Carbodiimide crosslinkers

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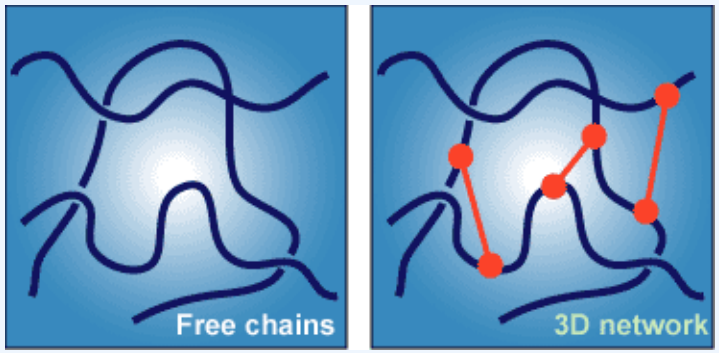
Crosslinking

2K systems

In a “real 2K system” the binder is synthesized during application, by means of a reaction between a polyol and an isocyanate crosslinker. In this case, if there is no crosslinker there is no binder.

Polymer + crosslinker

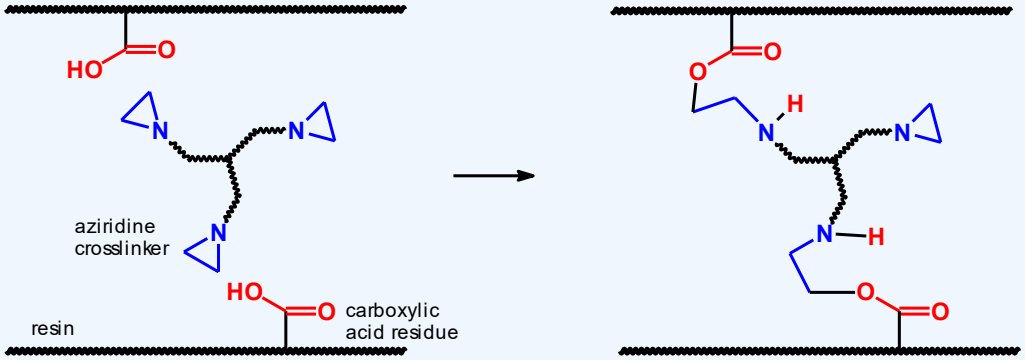
Stahl Polymers binders are already polymerized and film forming. Function of the crosslinker is to improve specific characteristics (mechanical properties, chemical resistance,...).



Main types of crosslinkers

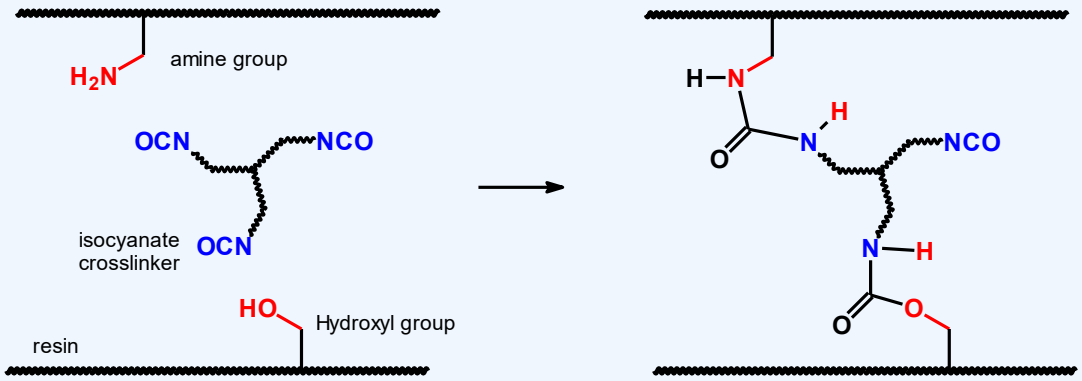
- Aziridines
- Isocyanates
- Polycarbodiimides
- Melamines

Aziridine



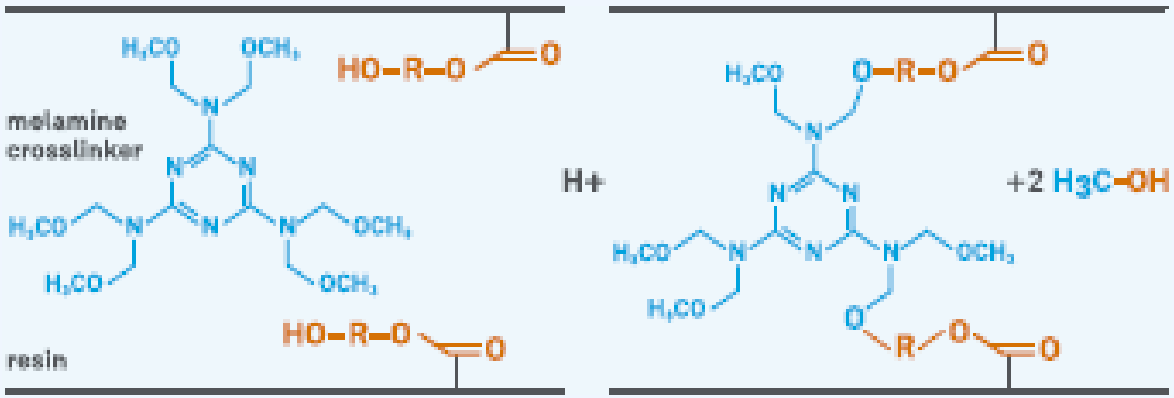
Aziridines are very effective and allow long pot lives... but they are hazardous chemicals!

Isocyanate



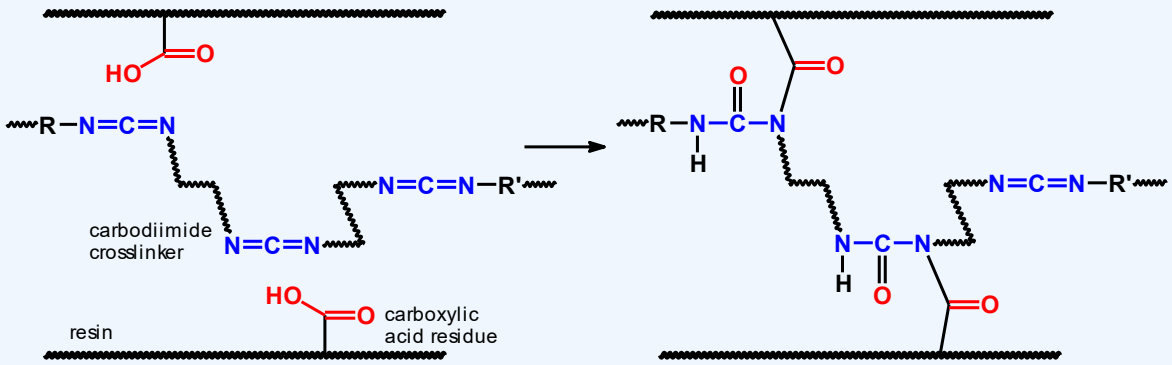
Isocyanates are versatile and effective, but pot lives are short due to their sensitivity to moisture. Less severe labelling than aziridines.

Melamine



Melamine crosslinkers react with –OH groups at high temperature (150ºC) so they are used in oven curing systems in combination with specific binders

Polycarbodiimide (CDI)



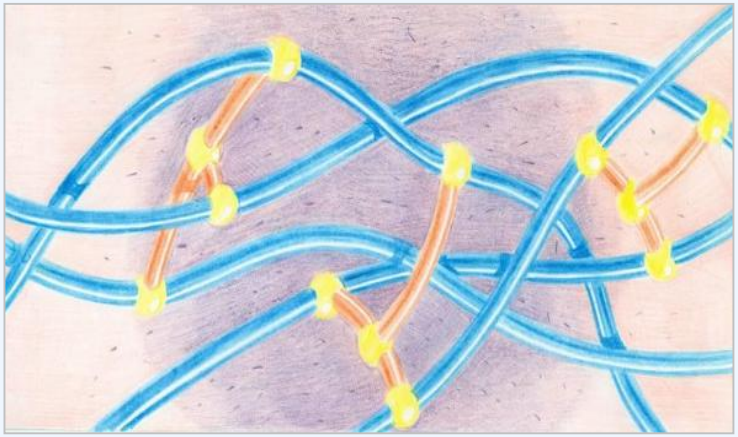
Carbodiimide groups –N=C=N- react with carboxylic groups –COOH at room temperature. Polycarbodiimide crosslinkers are label-free and allow to achieve long pot lives.

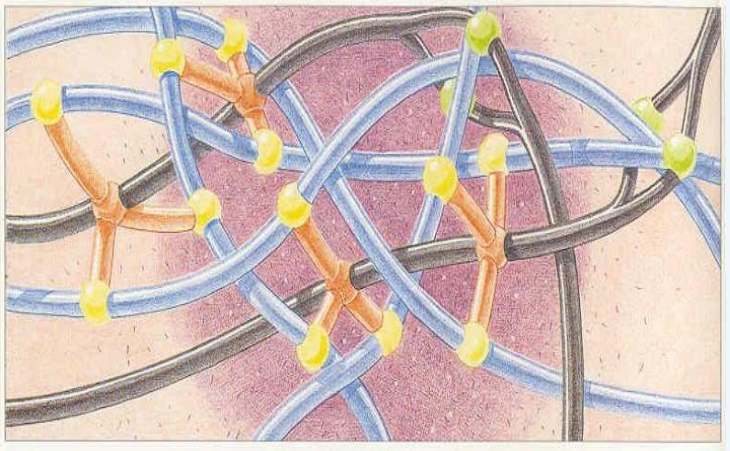
Crosslinkers comparison

	Polycarbodiimide *	Isocyanate	Aziridine	Melamine
Reactivity	-COOH	-OH, -NH_2, water	-COOH	-OH
Pot life	Up to weeks	Up to 6 h	12 h	Very long
GHS symbols	none			
R-phrases	none	R43/52/53	Muta. Cat 3, R22/38/41/43/68	Carc. Cat 2 R43/45/52/53
Moisture sensitivity	low	very high	high	low
Gas release	none	CO_2	none	none

(*) Not all products have all properties

Normal and multifunctional CDI





Normal polycarbodiimides contain –N=C=N- as only functional group
Multifunctional ones contain a 2nd reactive group that creates an extra crosslinking network and helps to achieve even better performance.

Summary of Stahl CDIs

Product	Physical state	Type	Active matter (%)	g/eq. (on act. matter)
Picassian® XL-701	Fluid liquid	Multifunctional	50	590
Picassian® XL-702	Fluid liquid	Waterborne	40	540
Picassian® XL-725	Viscous liquid	Multifunctional	100	700
Picassian® XL-732	Fluid liquid	Waterborne	40	460

Notifications of Stahl Polymers' CDIs

Country	Australia	Canada	China	Europe	Japan	Korea	Philippines	USA
Inventory	AICS	DSL/NDSL	IECSC		ENCS	ECL	PICCS	TSCA
XL-701	⊖	✓ max 21 MT/y	✓	⊕	✓ max 1 MT/y	⊖	✗	✓
XL-702	✓	✓ max 25 MT/y	⊖	⊕	✓	⊖	✗	✓
XL-725	⊖	✗	⊖	⊕	✓ max 1 MT/y	⊖	✗	✓
XL-732	⊖	✓ max 25 MT/y	⊖	⊕	✓	⊖	✗	✓
	✓	Compliant	⊖	under preparation				
	⊕	Exemption	✗	not yet planned to comply				

Tips for application

- CDIs react with carboxylic groups. At pH ≥ 8.5 carboxylic groups are in the inert carboxylate form, therefore: binder formulation at pH ≥ 8.5 → LONG POT LIFE
- Reaction takes place at room temperature
- Once the coating is applied, volatile amines evaporate, pH drops and crosslinking reaction starts
- 2nd reactive group of multifunctional CDIs is sensitive to water, in this case pot life is up to 12 h. These products should be stored under protective atmosphere
- Optimum quantity of CDI must be found out through lab work, but it is usually 3 to 7% on binder formulation
- Crosslinking effectivity is evaluated by means of chemical resistance test

Examples of application

Binder	CDI	Chemical	Resistance without CDI	Resistance with CDI
Picassian® AC-126	6% Picassian® XL-701	Ethanol 48%	3	5
Relca® HY-460	3% Picassian® XL-725	Ethanol 48%	1-2	4
Relca® PU-477	2.5% Picassian® XL-725	Ink	3	5
Relca® PU-674	7% Picassian® XL-732	Acetone	3	5
Relca® PU-625	6% Picassian® XL-701	Ethanol 48%	1	5

Summary of CDIs

- Polycarbodiimides are a good alternative to isocyanate and aziridine crosslinkers
- They react with the carboxylic groups in the binder
- Right combination “binder – CDI” has to be found empirically (lab tests)
- Benefits of CDIs include:
  - ❑ improved chemical resistance
  - ❑ improved adhesion
  - ❑ no classification/labelling
  - ❑ long pot lives
  - ❑ no gas release
  - ❑ reaction at room temperature