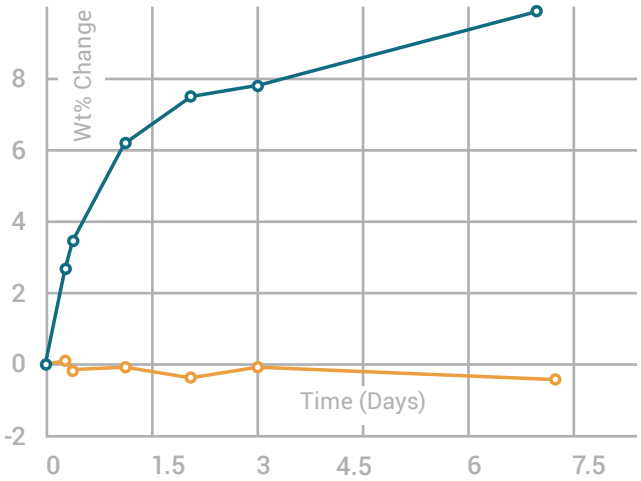
ASTM Method 2240. Measured after 4 weeks.

HOT OIL SWELL SHOWS EXCELLENT OIL RESISTANCE

WT% CANOLA OIL PICK-UP 68˚C

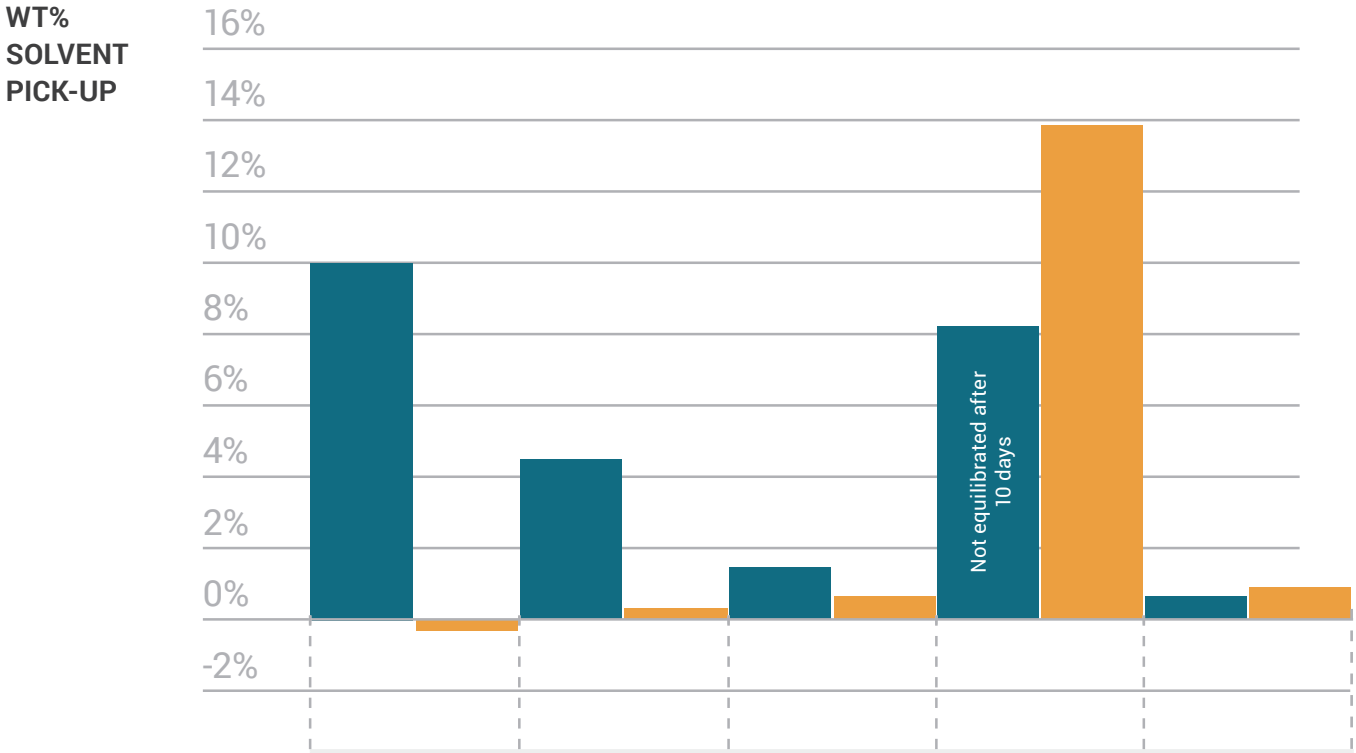


WT% IRM 903 OIL PICK-UP 68˚C



MEASURABLE PERFORMANCE

VERCET-BASED POLYURETHANE SOLVENT RESISTANCE: 10 DAY SWELL VALUES



	IRM 903 OIL	CANOLA OIL	N-HEXANE	ETHANOL	WATER
CONTROL	10.00%	4.50%	1.50%	8.10%	0.60%
VERCET P2025X	-0.20%	0.20%	0.60%	13.90%	0.90%

Wt% data collected 68˚C

POLYOLS FOR POLYURETHANES IN REACTIVE HOT MELT ADHESIVES

Polyol	Vercet P2025X	Control, (HDO-Adipate)
%NCO	2.0	2.5
Viscosity (mPa*s, 120˚C)	+100,000	14,000
DSC Transition (˚C)	51	53

PREPOLYMER FORMULATION

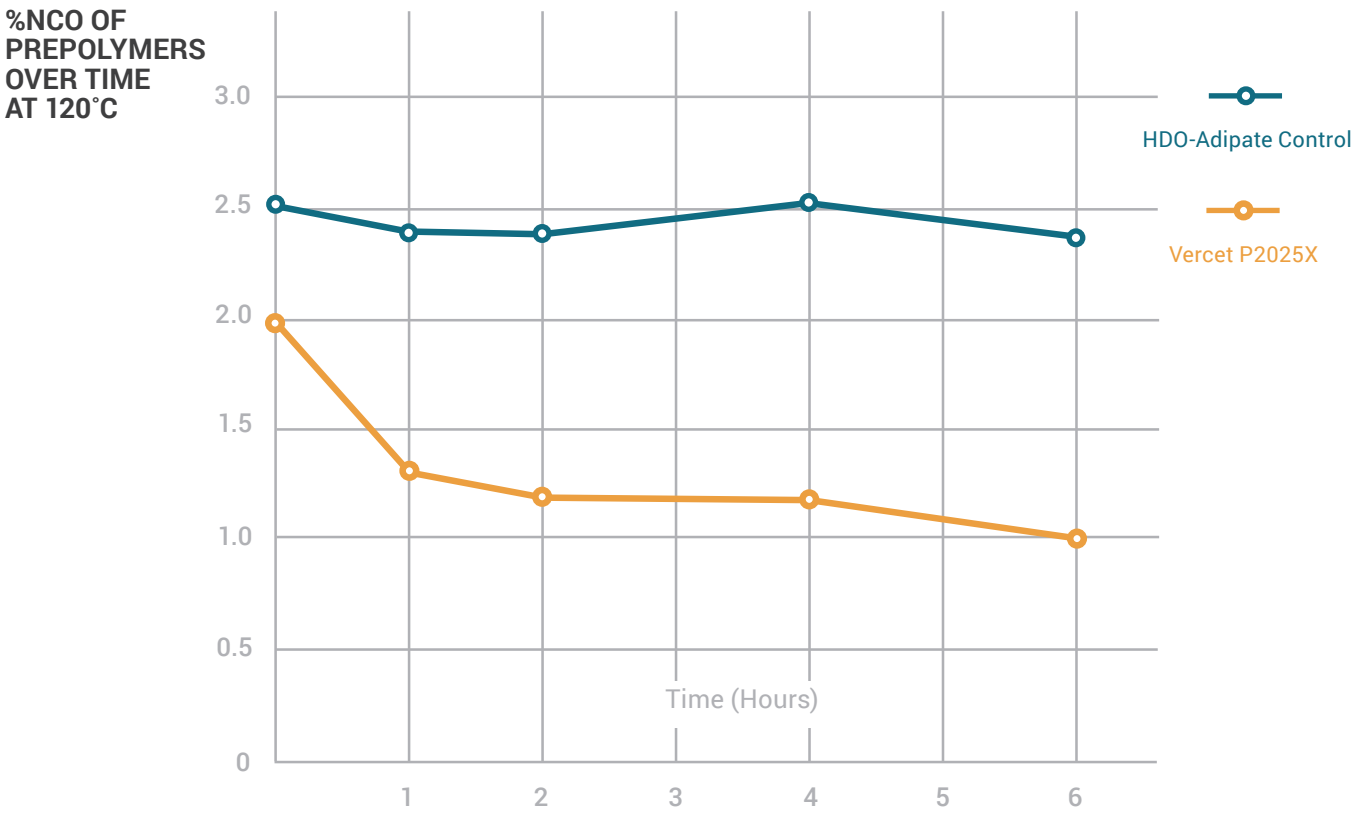
- 85% Vercet-based polyol
- 15% 4,4' MDI
- Isocynate index 1.05
- Reaction time 2-3 hours

ADHESIVE FORMULATION

- 88 Wt% Vercet-based prepolymer
- 10 Wt% DEG-adipate prepolymer
- 1.0 Wt% Epoxy silane adhesion promoter
- 1.0 Wt% DMDEE catalyst

REACTIVE HOT MELT ADHESIVES PERFORMANCE

STABLE NCO PREPOLYMER ENSURES STORAGE AND POTLIFE STABILITY



VERCET RESINS FOR ADHESIVES

Vercet offers high polarity, amorphous PLA resins, customizable to a range of viscosities, glass transition temperatures, and are compatible with common adipate polyesters and ethylene vinyl acetate co-polymers enabling formulation flexibility. These bio-based resins improve overlap shear strength to metal, wood, and polar polymers, improve peel adhesion failure temperature, and greatly improve solvent/oil resistance.

PROPERTIES

TUNABLE SET TIME, VISCOSITY, & GREEN STRENGTH IN RESINS

Physical Properties[1]	Vercet Resin Grades[2]					Method
	A1000	A1010X	A1020X[3]	A1030X	A1050	
Specific Gravity	1.24					ASTM D792
Tg-Range (°C)	54-57	48-56	48-56	48-56	54-57	NW Internal DSC Method, Tg mid-point, 2nd heat
Brookfield Viscosity (Pa*s) 120°C			30-50	320-340		NW Internal Brookfield Method (#27 Spindle)
150°C		140-160	5-10	30-50		
180°C	>1,000	20-35				
200°C	310-340				>1600	
Melt Flow Index (g/10min)	10 @ 180°C	80 @ 150°C	600 @ 150°C	450 @ 150°C	10 @ 210°C	ASTM D1228

1. Typical properties; not to be construed as specifications
2. X suffix denotes experimental grade resin
3. Pellets of A1020X may cold flow due to its low viscosity and could require additional handling

VERCET RESINS AS TACKIFER FOR HOT MELT ADHESIVE

HOT MELT ADHESIVE FORMULATION

Resin	Wt%
EVA resin (80% vinyl acetate)	33%
PEG 8000 wax	33%
Vercet PLA tackifier	33%
Anti-oxidant	1%

GREATER PEEL ADHESION FAILURE TEMP.

Adhesive	SAFT (°C)	PAFT (°C)
Control	61	50
A1020X	61	61

SAFT and PAFT via modified ASTM D4498. A 10 mil x 1" x 1" adhesive specimen on Kraft paper tested in the shear mode (500g weight) and peel mode (100g weight) by hanging in an oven that was then ramped up at 30°F/hr from RT. The temperatures at failure were recorded.

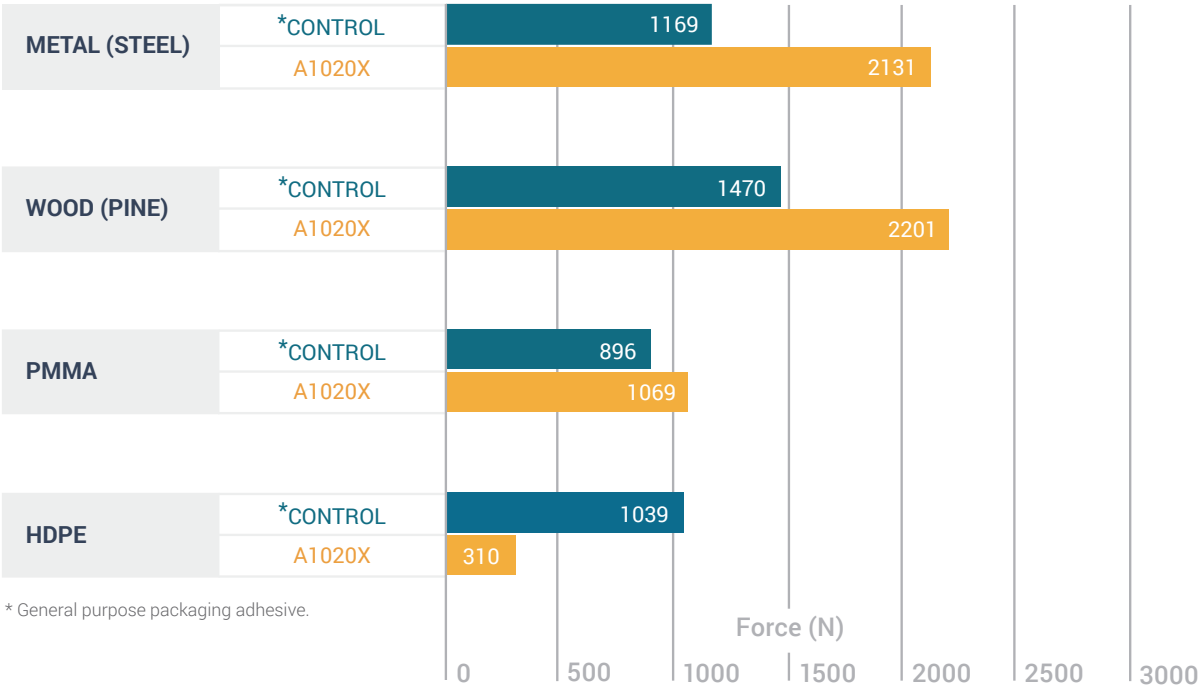
AT 1:1 MIXING RATIO:

- Veret PLA resins are compatible with EVA copolymers containing >60% vinyl acetate (VA).
- Vercet PLA resins are incompatible with resins such as hydrogentated wood rosin, styrene-isoprene block copolymers, and paraffin or soy waxes.

HOT MELT ADHESIVES

EXCELLENT BONDING TO POLAR SUBSTRATES

OVERLAP SHEAR STRENGTH

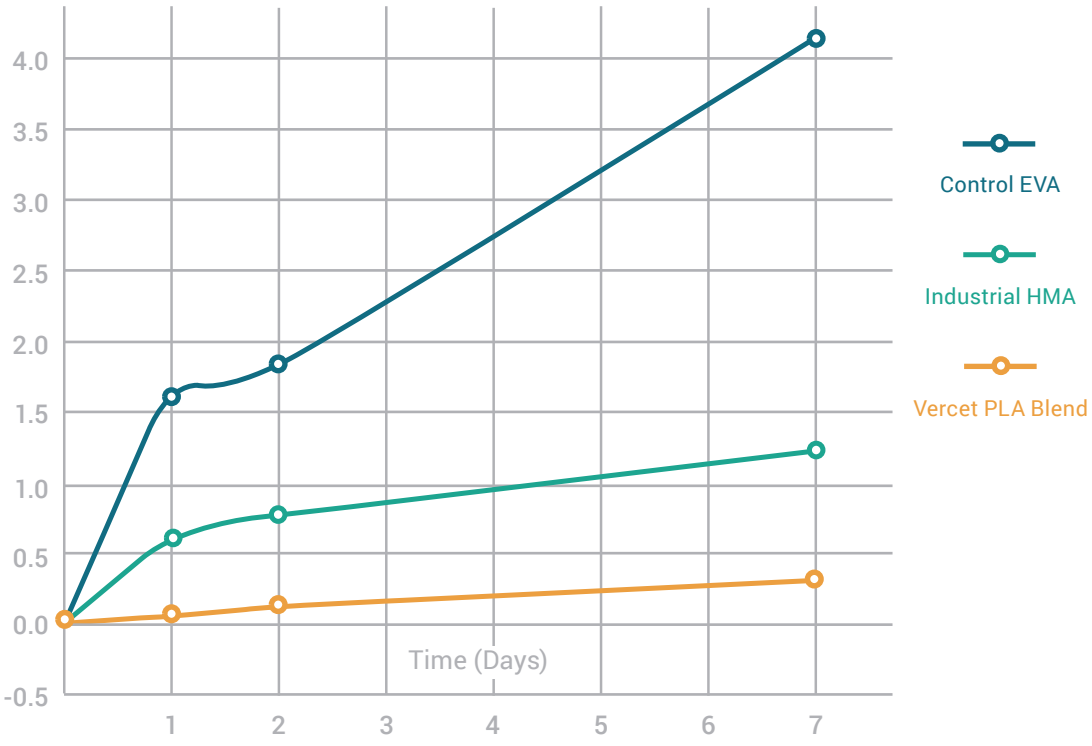


* General purpose packaging adhesive.

HOT MELT ADHESIVES

LOW OIL SWELL SHOWS IMPROVED OIL RESISTANCE

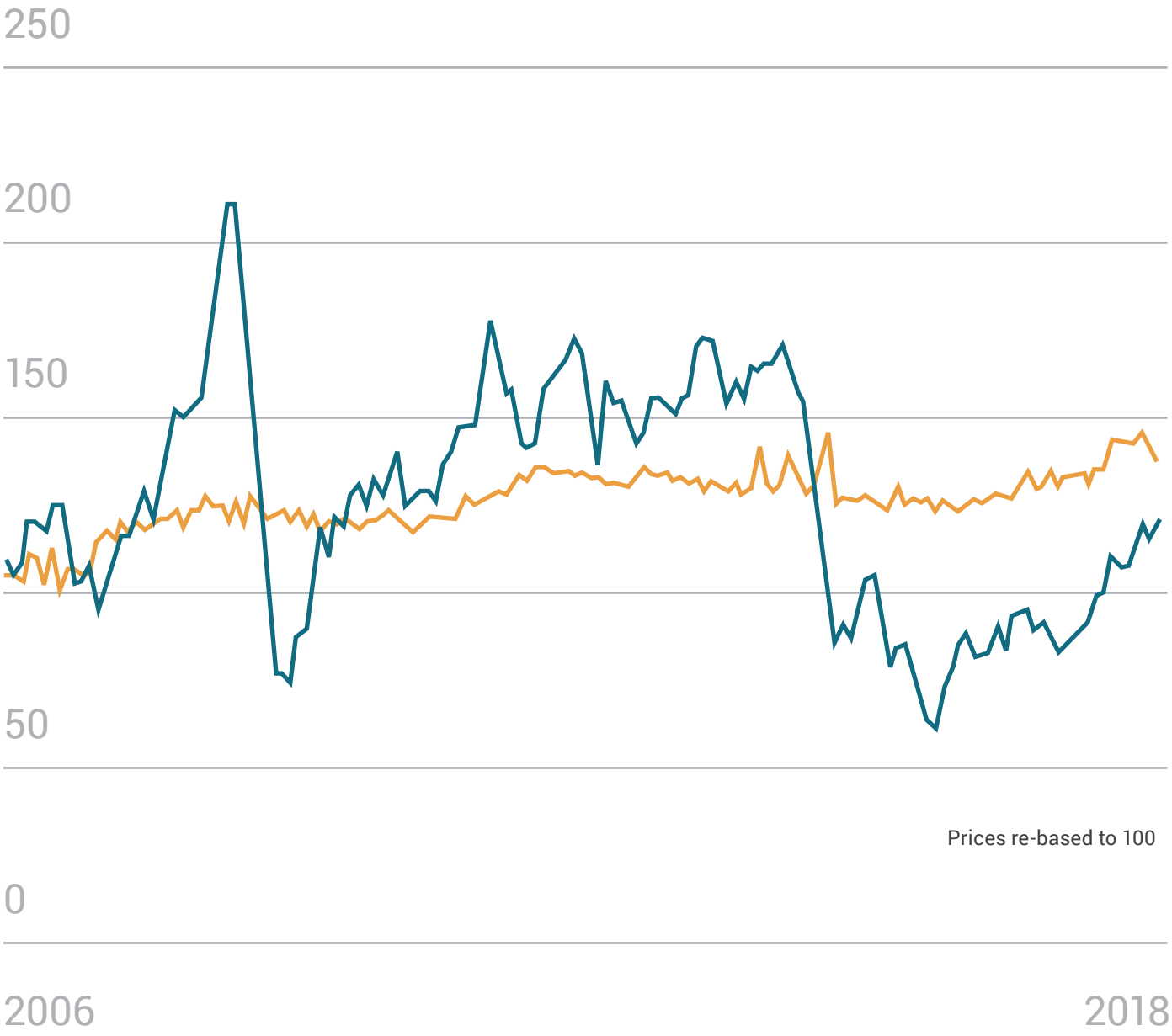
WT% CANOLA OIL PICK-UP, ROOM TEMPERATURE



BENIGN BY DESIGN

REDUCING VOLATILITY IN PRICING THROUGH ALTERNATIVE FEEDSTOCKS

Renewably-sourced Vercet lactide-based products bring sensible, elegant, and cost-effective solutions based squarely on the principles of green chemistry to supply chains that, until now, were coupled with traditional fossil-petroleum solutions and their inherent price volatility.



Vercet™

HOW CAN WE HELP YOU?

To learn more about Vercet custom solutions, please contact a member of our Performance Chemicals team.

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