Foga samman

Inom industrin:

- mekanisk fastsättning
- med adhesiv
- med värme eller
- med enbart lösningsmedel

Svårt uppnå reversibilitet

Limning

- Tillräckligt nära för sekundära krafter att uppstå

Plastytan mikroskopiskt sett toppar och dalar

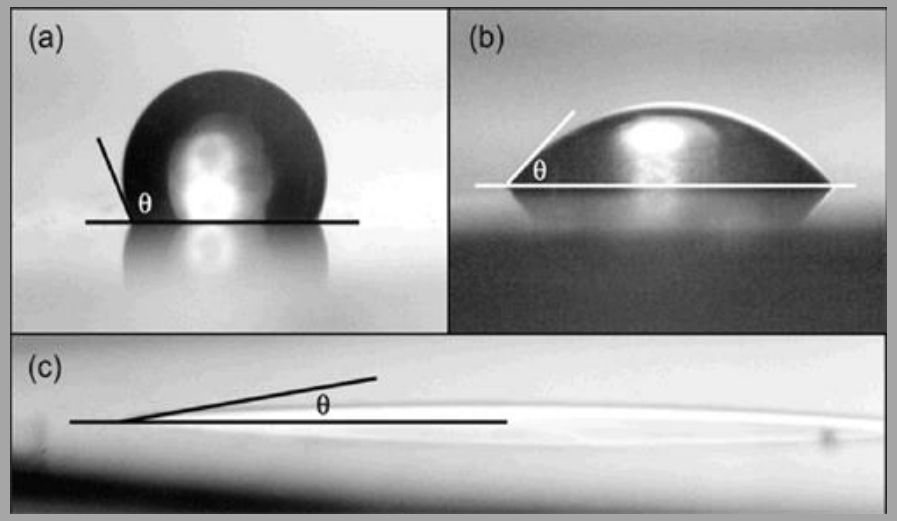
- väta ytan, undantränga luft eller föroreningar

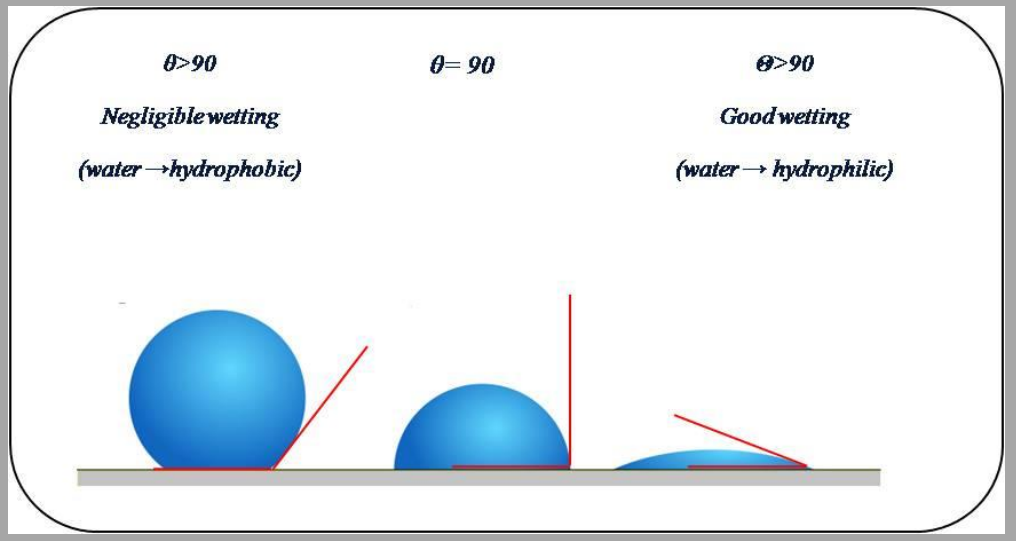
- Faktorer: ytspänning, viskositet, temperatur och ytans form

Faktorer som påverkar plasternas beteende

- deras kemiska struktur
- vilka slags bindningar
- molekylvikten
- makrostrukturen

- Vätning – kontakt på molekylär nivå
- God vätning ger större kontaktyta, möjlighet för van der Waal och vätebindningar att utvecklas
- Beakta ytspänning – för att väta behöver adhesivets ytenergi var lägre än det som ska limmas
- Många plaster låg ytenergi, svårt hitta möjliga limmer för etenplast, propenplast och teflon



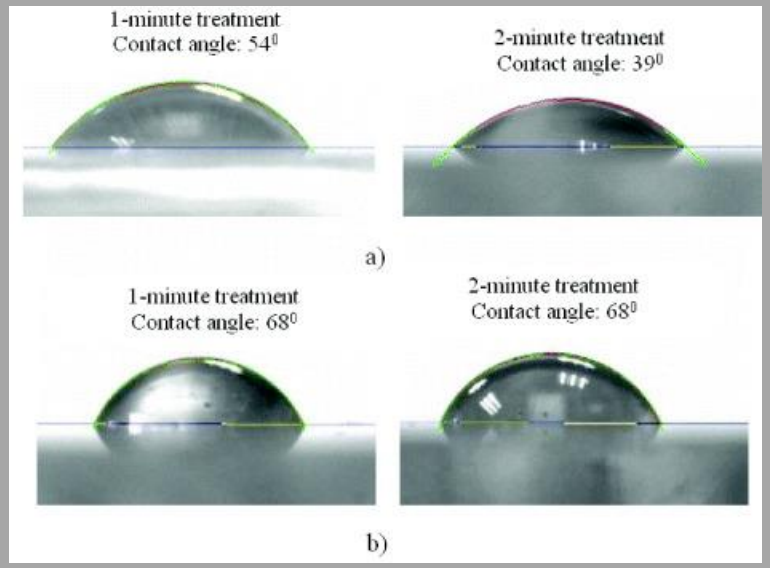


- Vatten 73 mN/m

flesta plaster 30-45 mN/m, ex. så låg som silikon 18 mN/m

- Vikt av rena ytor

- Svåra PE, PP, vissa polyestrar, teflon – inom industrin plasmabehandling (elektriskt aktiverad inert gas, tillför tillfällig energi som ökar ytenergin)



Material	Ytenergi mN/m 20° C
Akrylat	32
ABS	35
Aluminium	Ca 500
Koppar	Ca 1000
Cyanoakrylat	37
Epoxy	47
PA	46
PC	46
PE	31
PMMA	39
PS	33
PVC	39
Silikon	24
Vatten	73

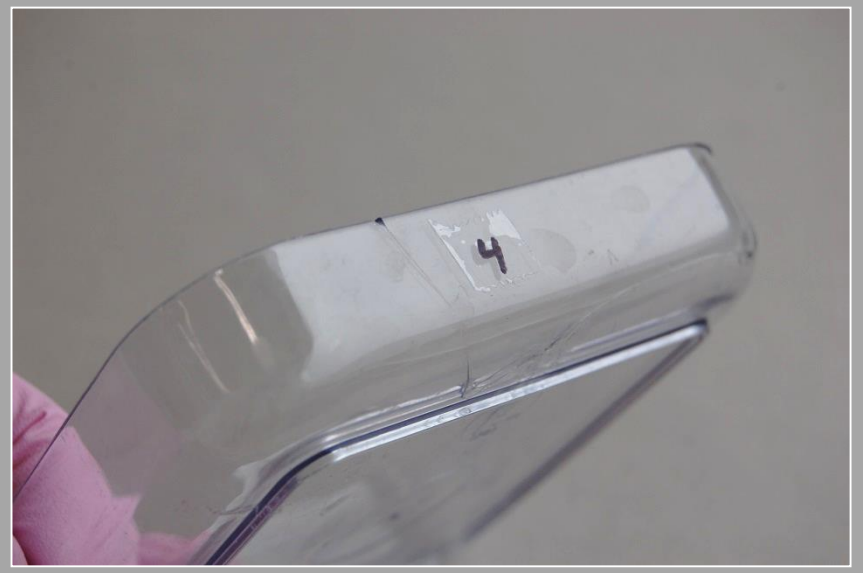
Olika slags lim

Många sätt att dela in, efter ursprung (naturliga eller syntetiska), efter hur det härdar/torkar

Ickereaktiva	Reaktiva	Självhäftande
• Dispersion • Kontaktlim (ofta gummibaserat) • Värme, smältlim • Lösningsmedel med adhesiv • lösningsmedelssvetsning	• Enkomponents (ex. cyanoakrylat) • Flerkomponents (PUR, epoxy, vissa akrylater) • Ovan + UV-katalysator	• tejper

Faktorer vid limning

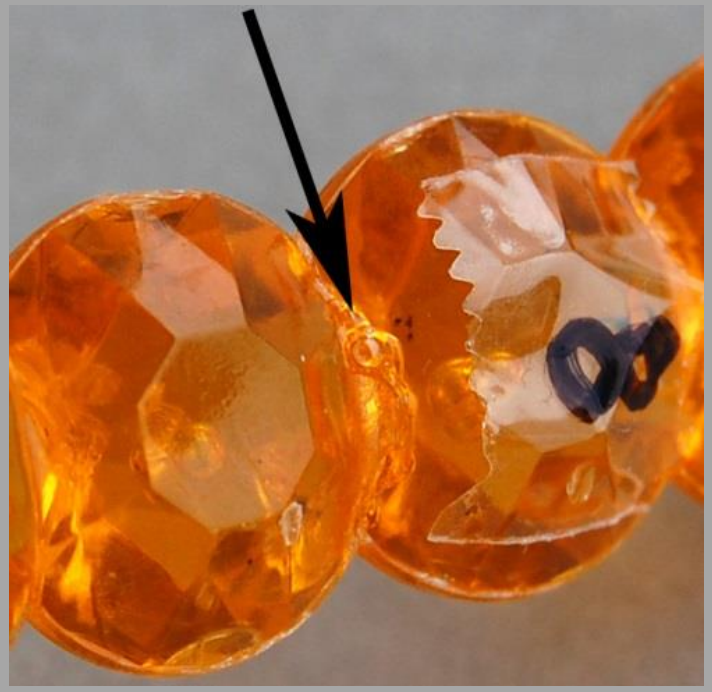
- Fysisk och kemisk förändring över tid för limmet – krympning, gulning, styrka, nedbrytning
- Brytningsindex om plasten är transparent
- Tg, rörlighet och utvidgning i förhållande till temperaturen
- Plastens känslighet gentemot lösningsmedel



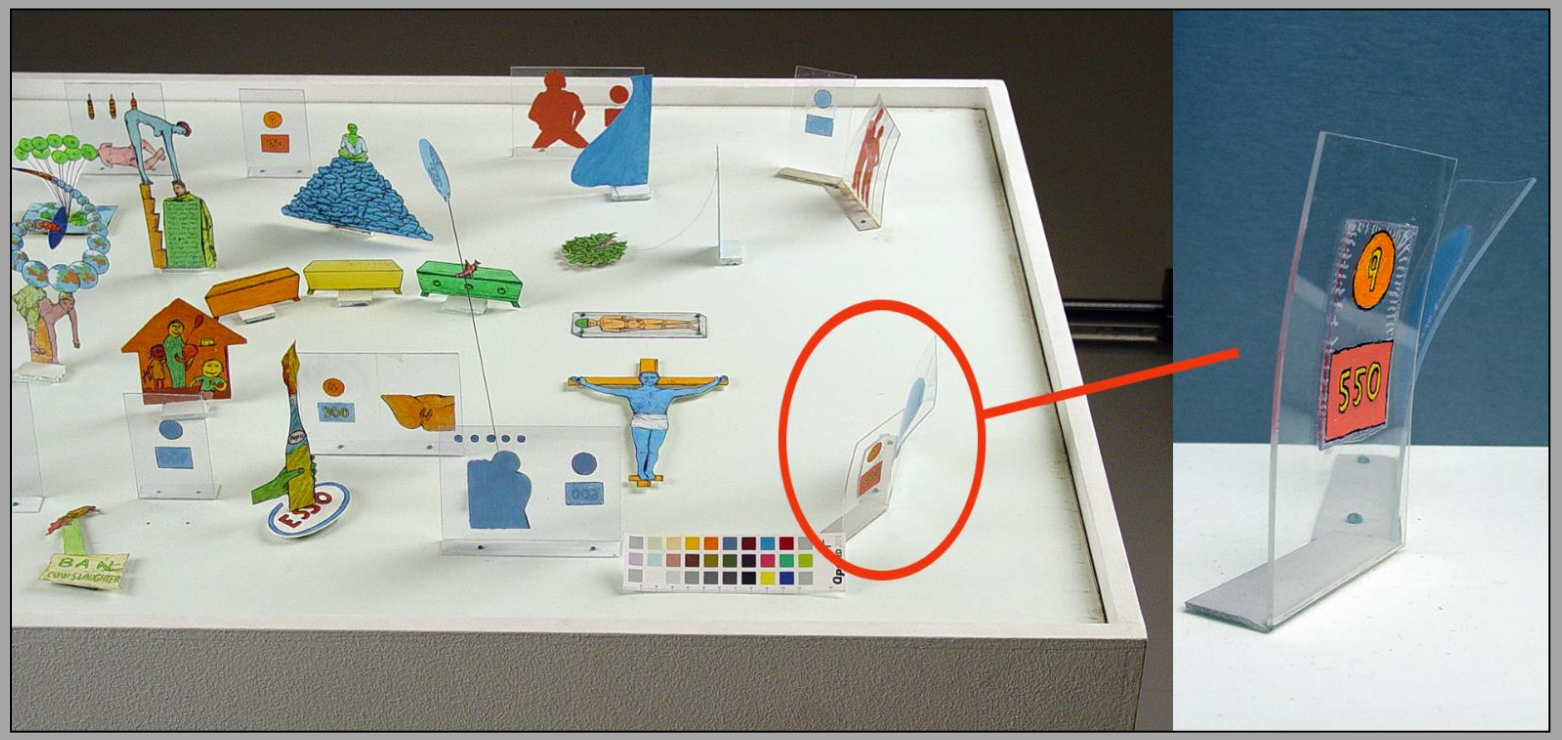
- Analysera belastning, vilka krafter, behövs strukturellt bärande lim ?

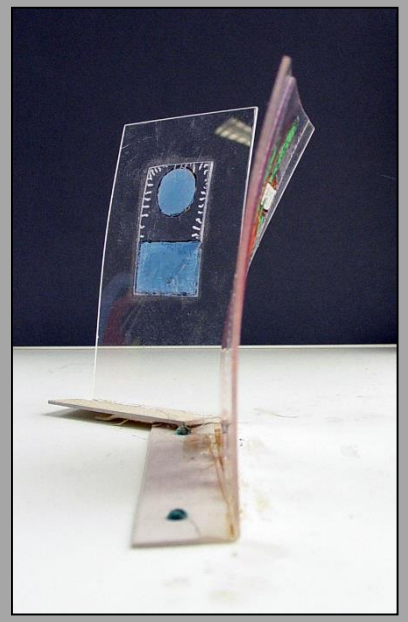
(Inom industrin ofta epoxy, PUR, akryl om bärande)

- Arbetsegenskaper – viskositet, bubbelformationer
- Applicering – borste, spruta, från tub
- härdningstid
- Reversibilitet
- hälsoaspekter



Deformation i plastkomponenter i skulptur av Öyvind Fahlström





Närbild bubbelfenomen i limlager

Testning

- Utifrån föremålets specifika förhållande
- Använda standard
- Ex. gjort för p-PVC, PMMA, UP, PS,

Exempel testning, projekt om Lim för styrenplast

Background

Survey and damage assessment - Breakage, cracks, losses

Research project 2012 together with Royal Institute of Technology and Swerea KIMAB, Stockholm *

In collaboration with conservators

How does it affect the plastic? Chemical and mechanical changes?

Before and after light ageing test materials

Detail from *Trappan,* 1967, by Kjartan Slettemark

* *Joining plastics together – what happens over time? A comparative study of seven different adhesives for adhering polystyrene and their long-term effect*

Swedish National Heritage Board, Royal Institute of Technology, Swerea KIMAB

Adhesives for adhering polystyrene plastic and their long-term effect
Thea Winther, Judith Bannerman, Hilde Skogstad, Mats K. G. Johansson, Karin Jacobson, and Johan Samuelsson
Studies In Conservation Vol. 60 , Iss. 2,2015

Choice of plastics and adhesives

- Damage assessment – polystyrene, PS.

  One transparent general purpose PS, one white; HIPS (High Impact Polystyrene), extruded sheet plastic

- Which adhesives based on questionnaire to conservators, discussion conservator group

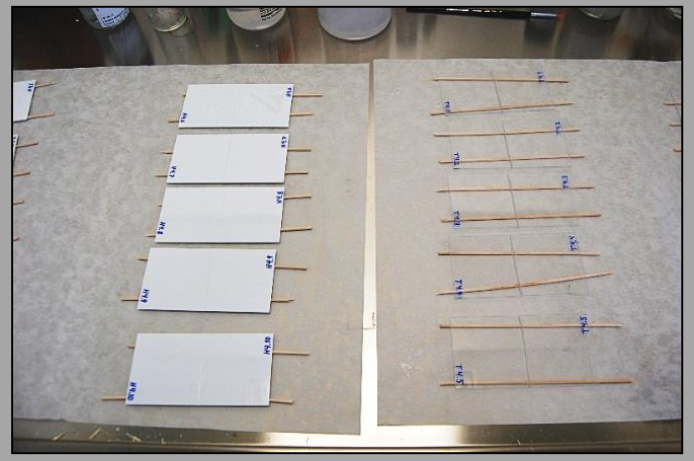
- Screening of 20 – 7 chosen, four acrylates; three in solvents (one in two different solvent mixes), one dispersion, two epoxies and one cyanoacrylate

Adhesive name	**Ratio/solvent**	**Adhesive type**
Paraloid B72	40% in ethanol	Acrylate, in solution
Paraloid B72	40% in 1:1 acetone:ethanol	Acrylate, in solution
Paraloid B67	40% in 2-propanol	Acrylate, in solution
Acrifix 116	Solids ca 10% in solvent mix	Acrylate, in solution
Primal AC 35	Solids ca 45 %	Acrylate dispersion
Hxtal Nyl-1	3:1 (resin : hardener)	Epoxy 2 component
Araldite 2020	100g:30g (resin:hardener)	Epoxy 2 component
Loctite Super Attack Precision (Loctite SAP)	-	Cyanoacrylate

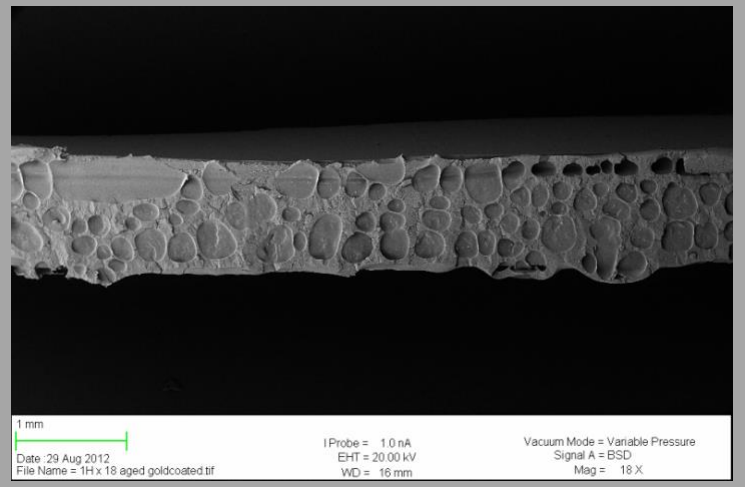
- Investigate deterioration and properties for substrate and adhesive by comparison before and after light ageing *, before and after adhesive joining

- Assess working properties and visual aspects

- Tensile testing (strength), colour changes, SEM, FTIR, hardness, type of break



Samples curing after adhering

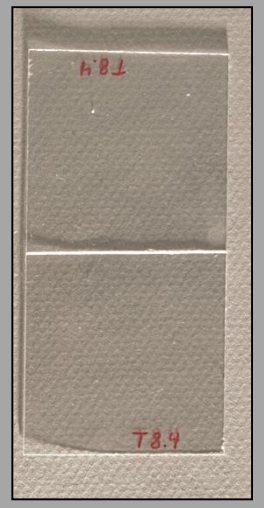


SEM image for assessing type of break. Break edge of sample with Paraloid B72 on HIPS.

*
- metal halide light bulb with radiation in the ultraviolet and visible range
- For 24 days, for the visible component correspond to 60 years with 100 lux 8 hours per day, 7 days a week, 365 days per year
- Average exposure 30700 lux and a UV component of 13±1.7 W/m^2 at 26-28°C and 44%±1% RH.

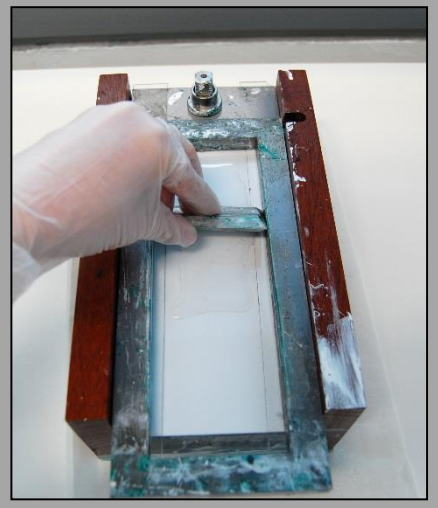
adhered edges
pull-to-break, adhere, pull-to-break

- Working properties and visual impression
- Tensile testing
- Type of break



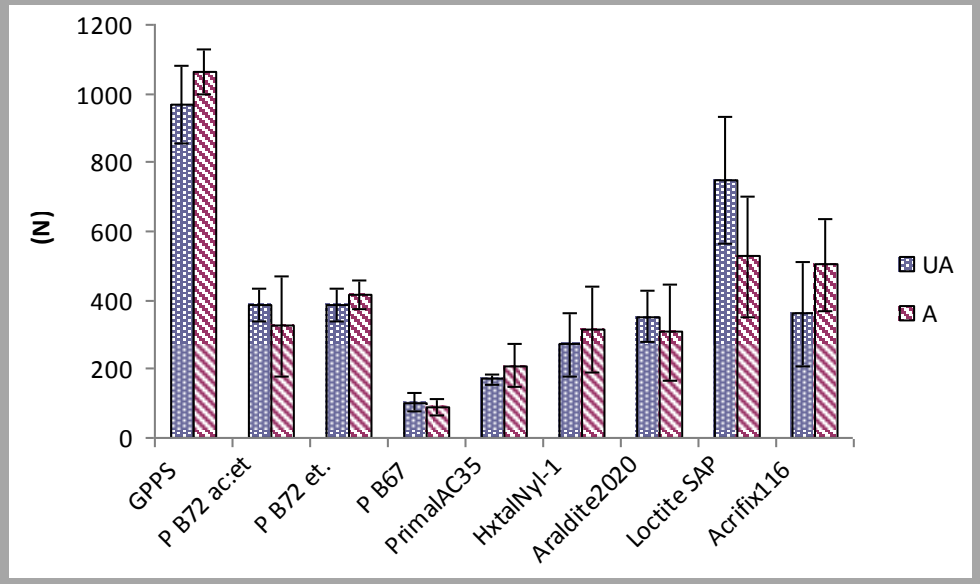
adhesive open layer on plastic surface

- Colour measurements
- Hardness
- Investigation SEM and FTIR

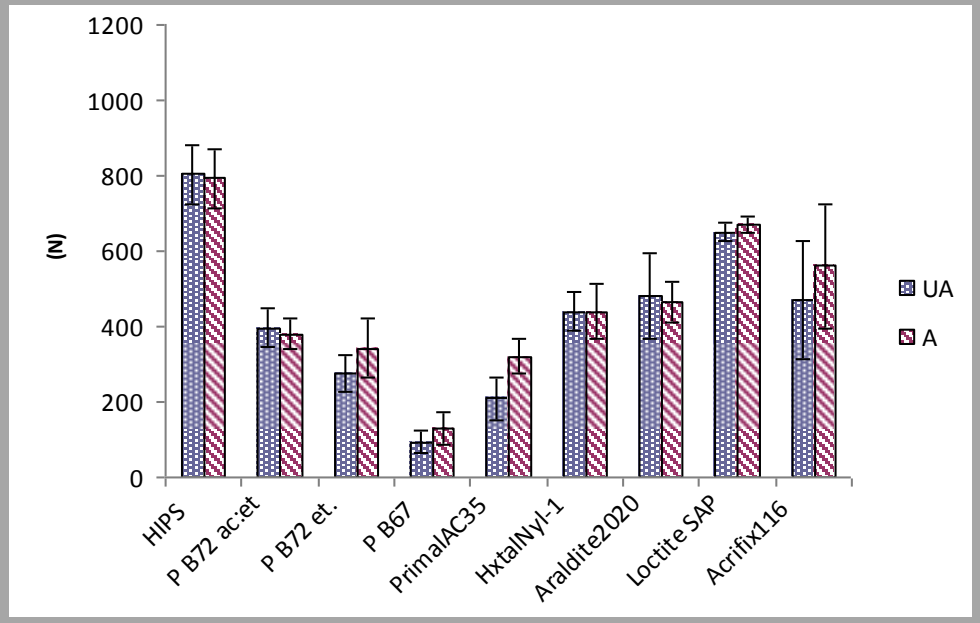


Tensile testing

Tensile testing adhesives on transparent polystyrene



Tensile testing adhesives on HIPS



- Loctite SAP on transp. polystyrene weakened after ageing
- Acrifix 116 and Primal AC35 showed increased break force

UA – Unaged
A – Light Aged

n=5

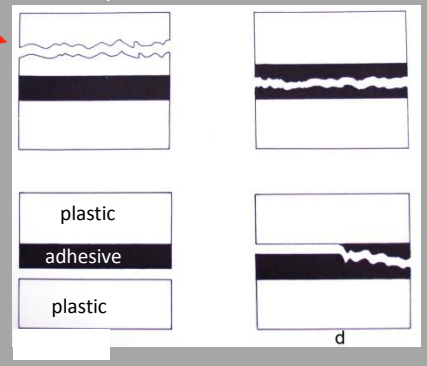
Type of break

Adhesive	Transp.	HIPS
Paraloid B72	Cohesive in the adhesive	Cohesive in the adhesive
Paraloid B67	Cohesive in the adhesive	Cohesive in the adhesive
Acrifix 116	Cohesive in the adhesive	Cohesive in the adhesive
Primal AC35	C/A	C/A
Hxtal Nyl-1	Adhesive	Adhesive
Araldite 2020	Adhesive	Adhesive
Loctite Prec.	C/A	C/A

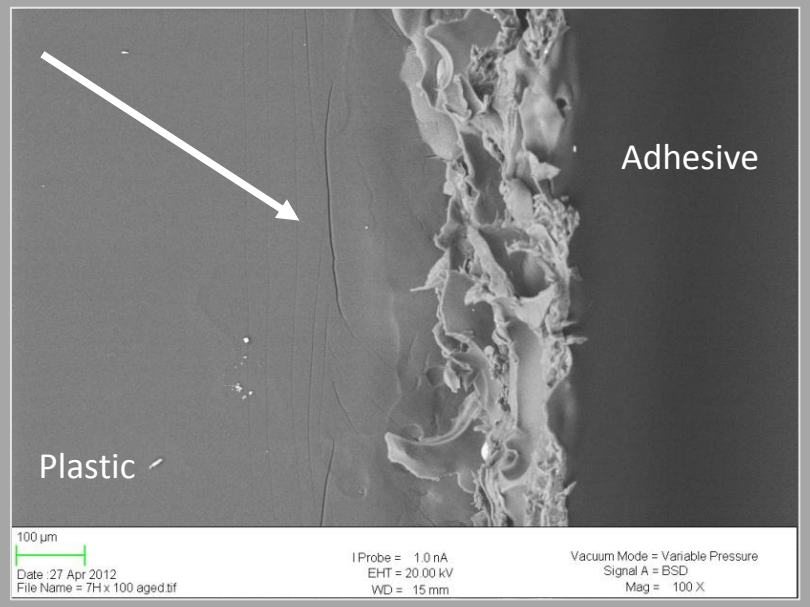
C/A - Cohesive in the adhesive and adhesive break

- No adhesive caused a break in the plastic.
- Each adhesive had the same type of break after as before ageing.

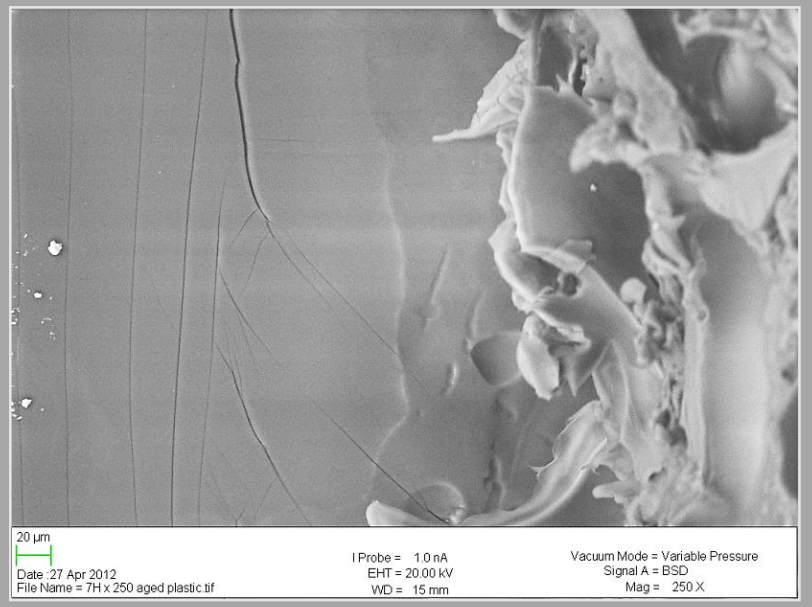
Cohesive break in the plastic



From Pocius (1997)

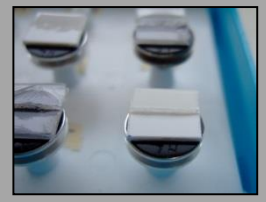


Example of damage to plastic caused by adhesive.
Acrifix 116 aged on HIPS. SEM x100

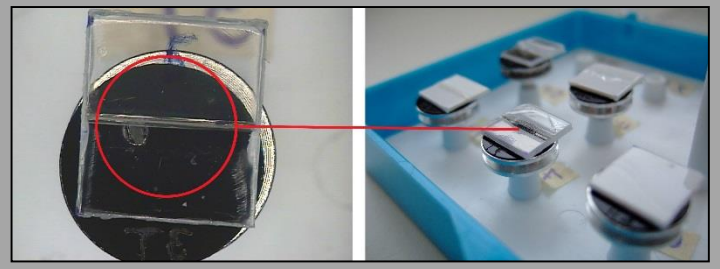


Acrifix 116 aged on HIPS. SEM x250

- Samples with Acrifix 116 and cyanoacrylate showed damage to the plastic in SEM
- The effect was more clear on HIPS than on transparent polystyrene

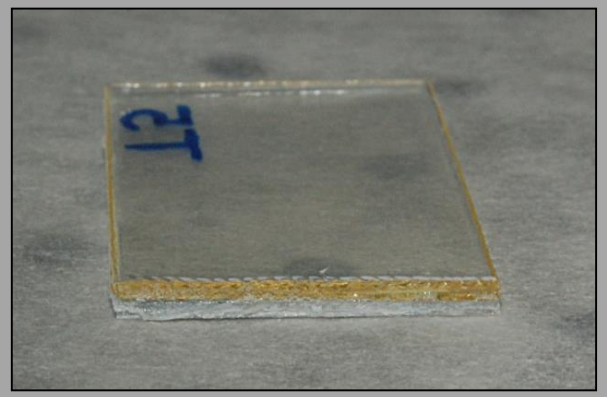


Samples on SEM stubs

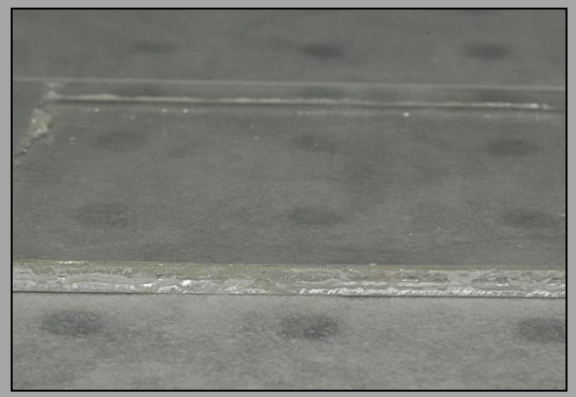


Hxtal NYL-1 before and after (top) ageing on HIPS

Araldite 2020 before and after (top) ageing on transparent polystyrene



Cross-section aged Araldite 2020 on transparent polystyrene



Cross section aged Hxtal NYL-1 on transparent polystyrene

- Loctite SAP and Araldite 2020 - high degree of increased yellowing after ageing.
- Acrifix 116 and Hxtal NYL-1 – no increased visual yellowing after ageing.
- The Paraloids and Primal AC35 showed minimal increased visual yellowing after ageing.

Table for transparent general purpose polystyrene

Adhesive	Health-aspects	Working prop.		Colour		Hardness		Bond strength		Bond break		Damage/affect to plastic	
		U		U	A	U	A	U	A	U	A	U	A
Paraloid B72 in acetone: ethanol *Acrylate*	Irritant	F		G	G	1	1	2	2	Cohesive in adh.	Cohesive in adh.		
Paraloid B72 in ethanol *Acrylate*	Irritant	G		G	G	1	1	2	2	Cohesive in adh	Cohesive in adh.		-
Paraloid B67 in 2-propanol *Acrylate*	Irritant	F		G	G	3	1	3	3	Cohesive in adh.	Cohesive in adh.		
Acrifix 116 *Acrylate*	Irritant	G		G	G	3	3	2	1	Cohesive in adh.	Cohesive in adh.	x	x
Primal AC35 *Acrylate dispersion*	Slight irritant	G		F	F	3	2	3	3	C/A	C/A		
Hxtal Nyl-1 *Epoxy*	Corrosive	P		G	G	1	1	2	2	Adhesive	Adhesive		
Araldite 2020 *Epoxy*	Corrosive	P		G	P	1	1	2	2	Adhesive	Adhesive		
Loctite Super Attack Prec. *Cyanoacrylate*	Irritant	F		F	P	2	2	1	1	C/A	C/A	x	x

C/A – Cohesive break in the adhesive and adhesive break

Explanation hardness (durometer) values in table
1 = 97, 1 – 99 (hardest)
2 = 95, 1 – 97
3 = 93 – 95

Abbreviations in table
U – unaged
A - Aged

Explanation bond strength values in table
1 = 500 – 750 N
2 = 250 – 499 N
3 = 0 – 249 N

Assessment
F – Fair
G – Good
P - Poor

Table for HIPS

Adhesive	Health aspects	Working prop.		Colour		Hardness		Bond strength		Bond break		Damage/affect to plastic	
		U		U	A	U	A	U	A	U	A	U	A
Paraloid B72 in acetone/ethanol *Acrylate*	Irritant	F		G	G	1	1	2	2	Cohesive in adh.	Cohesive in adh.		
Paraloid B72 in ethanol *Acrylate*	Irritant	G		G	G	2	1	2	2	Cohesive in adh.	Cohesive in adh.		-
Paraloid B67 *Acrylate*	Irritant	F		G	G	3	2	3	3	Cohesive in adh.	Cohesive in adh.		
Acrifix 116 *Acrylate*	Irritant	G		G	G	3	3	2	1	Cohesive in adh.	Cohesive in adh.	x	x
Primal AC35 *Acrylate dispersion*	Slight irritant	G		F	F	3	2	3	2	C/A	C/A		
Hxtal Nyl-1 *Epoxy*	Corrosive	P		G	G	1	1	2	2	Adhesive	Adhesive		
Araldite 2020 *Epoxy*	Corrosive	P		G	P	1	1	2	2	Adhesive	Adhesive		
Loctite Super Attack Prec. *Cyanoacrylate*	Irritant	F		F	P	2	1	1	1	C/A	C/A	x	x

C/A – Cohesive break in the adhesive and adhesive break

Explanation hardness (durometer) values in table
1 = 97, 1 – 99 (hardest)
2 = 95, 1 – 97
3 = 93 – 95

Abbreviations in table
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Explanation bond strength values in table
1 = 500 – 750 N
2 = 250 – 499 N
3 = 0 – 249 N

Assessment
F – Fair
G – Good
P - Poor

Tested adhesives on old polystyrene objects

Tested adhesives:

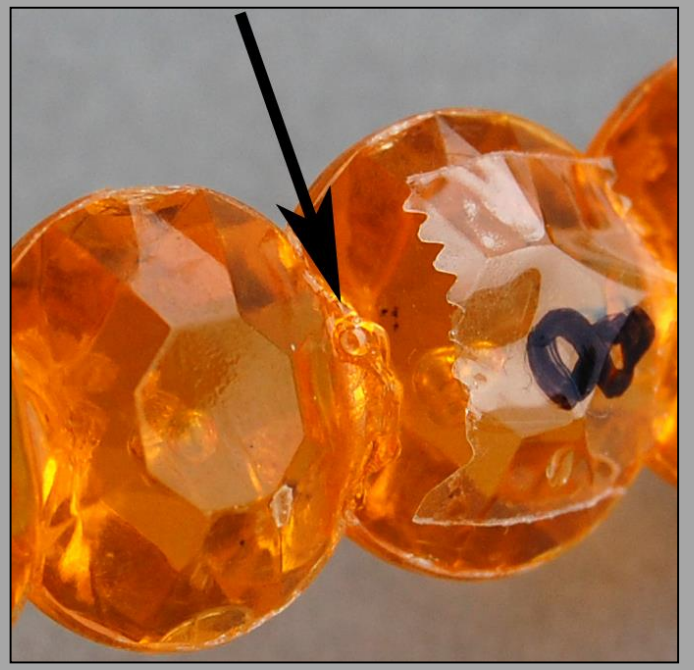
Paraloid B72 in ethanol

Hxtal Nyl-1

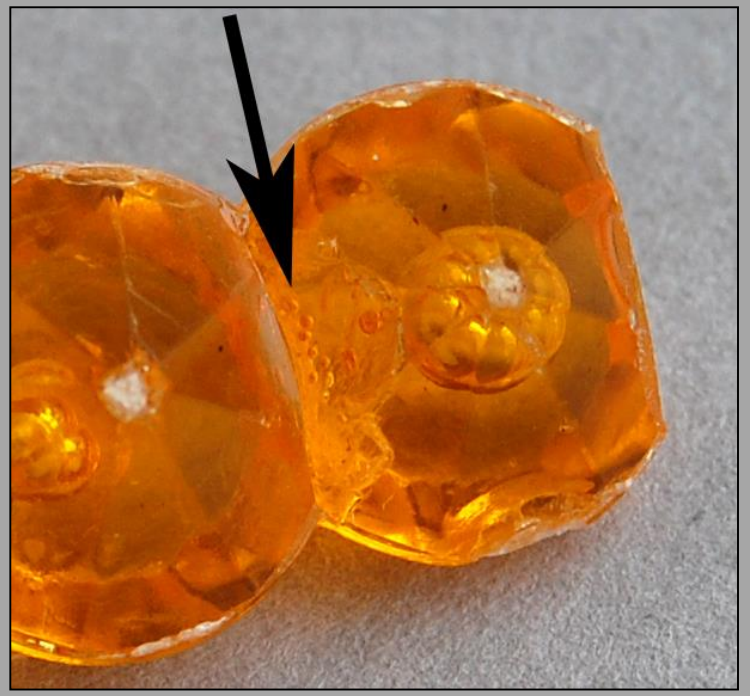
Primal AC35

Loctite SAP

Adhesive bond Paraloid B72 in ethanol. Note bubbles in bond



Adhesive bond Paraloid B72 in ethanol



Adhesive bond cyanoacrylate

Hxtal Nyl-1

Loctite SAP

Trappan
by Kjartan Slettemark (1932-2008)
1967
92 x 84 x 220 cm

Photo: Per Anders Allsten,
Moderna Museet

Polystyrene letters in synthetic resin (polyester)

Epoxy chosen – no detected damage, enough strength, aethetics, working properties

Minimum amount by small brush

Supports for at least 24 h

Conclusion

The cyanoacrylate Loctite SAP strongest, Paraloid B67 and acrylate dispersion Primal AC35 weakest

No great weakening of the bonds from light ageing apart from for the cyanoacrylate on transparent polystyrene

No adhesive caused a break in the polystyrene when pulled apart

Epoxies had adhesive type of break

Most yellowing seen for Loctite SAP and Araldite 2020

Greatest potential for damage from Acrifix 116 and Loctite Super Attak Precision

Several aspects correlated to the research results when tested on objects apart from structure and thickness of break edge and inner tensions from production – distorsions

Used in practice for artwork with satisfying result

Konsolidering

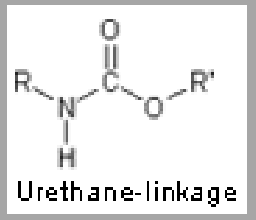
- Vid vittrande material

- Framförallt för skummad PUR, även för gummi

- Gjorts försök för CN, CA

Konsolidering av skummad polyuretan

- Diisocyanat + polyol – uretangrupper i kedjan, mängdförhållande ger mjukhet. PUR i många olika slags former, hårt, mjukt, ytbehandling, elastomer. Konsolidering testad för mjuk skummad av etertyp. Två processer under produktionen, en gasbildande under polymerisationen.



- Etertyp – nedbrytning främst fotooxidation, av estertyp – känsligt fukt

- Testats gelatin, metylcellulosa, akrylatdispersion, dispersion med PUR

- Materialet i OK tillstånd

- Ljusåldrad skummad PUR av etertyp – nedbrytning visar sig som minskning av cellvägg

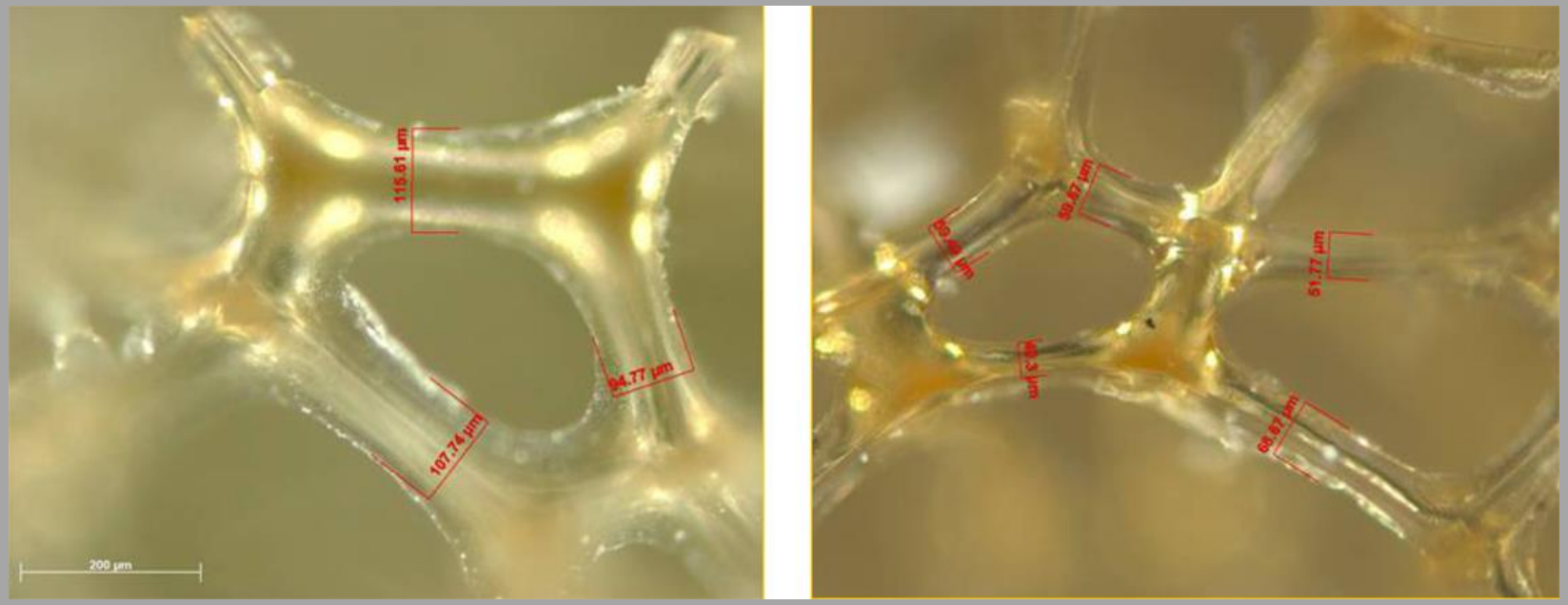
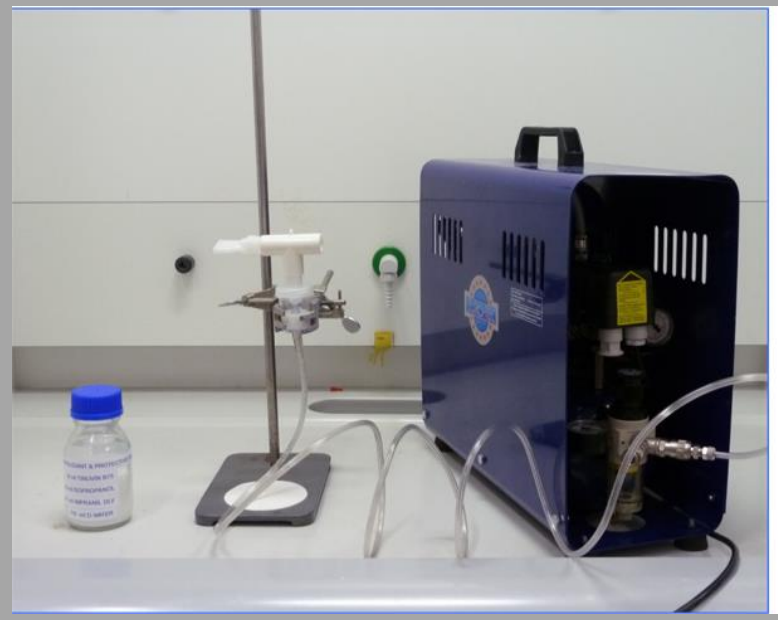


Bild från work-shopmaterial © Thea van Oosten och Anna Lagana

- Impranil DLV, polyuretandispersion - + Tinuvin B75 (antioxidant mot ljus och värme)

- Krävs nebulisator för att ge tillräckligt små droppar + tryckluft



- Testat inträngning – ger 10-15µm lager runt cellvägg, viktigt att inte hålla för länge för bibehållen flexibilitet

- Annat testat AAAS, (aminoalkylakoxysilanes) problem med inträngning

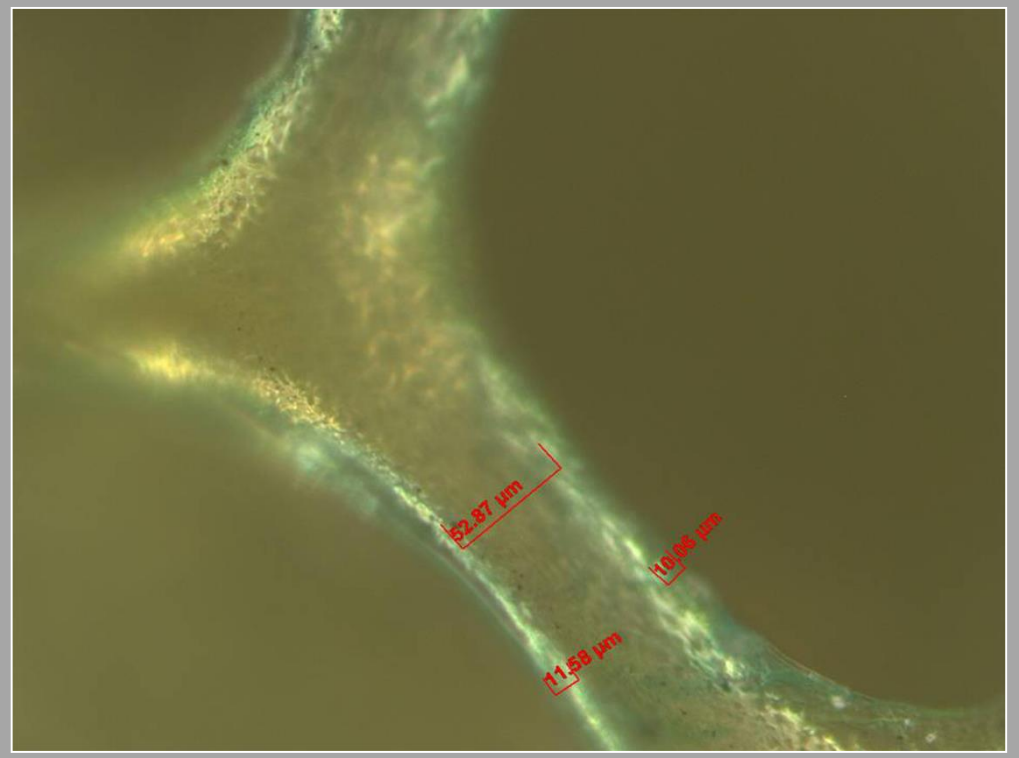


Bild från work-shopmaterial © Thea van Oosten och Anna Lagana

- Jämförande mellan behandlat och icke behandlat, testmaterial och från skulptur
- FTIR visade grad av nedbrytning (hydroxylindex)

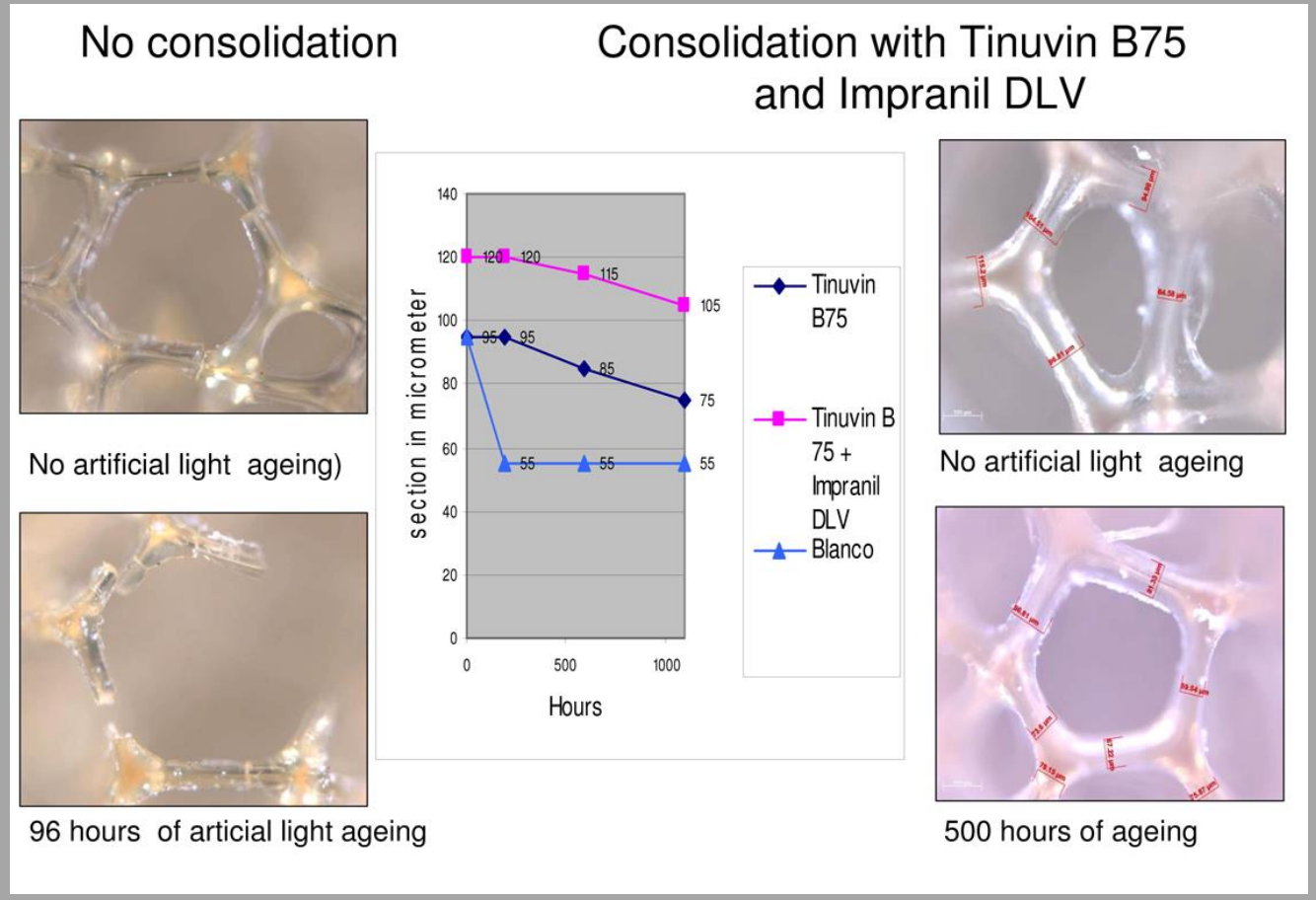
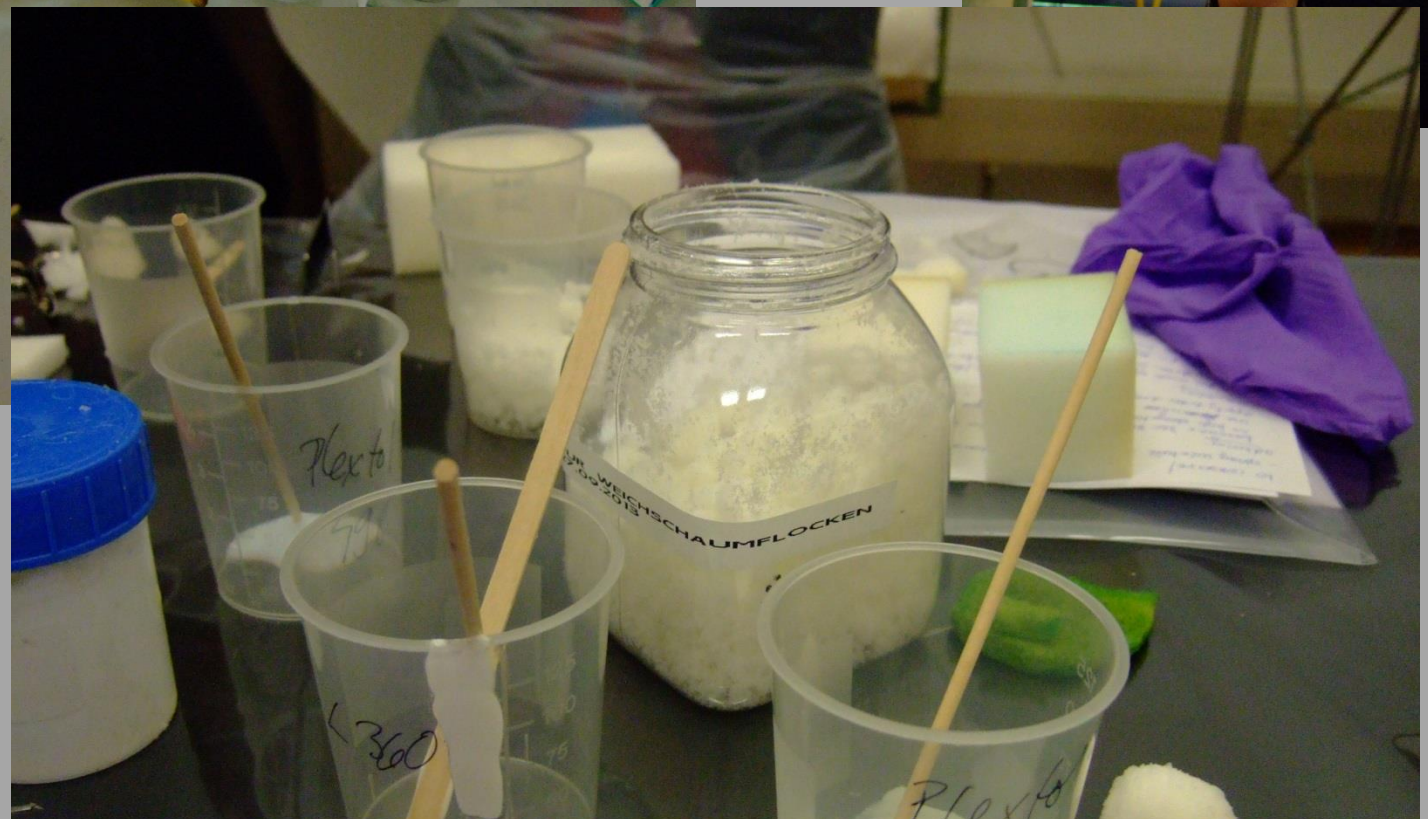
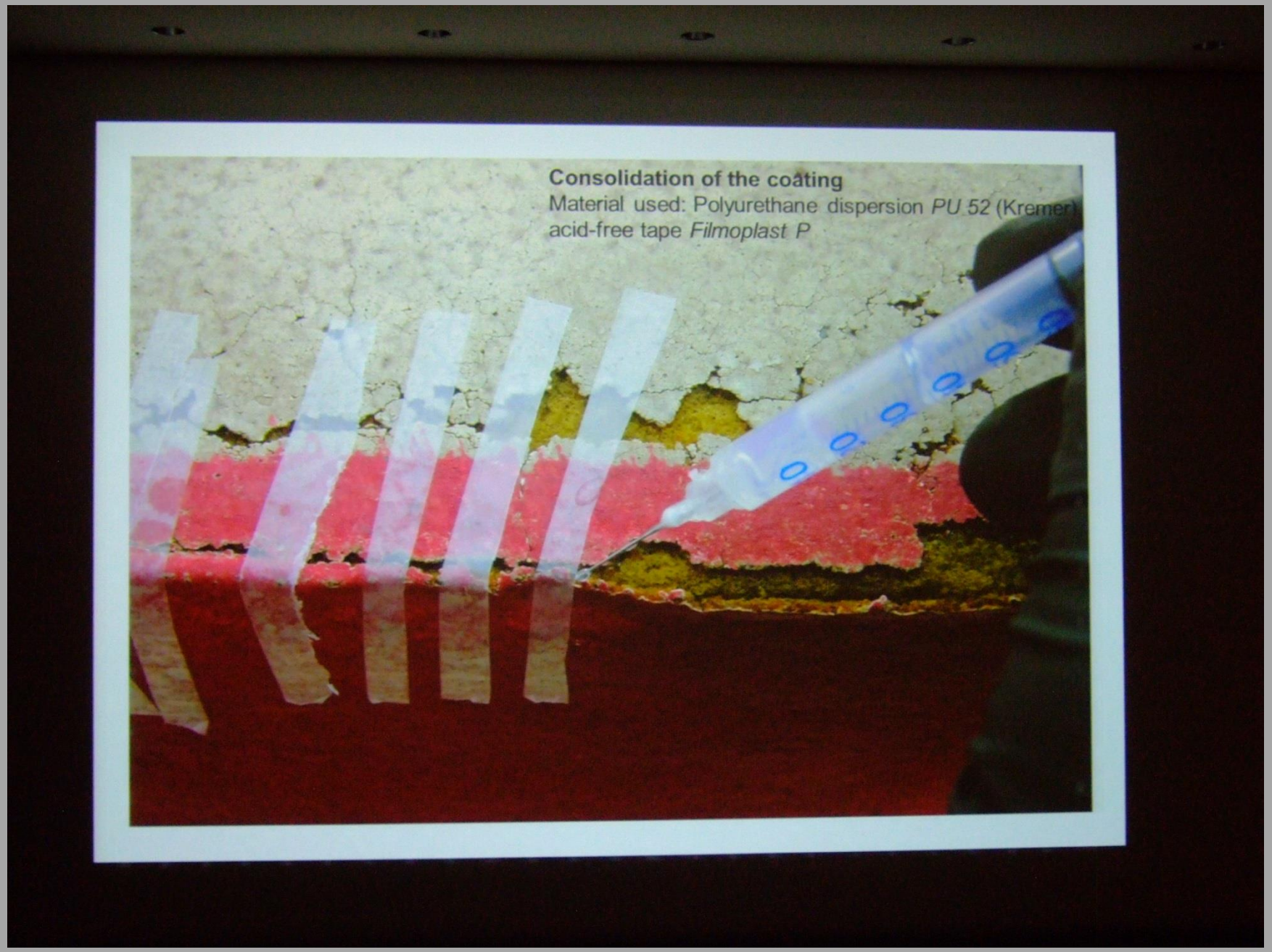


Bild från work-shopmaterial © Thea van Oosten och Anna Lagana

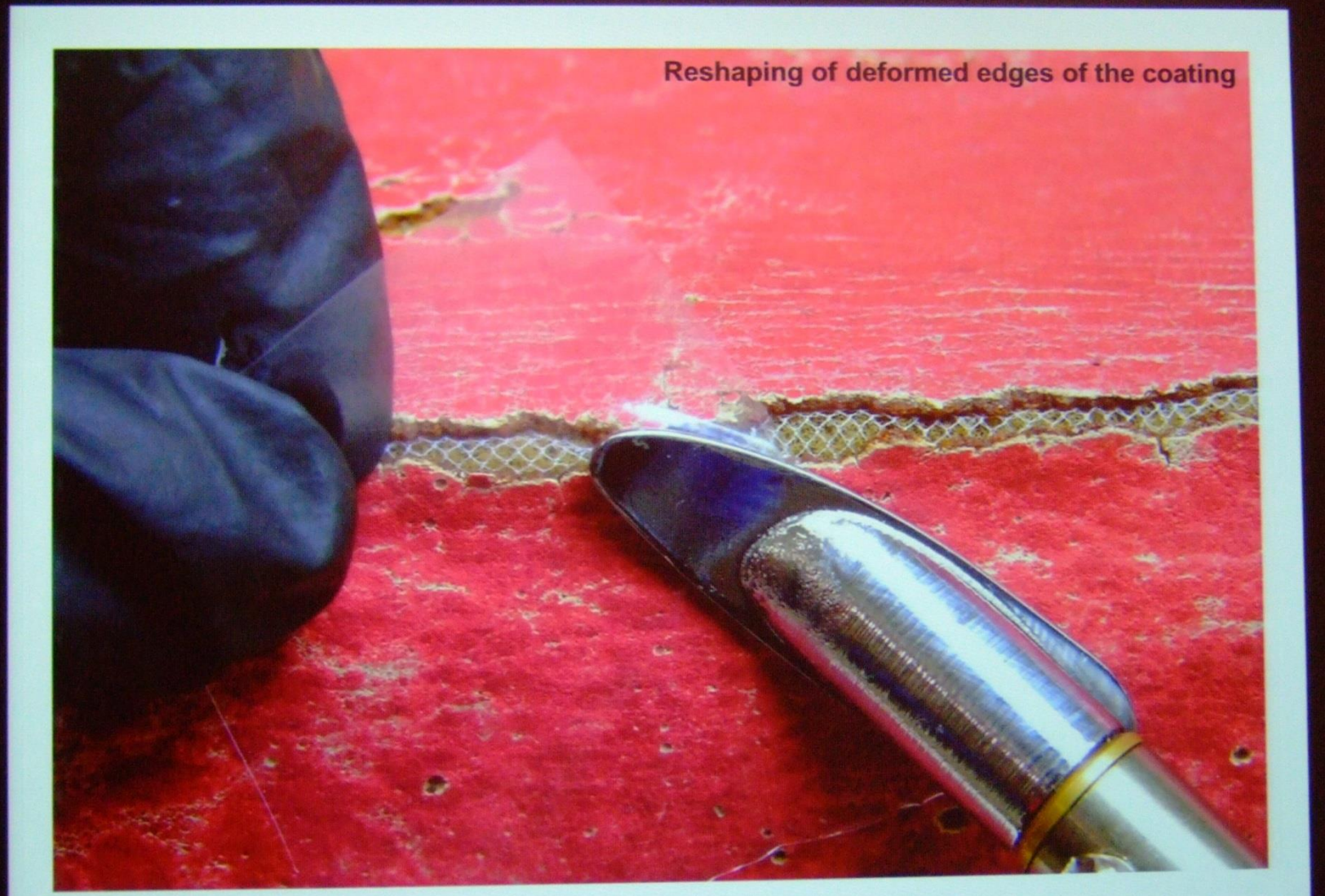
- Bedöma hur nedbruten – hur är ytan, vilken tjocklek, är det bemålat, ytbehandlat?

Mer skadat längre tid, 1-5 min, först 3% Tinuvin i isopropanol, sen 5% Tinuvin i Impranil DLV


WEICHSCHAUMFLOCKEN



Susane Graner Vitra
Design Museum



Susane
Graner
Vitra Design
Museum

Susanne Graner/Luise Lutz

Waving the Flag

Future Talks 013
23.10. – 25.10.2013

Vitra
Design
Museum

Prins Eugens resebadkar. Tidigt 1900-tal. Nordiska Museets samling

Flagnande gummering – matt yta, krav inträngning.

Använt metylcellulosa, Aquasol