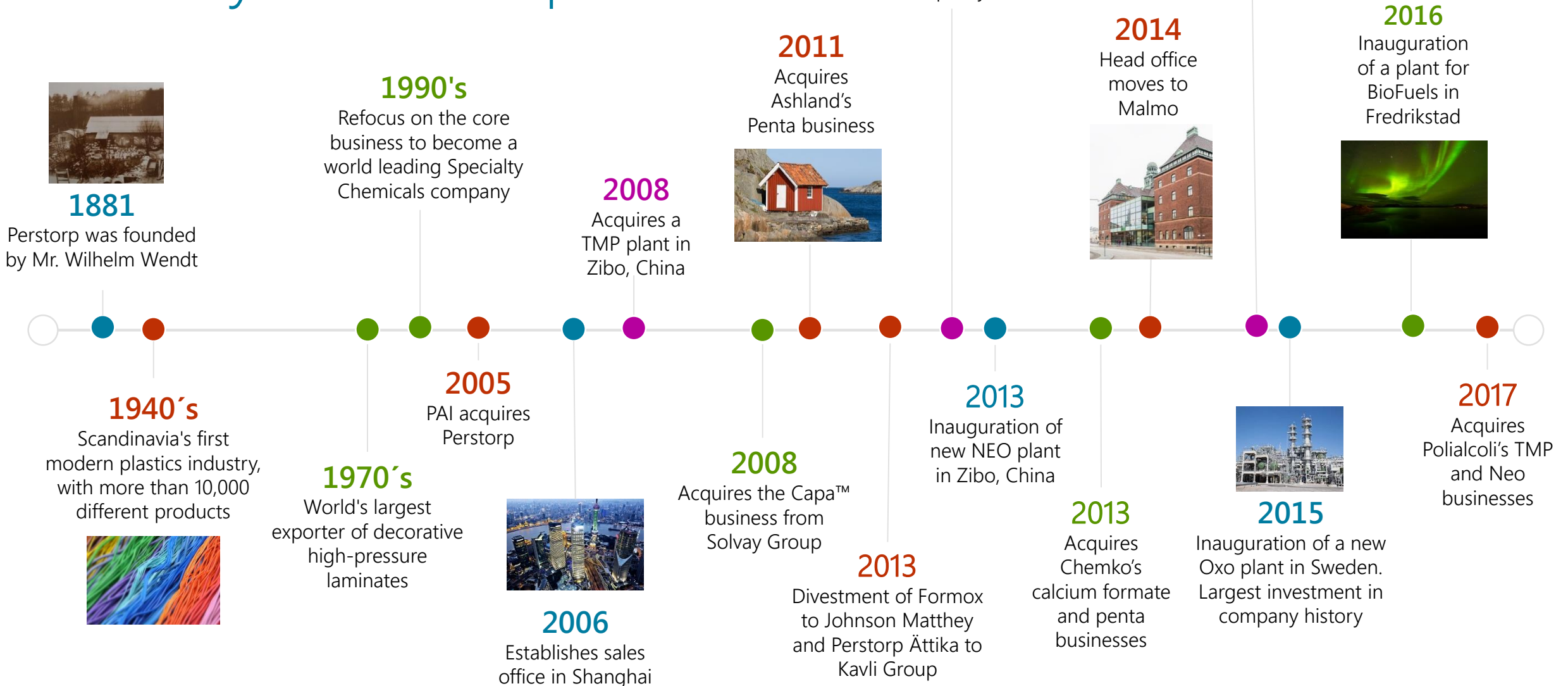




Optimizing flexible PVC formulations based on polyol ester plasticizers

PVC Formulation
April 10-12, 2018, Cologne
Anders Magnusson

A leading player with 136 years of expertise



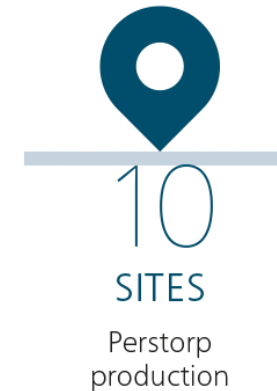
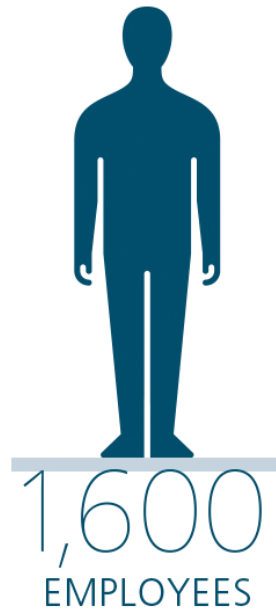
Perstorp in the plasticizer industry

- Fully integrated plasticizer producer since 1980's
- Launched **Emoltene™** 100 (DPHP) in 2009 for durable applications
- Investment announced in 2011 to build a new production platform for new plasticizers
- Exited from DOP business completely early 2012
- Investment completed by Q1 2015
- Launched **Pevalen™** in 2013, a **genuine non-phthalate** based on polyolester
- Storage facilities in UK, Belgium, Germany, Portugal and US
- Member of **European plasticisers**, **VinylPlus** and founding member of **PlasticiserPlus**



Perstorp in brief

- World leader in several sectors of the specialty chemicals market
- Pioneer in formalin chemistry, plastics and surface materials
- Since December 2005 controlled by PAI partners, a leading European private equity company
- Present in 26 countries and production plants in Europe, Asia and North America
- Sales offices in all major markets



PVC Formulation Ingredients

Heat stabilizers

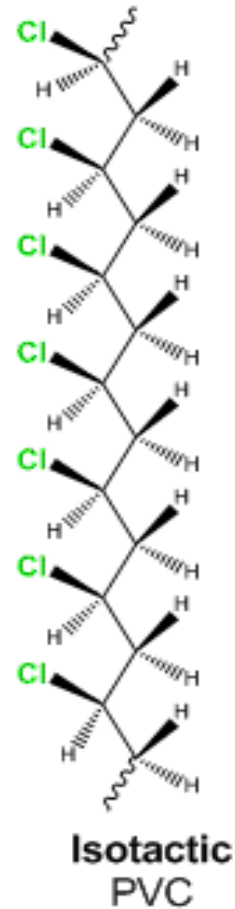
Lubricants

Adhesion promoters

Hydrocarbon oils

Antioxidants

Impact modifier



Plasticizers

Pigment

Blowing agents

Filler

Flame retardents

Viscosity modifier



A jungle of Plasticizer alternatives

Benzoflex Flexidone

Eastman 168™

Santicizer Platinum

Diplast Pevalen™

SoftNSafe TOTM

Emoltene™ Mesamoll

Hexamoll® DINCH

Palatinol Citroflex DOTP

PLS Green polysorb 37 Drapex Alpha 200

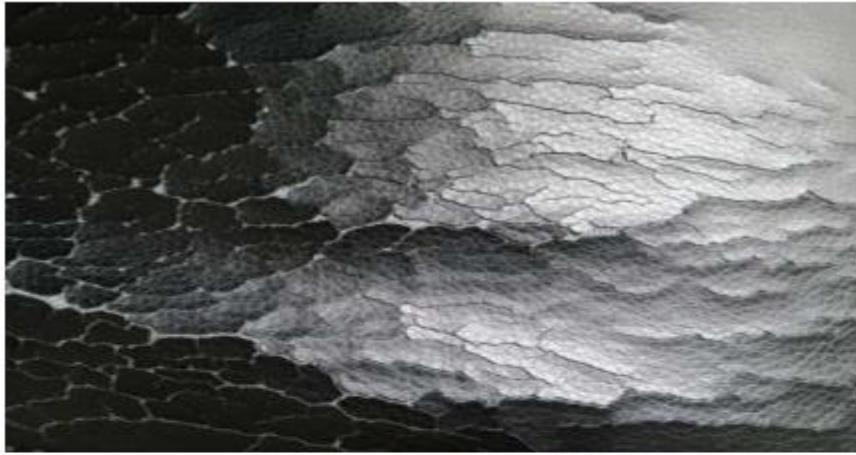
Changing plasticizer – how hard can it be?

- Easy replacement with no or little reformulation!
- Can substitute traditional phthalates easily!
- One size fits all!
- Quickly and efficiently switch (from classified DOP)!
- Substitution

What is the risk of improper reformulation?



PVC formulation related failure



What to consider when reformulating?

- Compatibility
- Processing
- Viscosity
- Hardness
- Plastisol stability
- Sustainability
- Legislation



Plasticizer Characteristics

Pevalen™ has high calculated compatibility and low volatility

Compatibility

Processing

Hardness

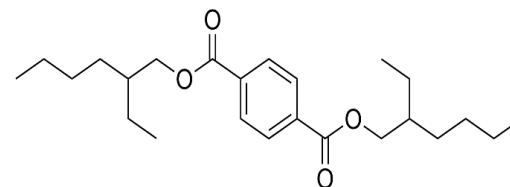
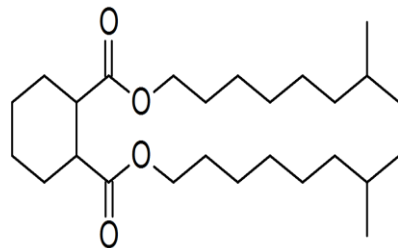
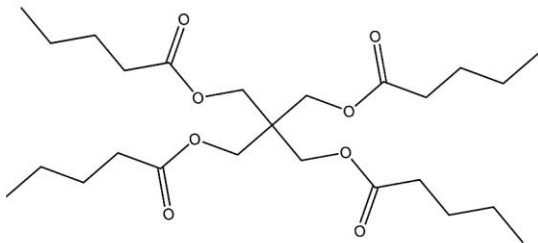
Viscosity

Plastisol stability

Sustainability

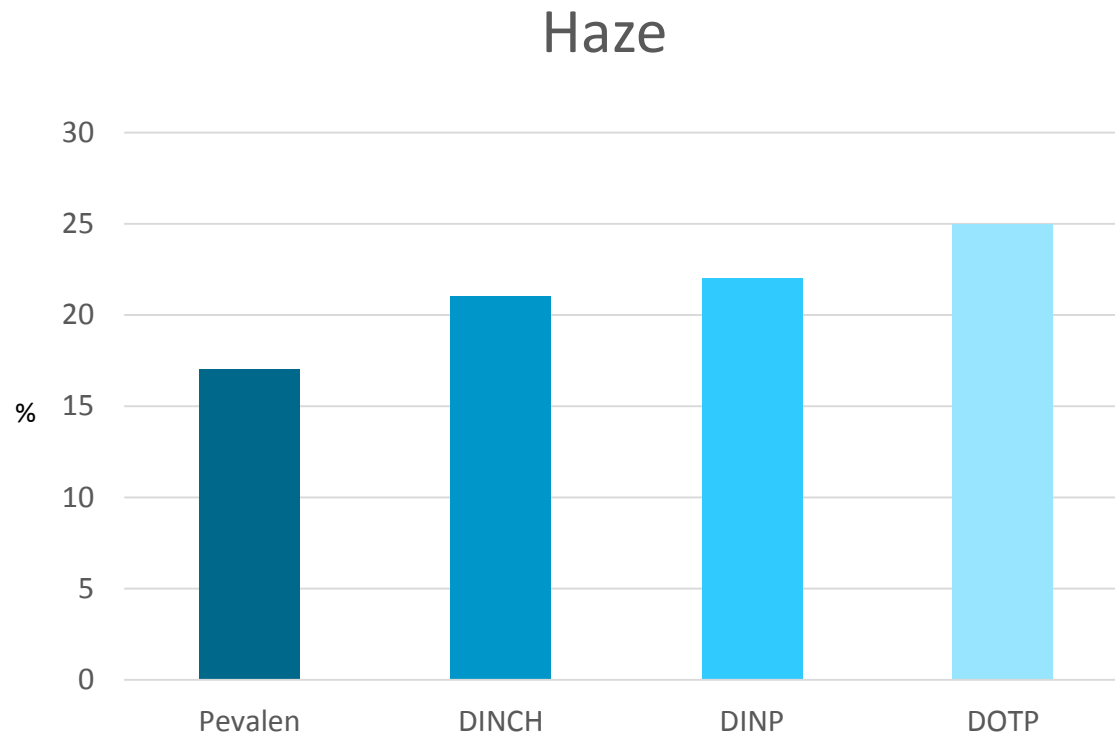
Legislation

Name	Solubility parameter (J ^{1/2} cm ^{-3/2})	Weight Loss (%)	Viscosity (mPas, 20°C)	Molecular weight (g/mol)
PVC	19.40			
Pevalen	18.39	11	35	472
DOTP	17.94	15	86	390
DINCH	16.76	19	52	420



Compatibility

Pevalen™ lower haze is a response to higher compatibility



Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



Compatibility

Pevalen™ higher weight flow is a response to higher compatibility

Compatibility

Processing

Hardness

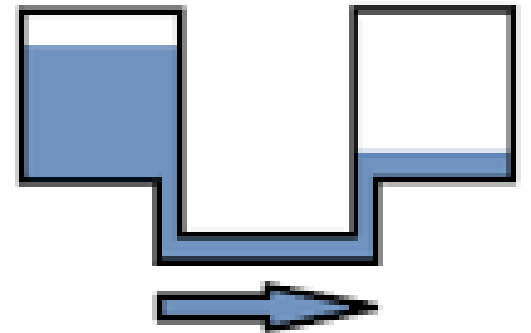
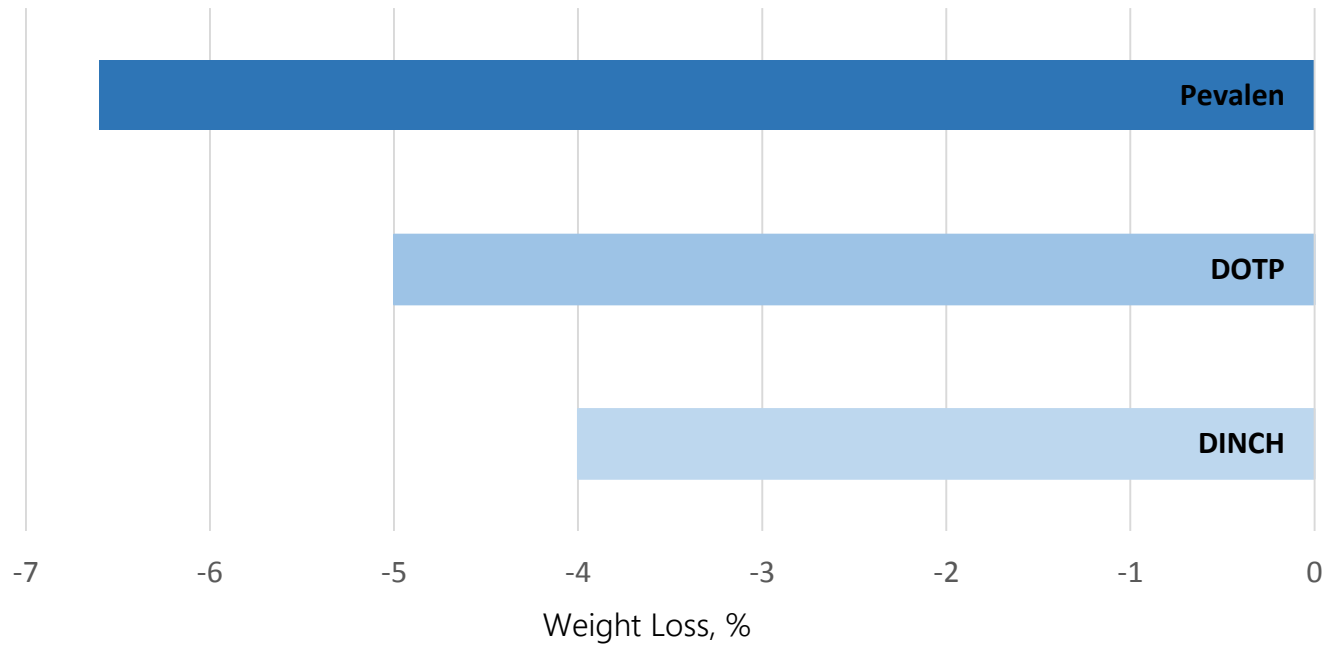
Viscosity

Plastisol stability

Sustainability

Legislation

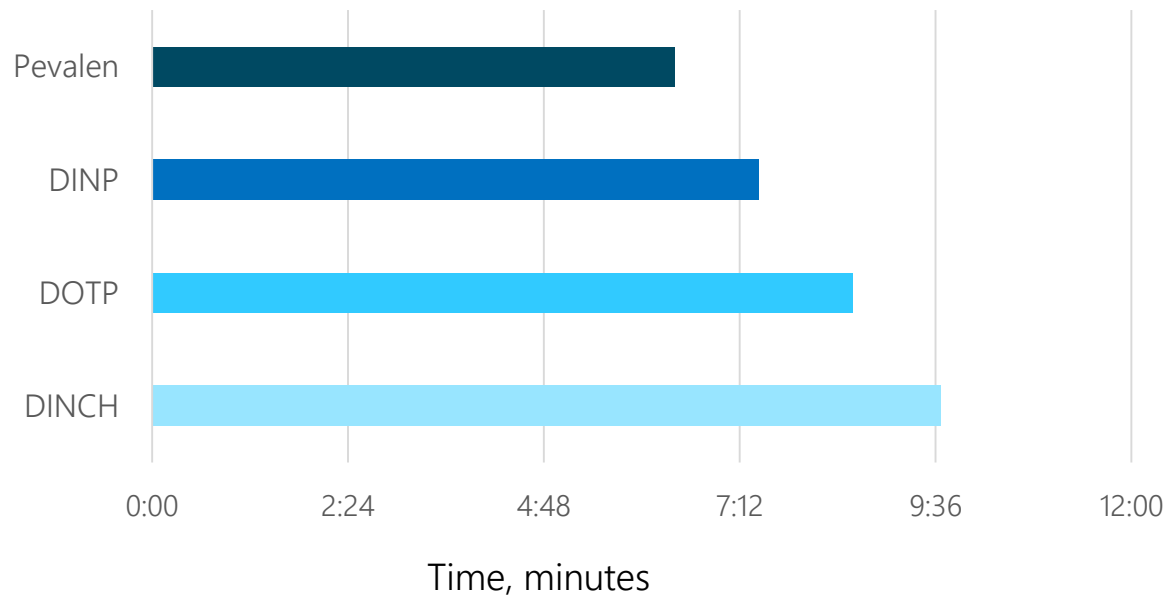
Diffusion from P-PVC to U-PVC



Plasticizer absorption time

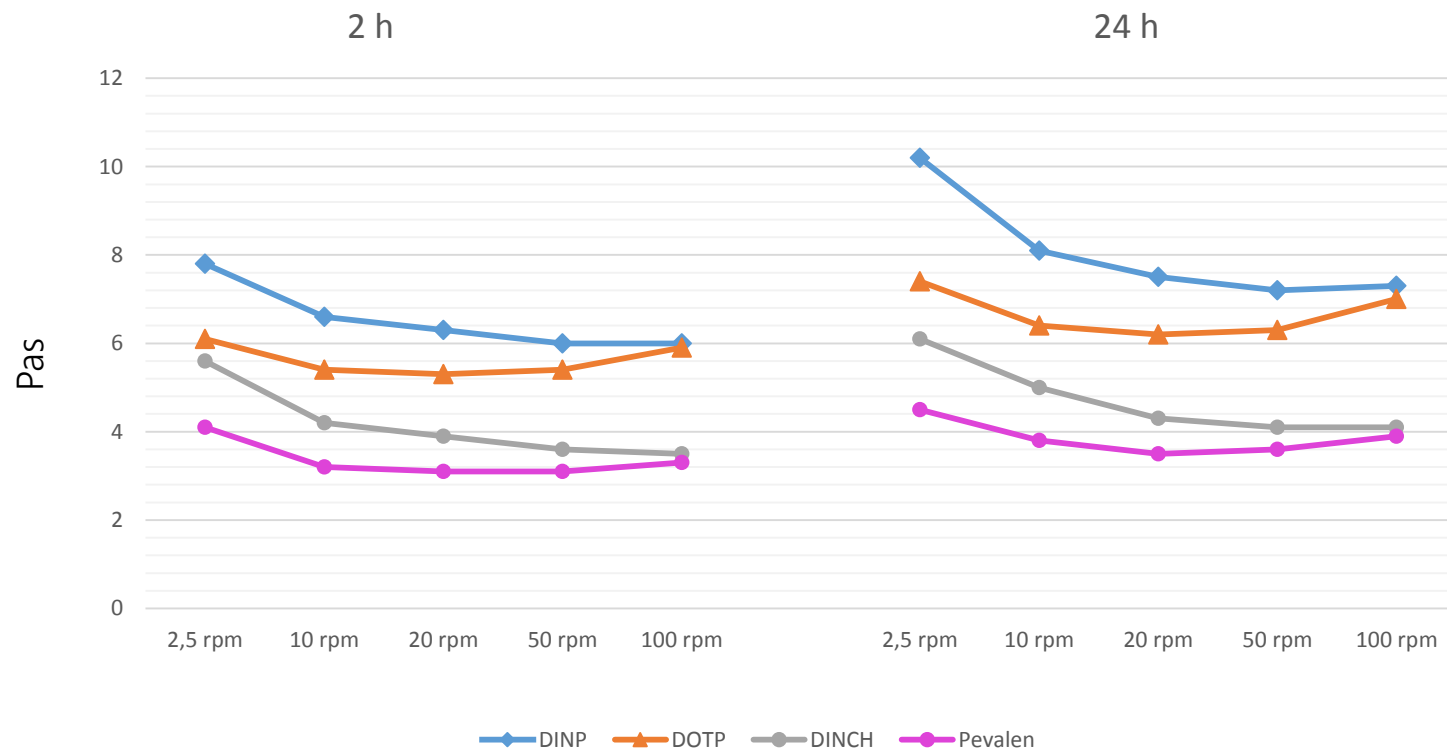
Pevalen™ has shortest absorption time
 → faster dry mixing processing, hence less energy required

Compatibility
 Processing
 Hardness
 Viscosity
 Plastisol stability
 Sustainability
 Legislation



Brookfield viscosity 2h and 24h

Pevalen™ yields plastisol with low initial viscosity and keeps its viscosity well over time



Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

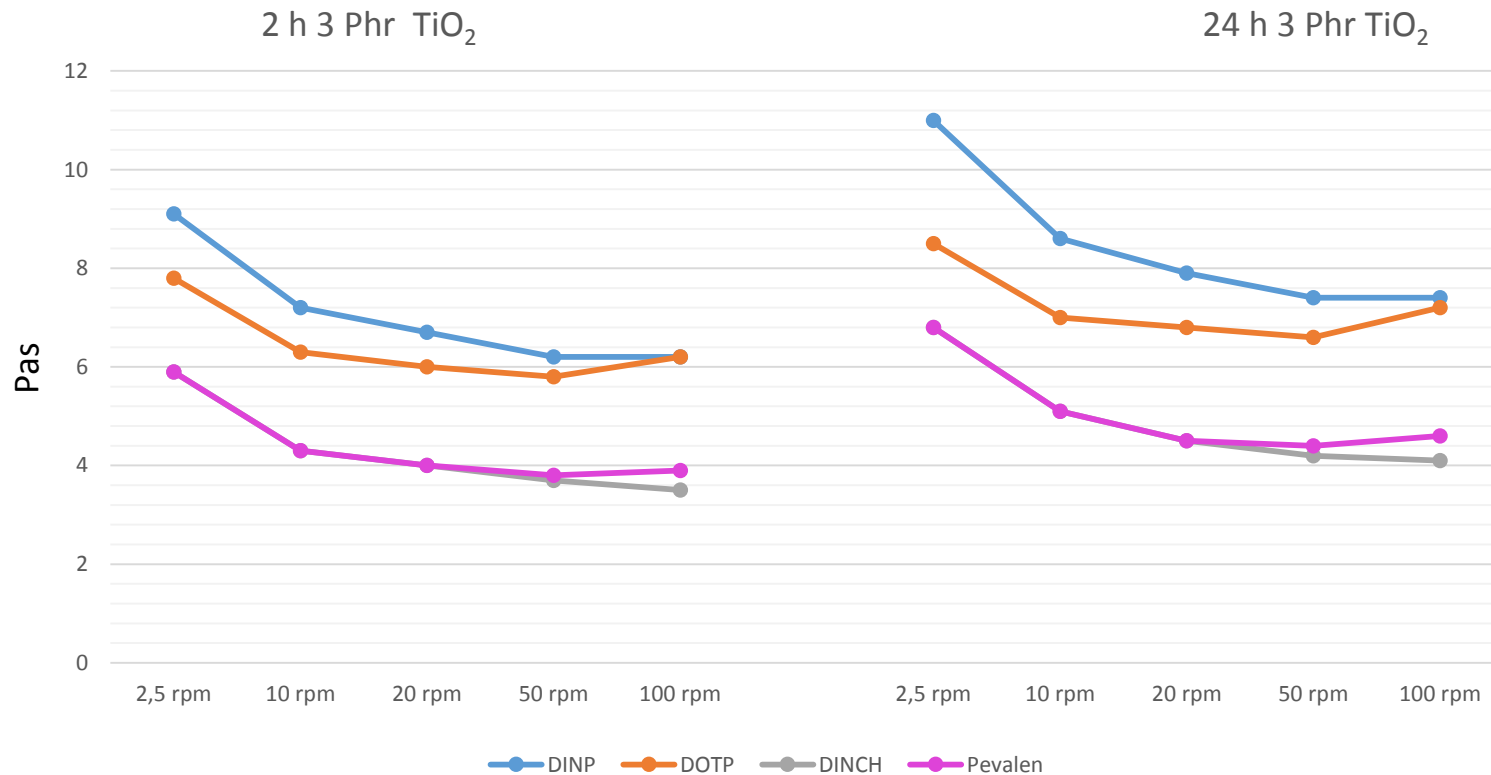
Legislation



Brookfield viscosity 3 Phr TiO_2 2h and 24h

Pevalen™ yields plastisol with low initial viscosity and keeps its viscosity well over time

Compatibility
Processing
Hardness
Viscosity
Plastisol stability
Sustainability
Legislation



Solution temperature

Pevalen™ has a higher solution temperature, but...

Name	Solution Temperature, °C
DOTP	130
DINCH	135
Pevalen	141

Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



Gelation

... Pevalen™ has faster gelation
 → enables high volume manufacturing and energy savings

Compatibility

Processing

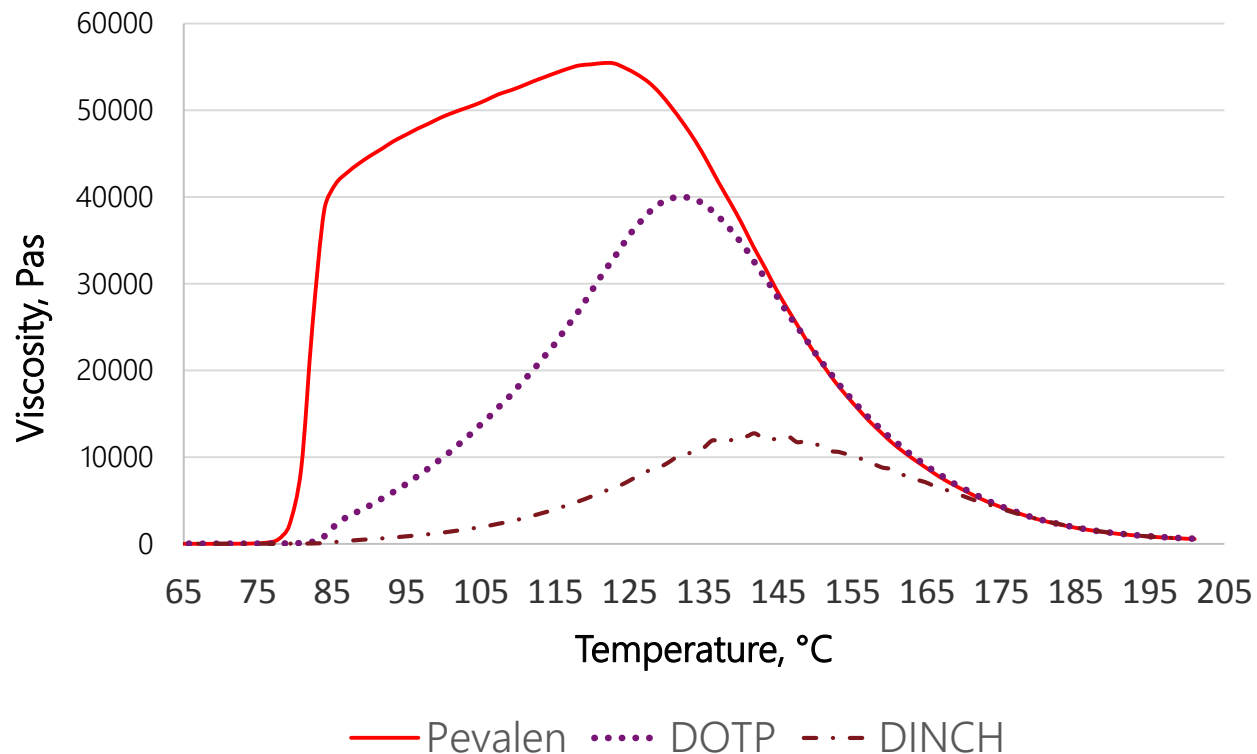
Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



Hardness

Pevalen™ yields softest material

→ less impact on raw material consumption and thereby less environmental impact

Compatibility

Processing

Hardness

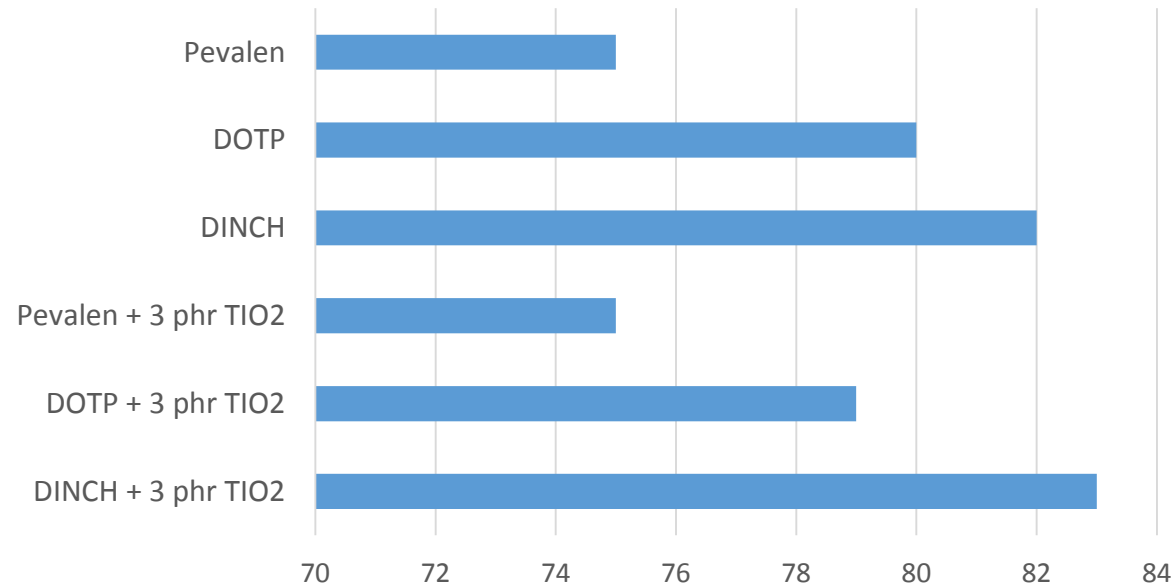
Viscosity

Plastisol stability

Sustainability

Legislation

Shore A in E-PVC



Hardness

Pevalen™ yields softest material

→ less impact on raw material consumption and thereby less environmental impact

Compatibility

Processing

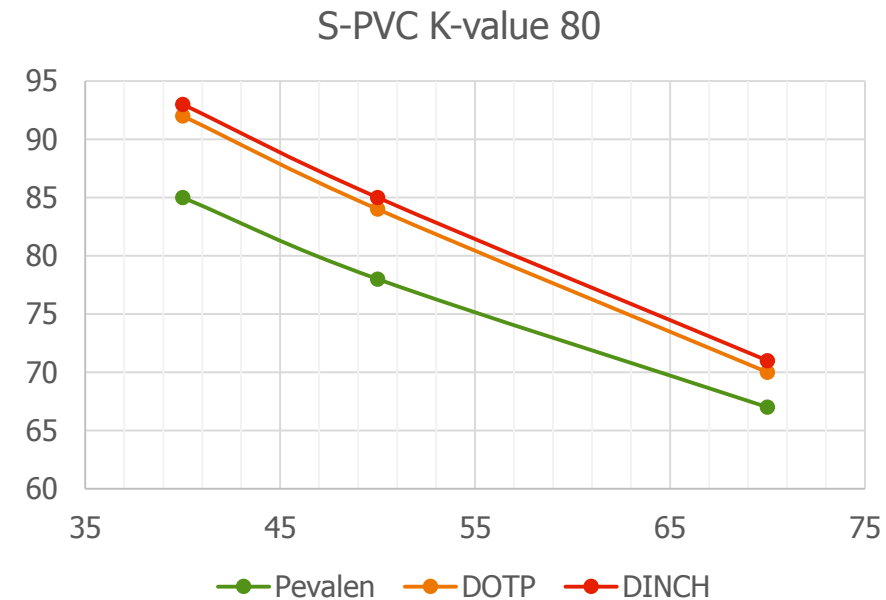
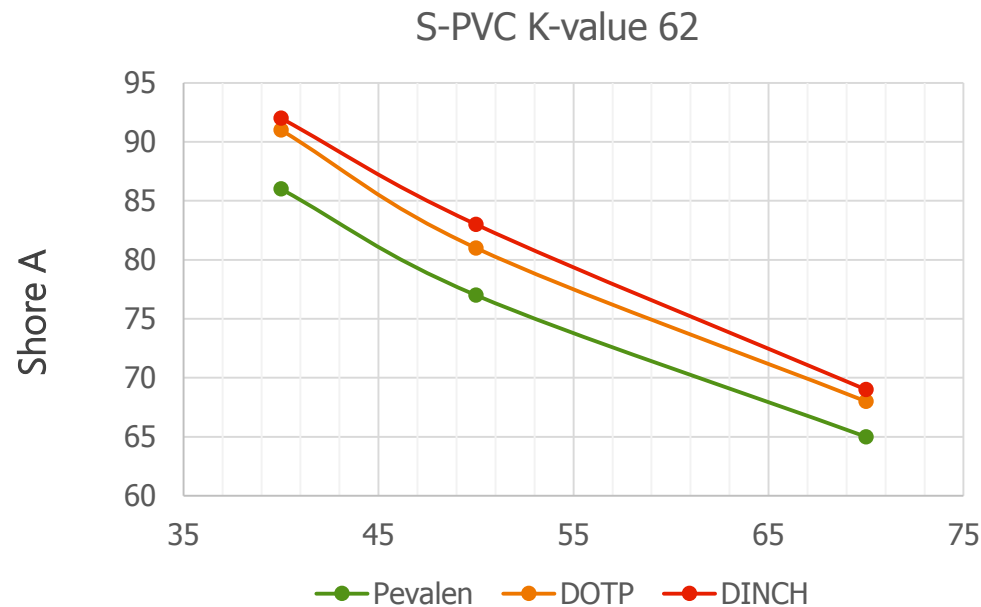
Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



Hardness

Pevalen™ yields softest material

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Compatibility

Processing

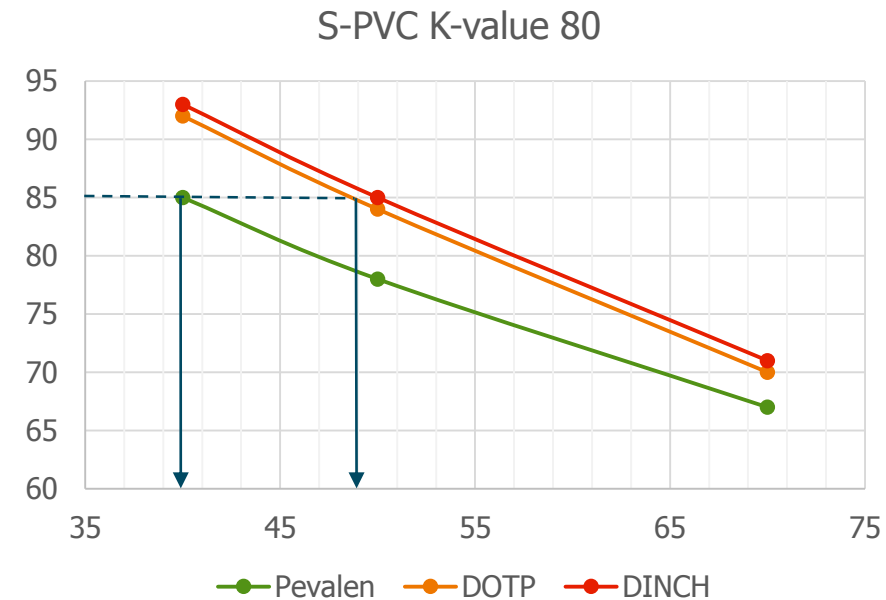
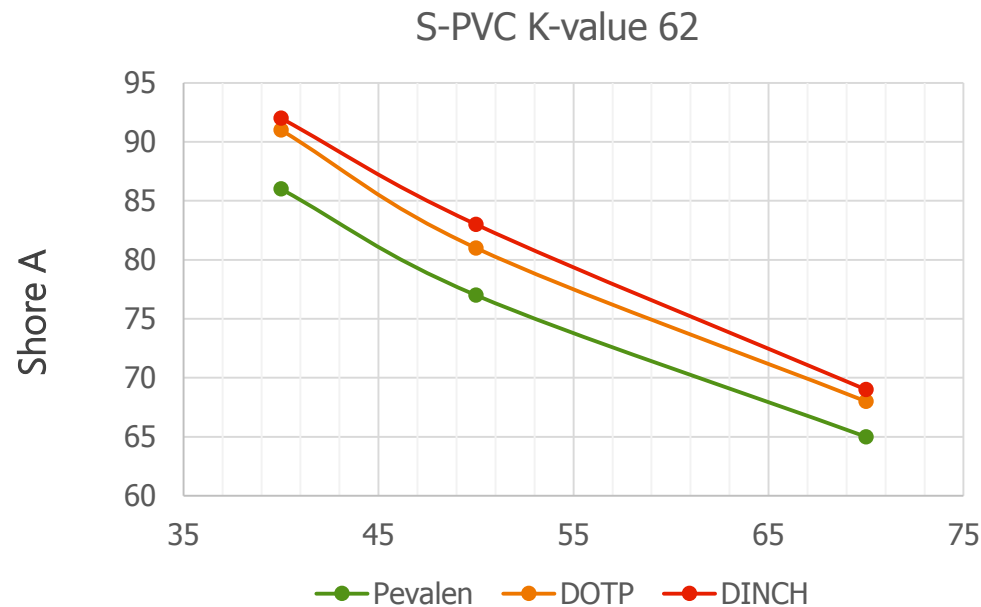
Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



Substitution Factor (S.F) vs DOTP

Pevalen™ yields softest material

→ less impact on raw material consumption and thereby less environmental impact

Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation

S-PVC K-value 52

- Shore A 85
+ SF 1,12
- Shore A 70
+ SF 1,09

E-PVC K-value 69

- Shore A 75
+ SF 1,13

S-PVC K-value 82

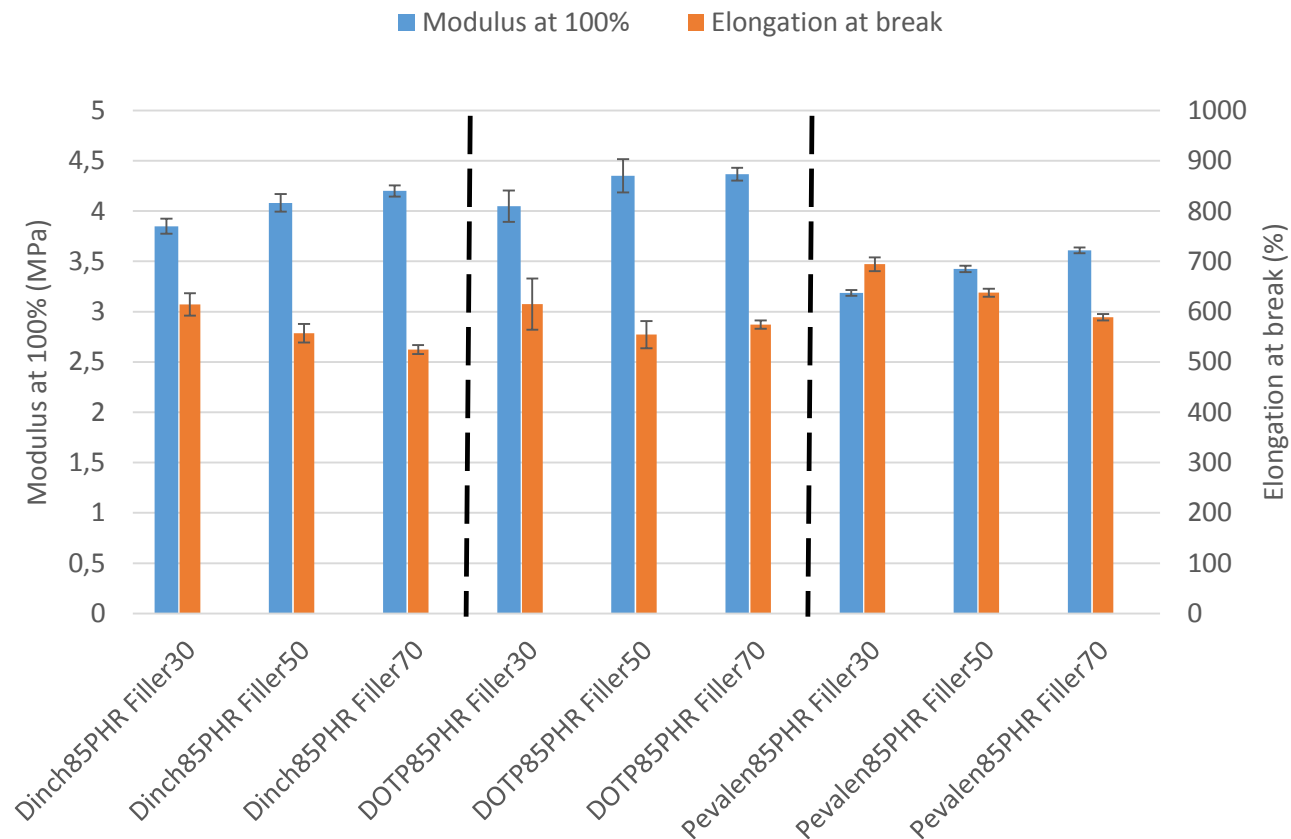
- Shore A 85
+ SF 1,25
- Shore A 70
+ SF 1,09



Tensile – S-PVC

Pevalen™ yields softest material and highest strain
 → enables higher content of filler

- Compatibility
- Processing
- Hardness
- Viscosity
- Plastisol stability
- Sustainability
- Legislation



Efficiency impacts viscosity

Requires BYK additive to counterbalance increased viscosity

Compatibility

Migration

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation

Pevikon P2170	100	100	100	100
Pevalen	50	50	50	50
Dinch	60			
Viskobyk 5120			3,5	7
Baerostab UBZ 711-1 RF	3	3	3	3

Hardness, Shore A	73	74	71	68
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Viscosity, 0h, cP	2050	2900	1850	1450
Viscosity, 4h, cP	2500	3600	2300	1650
Viscosity, 24h, cP	2750	4250	2750	1900
Viscosity, 72h, cP	2600	4850	3000	2050
Viscosity, 168h, cP	2750	5400	3000	1950



PVC grades impacts viscosity

PVC grades is a tool to formulate hardness and viscosity

Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation

Pevikon P2170	100	100			95
Pevikon P602				50	
Solvin 360 NA			50		
Solvin 382 NG			50	50	
Solvin 266 SC					5
Pevalen	50	55	50	50	50
Baerostab UBZ 711-1 RF		3	3	3	3

Hardness, Shore A	74	69	69	69	72
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Viscosity, 0h, cP	2900	2104	2851	3640	2647
Viscosity, 6h, cP		2851	4429	4174	2927
Viscosity, 24h, cP	4250	3462	5371	5371	3894
Viscosity, 48h, cP	4850	3945	5905	5142	4276



Plastisol stability

Proper formulated yields stable pigmented Pevalen™ plastisol

Compatibility

Processing

Hardness

Viscosity

Plastisol stability

Sustainability

Legislation



DOTP



Pevalen



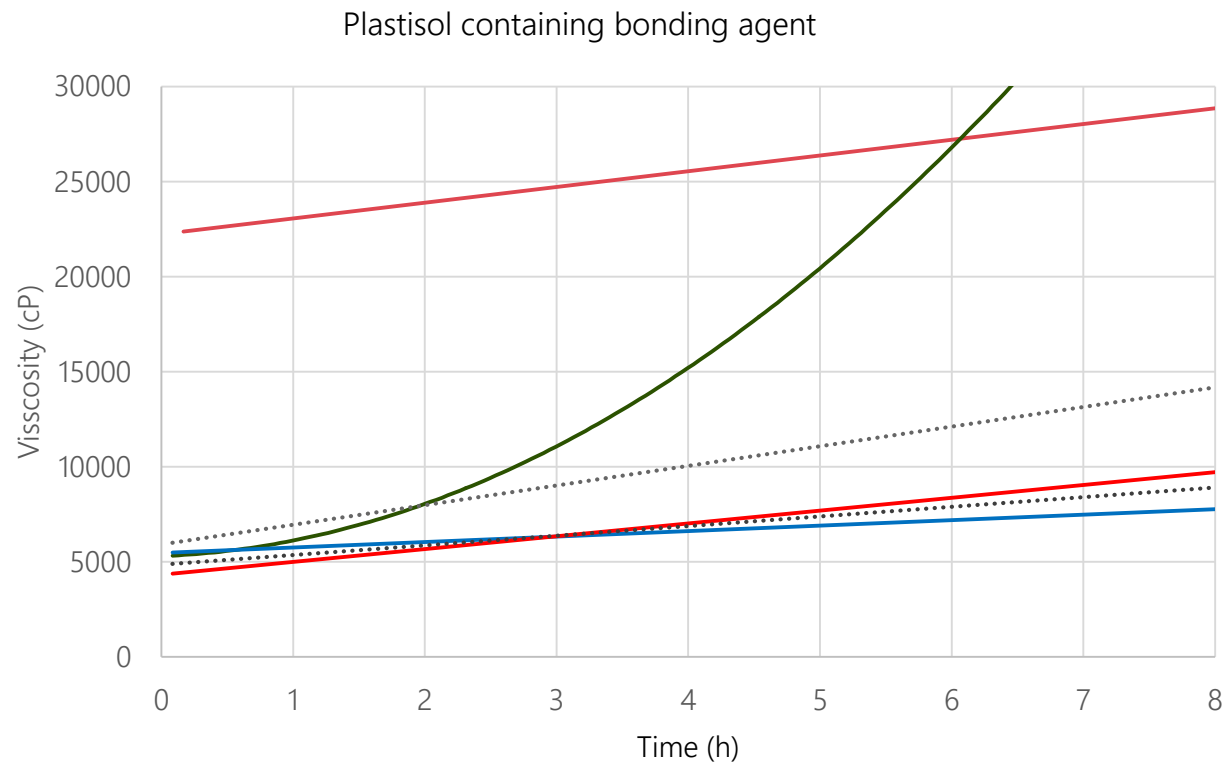
Reformulated Pevalen



Plastisol viscosity

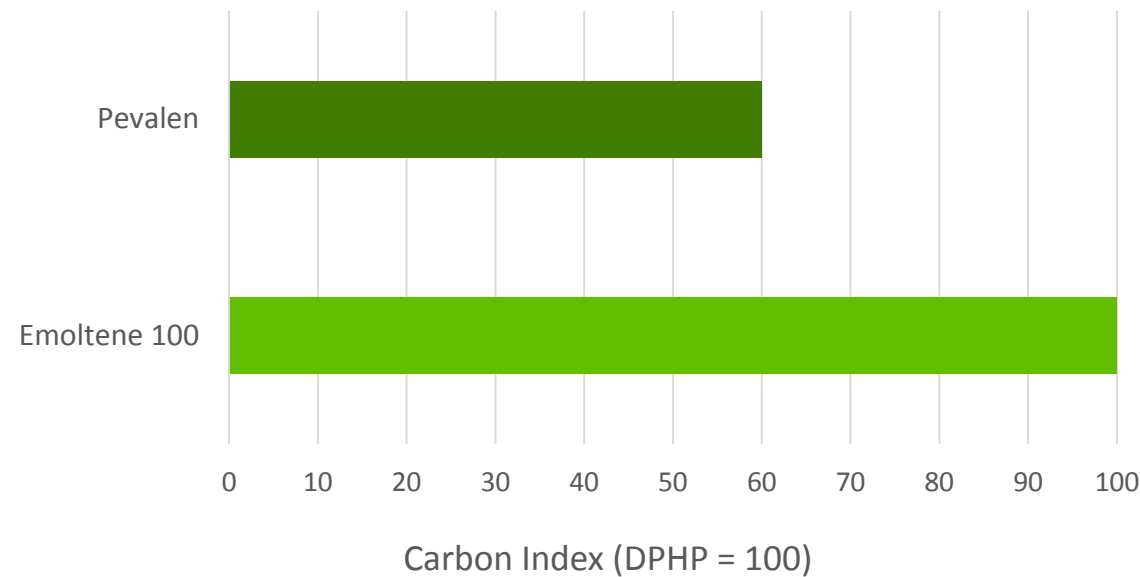
Proper formulated yields retained viscosity

Compatibility
Processing
Hardness
Viscosity
Plastisol stability
Sustainability
Legislation



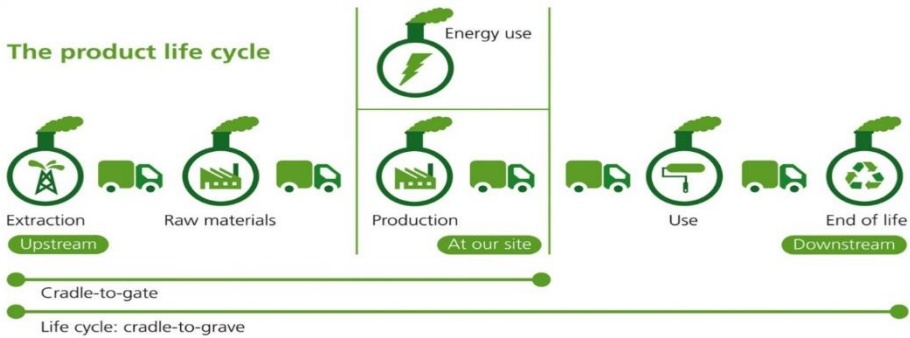
Carbon footprint

Improved sustainability upon Pevalen™ usage*



*DINCH and DOTP are expected to have a higher Carbon Index than DPHP/Emoltene 100 due to production characteristics

- Compatibility
- Processing
- Hardness
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Legislation

- Compatibility
- Processing
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CLASSIFIED PLASTICISERS	NON-CLASSIFIED PLASTICISERS			
	ORTHOPHTHALATES High Molecular weight $\geq 7C$ DINP DIDP DPHP		Sebacates DMS DBS Azelates DIDAz	
Included in REACH Candidate List or pending Authorisation	ORTHOPHTHALATES Low Molecular weight 3-6C DEHP DBP DIBP BBP	Cyclo-hexanoates	Terephthalates DOTP DBT	Adipates DEHA DINA DIDA DTDA
				Alkyl sulfonates ASE
	DCHP	Dibenzoates ODEB OXPDB	Trimellitates TOTM	Phosphate TPP
		Benzoates INB IDB	Vegetable Oil based Expoxidized, hydrogenated and acetylated vegetable oil	Citrates ATBC
				Butyrates
				Valerates

This table is for illustration purposes only. The list of plasticisers is non-exhaustive and box sizes do not accurately represent market volumes.



Changing plasticizer – how hard can it be?

- ❌ Easy replacement with no or little reformulation!
- ❌ Can substitute traditional phthalates easily!
- ❌ One size fits all!
- ❌ Quickly and efficiently switch (from classified DOP)!
- ❌ Substitution



Summary

- Different plasticizer molecular structure gives diverse properties
 - **Pevalen™** structure yields high compatibility improving clarity and the visual appearance
 - **Pevalen™** has a unique combination of high efficiency and low volatility
 - **Pevalen™** has an unique property combination of low viscosity and fast gelation
 - **Pevalen™** will in overall contribute to improved sustainability
- Proper formulating is essential and collaboration is key to success



One molecule
can change everything

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