

THE ULTIMATE POLYMERIC AZIRIDINE INNOVATION

NeoAdd™ PAX

All the performance, half the labeling



DSM

BRIGHT SCIENCE. BRIGHTER LIVING.

Agenda

- Introduction
 - DSM
 - Aziridine Crosslinking
- NeoAdd™ PAX Crosslinkers
 - The products
 - How they Work:
 - Compare and contrast with alternative crosslinkers
 - Reaction Efficiency + Kinetics
 - Application Data
- Conclusions

A brief introduction to DSM

- A 'purpose led, performance driven' science-based company active in Nutrition, Health and Sustainable Living
- Intrinsically innovative company: ~ 20% innovation sales (avg. last five years)
- Strategy well aligned with the UN Sustainable Development Goals
- Our purpose is to create brighter lives for all. We do this by tackling some of the world's greatest challenges – creating value for customers, shareholders, our people and society at large.

For a healthy and sustainable future!

DRF sustainability targets

PRODUCT PORTFOLIO

2025



0%

Phase out all Chemicals of High Concern from our finished products.

2030



- 28 %

Reduce GHG emission intensity (of scope 3) by 28% compared to 2016, to reduce our raw material carbon footprint.

2030



30%

At least 30% bio-based and/or recycled raw materials

A breakthrough innovation for low-toxicity crosslinking

NeoAdd™ PAX, a world-first polymeric aziridine crosslinker product family for waterborne coating systems, allows paint manufacturers, ink formulators and converters to retain all the high-reactivity performance benefits of traditional aziridines while only being burdened with the minimal labeling requirements typically associated with carbodiimides.



Labeling advantages of a low toxicity profile

NeoAdd™ PAX-521 & 523

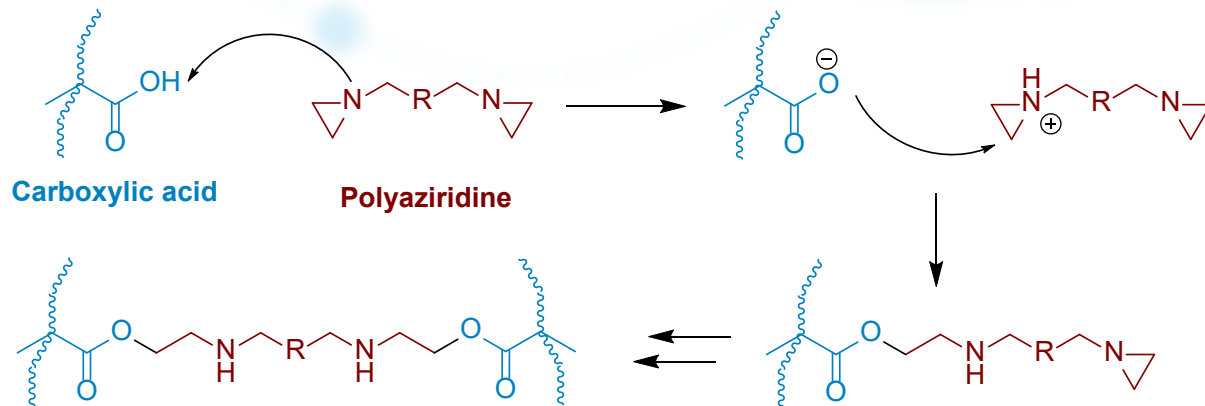
Polymeric Aziridines

* Related to the delivery solvent

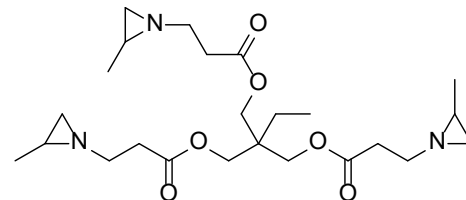
* *Skin sensitizer tests in progress

Aziridine Crosslinking 101

Aziridine groups react efficiently with **carboxylic acids** present in acrylic, polyurethane and polycondensate binders:



Crosslinker CX-100 is a classic polyaziridine crosslinker.

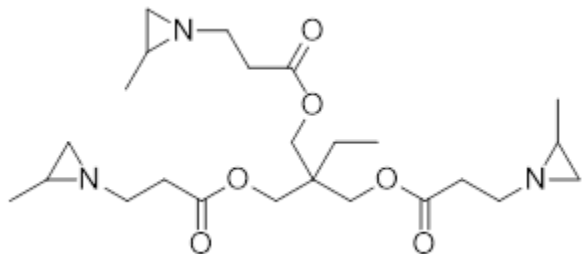


A safe and sustainable crosslinker: Polymeric aziridine

NeoAdd™ PAX's major benefits versus standard aziridines

- Low toxicity thanks to its high molecular weight
- Longer pot life due to its specially designed structure

Traditional aziridine (Crosslinker CX-100)



Molecular weight 467 Dalton

Polymeric aziridine (NeoAdd™ PAX-521 & 523)



Polymer backbone

Molecular weight >>1000 Dalton

Genotoxicity testing

NeoAdd™ PAX is non-genotoxic and non-mutagenic – providing a safer, more sustainable alternative to traditional aziridines.

Genotoxicity is the main limiter for use of traditional aziridines

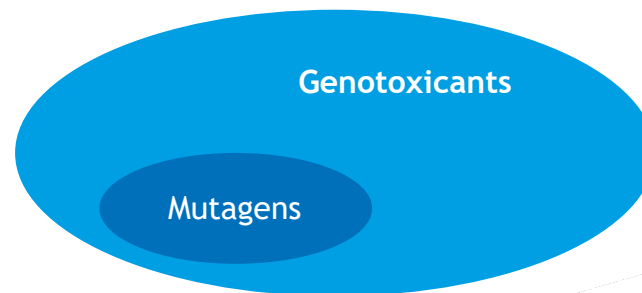
- NeoAdd™ PAX passed both the mutagenicity Ames test and Toxtracker test for genotoxicity. The Toxtracker test boasts 95% reliability vs only ~60% for the well-known AMES test

Mutagenicity is not synonym of genotoxicity (!)

- A mutagen creates a DNA damage that can be transmitted to the daughter cells, which could degenerate to different diseases (as cancer)
- A genotoxicant is defined as a substance causing ANY type of DNA damage, which may not always lead to a transmittable mutation and / or a disease

In summary:

- All mutagens are genotoxicants
- Not all genotoxicants are mutagens



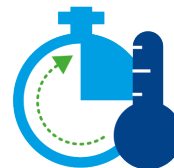
All the performance, half the labeling



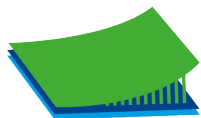
Low toxicity reduces
labeling
requirements



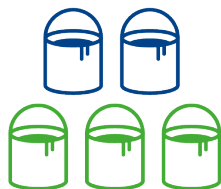
Excellent
chemical and
scratch
resistance



Quick and efficient
processing: crosslinks
at room temperature;
no need for stoving



Outstanding
adhesion to wide
range of substrates



Excellent potlife: up
to 7 days
depending on pH



REACH compliant ✓
TSCA & DSL pending
China ✓

NeoAdd™ PAX-521

NeoAdd™ PAX-521

Ideal for ink manufacturers and converters, NeoAdd™ PAX-521 is specially designed for use in water-based inks, lacquers, coatings and adhesives. It is non-genotoxic and expected to be Swiss Ordinance approved. NeoAdd™ PAX-521 is supplied as an 80% solution in ethyl acetate for use in various inks and coatings to improve chemical resistance and mechanical properties as well as enhance adhesion.*

** Toxicological tests have proven that NeoAdd™ PAX-521 and NeoAdd™ PAX-523 are non-genotoxic alternatives to crosslinkers currently in use. These test results were used as a basis for our petition to the Swiss Authorities regarding the polymer(s) in this product. We are expecting a positive response from the Swiss Authorities prior to November 30, 2020.*

A DSM patent-pending technology



NeoAdd™ PAX-523

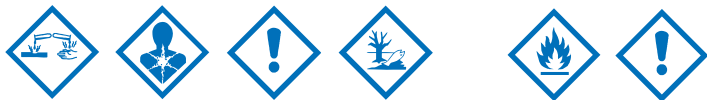
NeoAdd™ PAX-523

Developed for paint manufacturers, NeoAdd™ PAX-523 is specifically designed for use in waterborne industrial and architectural coating systems where superior performance is required. NeoAdd™ PAX-523 is supplied as an 80% solution in methoxy propyl acetate and can be used in a wide range of paints, floor coatings, plus leather and textile coatings to improve their chemical resistance and mechanical properties.

A DSM patent-pending technology



Labeling advantages of a low-toxicity profile



Traditional
Aziridine

Carbodiimide



NeoAdd™ PAX-521 & 523
Polymeric Aziridines

- * Related to the delivery solvent
- ** Skin sensitizer tests in progress

A DSM patent-pending technology



Drilling down into crosslinker qualities...

Two of the main types of crosslinkers used with carboxylic acid and functional in waterborne coatings

1. Aziridine
2. Carbodiimides
 - Carbodiimide crosslinkers are safer but compromise performance

	Aziridines	Carbodiimides
Cure	Room T cure	80C cure required
Addition %	2-3% on coating	5-10% on coating
Price/kg	Lower	Higher
Performance	Excellent	Good
Value in use	High	Low
Potlife	> 8 hours	Days
Ease of mixing in	Easy	More difficult
Toxicity	Bad	Good

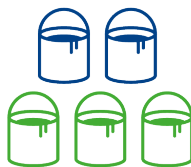
All the performance, half the labeling

Crosslinker	Isocyanate	Acid 2C	Aziridine	CDI	NeoAdd™ PAX
Potlife	1-6h	<8h	>8 hours	Days	Days
Reacts with	OH/NH/water		COOH	COOH	COOH
Toxicity					
Cost					
Performance	++	+	+	+/-	+
Resin type	Solvent/water	Solvent	Water	Water	Water

Our new, next-generation polymeric aziridine crosslinker combines high reactivity with low toxicity

But don't just take our word for it.

Let the performance data speak...



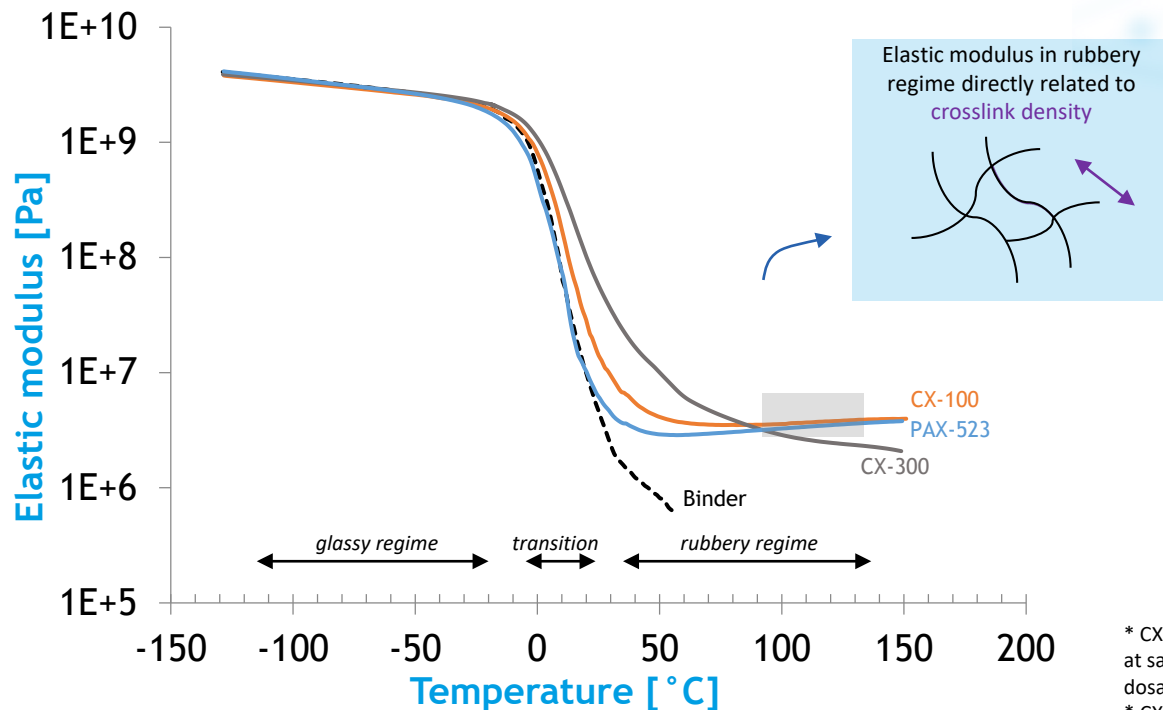
Crosslinking efficiency and reaction kinetics

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Crosslinking efficiency

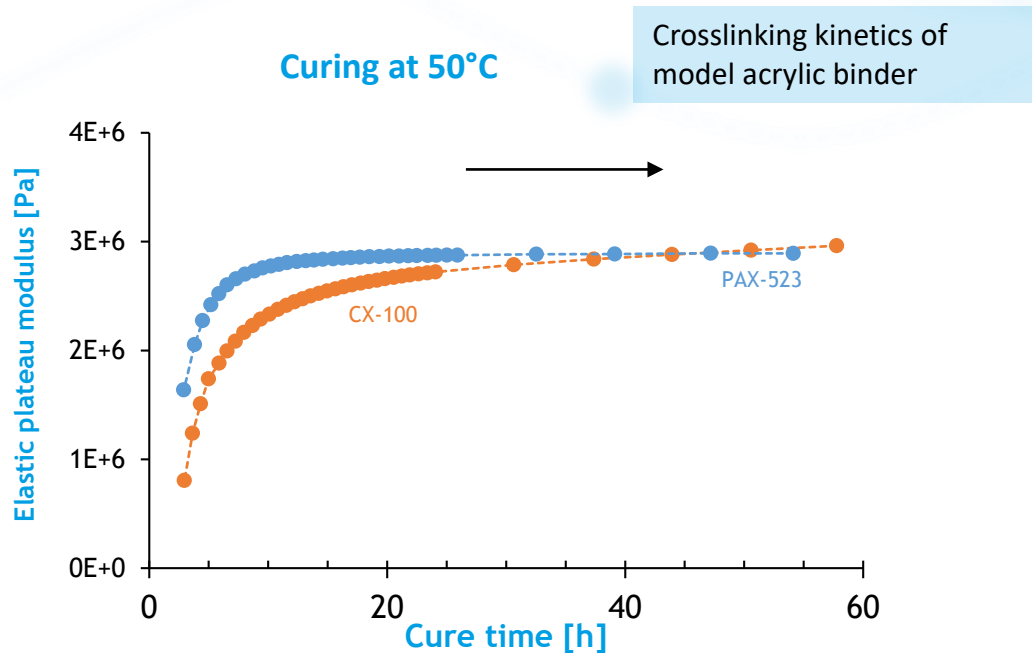
Fully cured model acrylic binder using different crosslinkers



- New polymeric crosslinker reaches similar crosslink density to traditional CX-100
- CX-300 alternative behaves differently and does not efficiently form network

* CX-100 and PAX-523 added at same equivalent aziridine dosage
* CX-300 added at 4 times weight dosage of CX-100

Reaction kinetics of NeoAdd™ PAX at 50°C

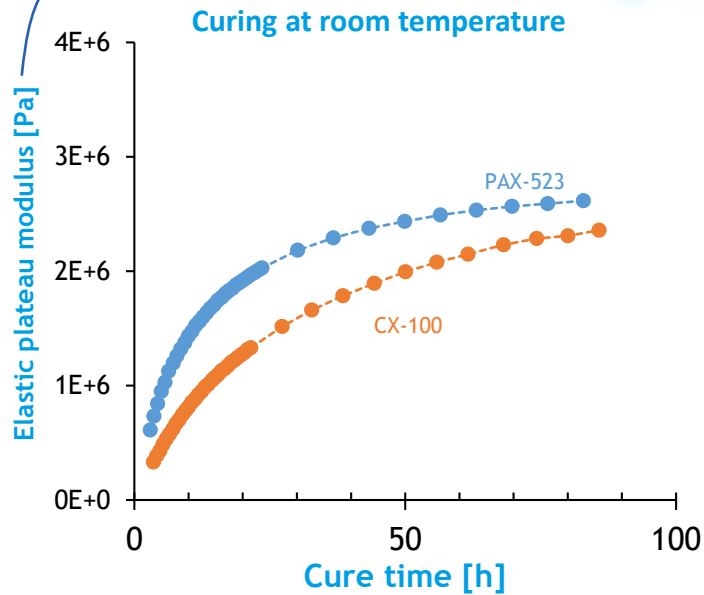


NeoAdd™ PAX-523

Reaction kinetics with PAX-523 are faster compared to CX-100 at 50°C

Reaction kinetics of NeoAdd™ PAX at Room Temperature

Elastic modulus represents network build-up and is directly related to crosslink density



NeoAdd™ PAX-523

Reaction kinetics with PAX-523 are faster compared to CX-100, both at room temperature.

Kinetics are slower at room temperature compared to 50°C, but similar end crosslink efficiency reached.

Wood coating, mechanical performance

*Floor coating formula based on NeoCryl® XK-12
(self-crosslinking acrylic)*

Formula based on		XK-12	XK-12	XK-12	XK-12
X-linker		blank	CX-100	CX-300	PAX-523

Dry properties: König hardness

1 Day RT	(s)	88	69	85	88
7 Days RT	(s)	120	112	123	112

Dry properties: BHMR

Test chart: 1 day RT	black marking	1	2	1	2
Test chart: 7 days RT	black marking	0	3	0	3
Test chart: 1 day RT	damage	1	4	1	2
Test chart: 7 days RT	damage	0	4	0	3
oak: 7 days RT	black marking	1	4	1	3
oak: 7 days RT	damage	1	5	1	5

Dry properties: Mechanical

		4	22	4	18
Nail scratch resistance		1	2	2	2

CX-100: 3 functional aziridine crosslinker - CX-300: Carbodiimide crosslinker
All coatings dried at RT for 1 week

A DSM patent-pending technology



Wood coating, stain resistance performance

*Floor coating on oak based on NeoRez® R-2180
(self-crosslinking polyurethane dispersion)*

Formula based on		R-2180	R-2180	R-2180	R-2180
X-linker		blank	CX-100	CX-300	PAX-523
Dry properties: Chemical resistances (oak)					
Water: 16h	recovery	5	5	5	5
Ethanol, 48%: 1h	recovery	2	5	4	5
Coffee: 16h	recovery	3	4	1	3
Tea: 16h	recovery	5	5	4	5
Andy detergent: 16h	recovery	5	5	5	5
Dreft detergent: 16h	recovery	5	5	5	5
Ammonia, 10%: 2m	recovery	4	5	5	5
Ammonia, 10%: 10m	recovery	3	5	3	5
Ammonia, 10%: 1h	recovery	2	5	3	5
Acetic acid 10%: 1h	recovery	5	5	5	5
Total after recovery oak		39	49	40	48

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Adhesion promotion

*Velvet formulation based on NeoRez® R-1038,
coated on BOPP film*

	R-1038	R-1038	R-1038	R-1038
X-linker	None	CX-100	CX-300	PAX-523
Addition factor	0	1	2.5	3.2
Appearance form. in jar	Good	Good	Good	Good
Coating appearance	Good	Good	Good	Good
Adhesion				
Initially	0	0	10	100
After 1 week	5	100	100	100
Coating appearance	Good	Good	Good	Good
Soft feel	Good	Good	Good	Good
Gloss	5/39	6/40	6/39	7/34
Haze	97	96	96	95
Sutherland rub test				
25 rubs	1	4	3	5
300 rubs	1	2	2	2
Dry Davenport				
Initially	0	39	13	40
After 1 week	0	0	0	0

60/85

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Conclusions: NeoAdd™ PAX Polymeric Aziridines

- Aziridine crosslinkers that are non-mutagenic and non-genotoxic
 - Aziridine performance with carbodiimide labelling
- Supplied 80% solids in ethyl acetate or methoxy propyl acetate
- Recommendations for Use
 - WB coatings & inks containing carboxylic acid functional binders
 - Improve chemical resistance & mechanical properties
 - Improve adhesion to difficult substrates
 - 4% - 6% Dosing based on resin solids of the system
 - Ladder study recommended
- For more information or a free sample
 - Please contact your DSM sales representative or Distributor
 - [DSMCoatingResins.com](https://www.DSMCoatingResins.com)

Questions?

- Thank you for attending this webinar!
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