Loris Cecchini, Stage Evidence Finestre II 2000, Private collection

Cultural Heritage Agency
Ministry of Education, Culture and Science

The Wear and Tear of Polyurethane rubber

Investigation into properties, degradation and treatments

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27 October 2011, Future Talks 011, Munich

PUR ester and ether elastomer objects

Loris Cecchini, Finestre II, 2000, Private collection

Hella Jongerius, Urn, 1994
Centraal Museum Utrecht

Hella Jongerius, Soft vase, 1994, Centraal Museum Utrecht

Saar Oosterhof, Table cloth with bowl, 1998, Centraal Museum Utrecht

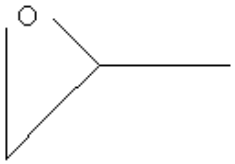
Gaetano Pesce, ring, 2011

Gaetano Pesce, bracelet, 2003

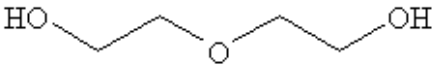
Gaetano Pesce, Pratt chair no. 2

Heringa van Kalsbeek, Untitled, 2011

How is PUR made?

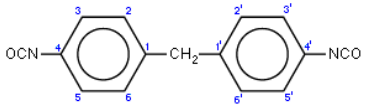


epoxide

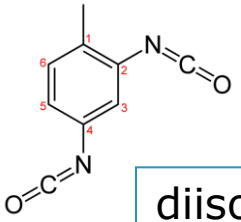


diol

diethylene glycol polyether



MDI

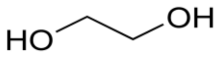


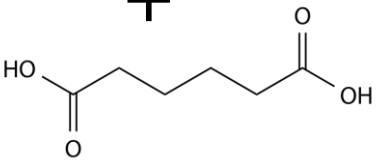
TDI

diisocyanate

PUR ether prepolymer

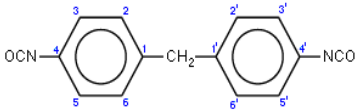
diol





adipic acid

ethyleneglycol-adipic acid polyester



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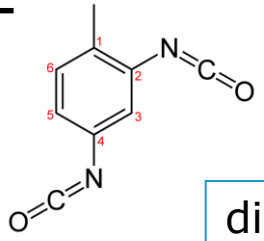
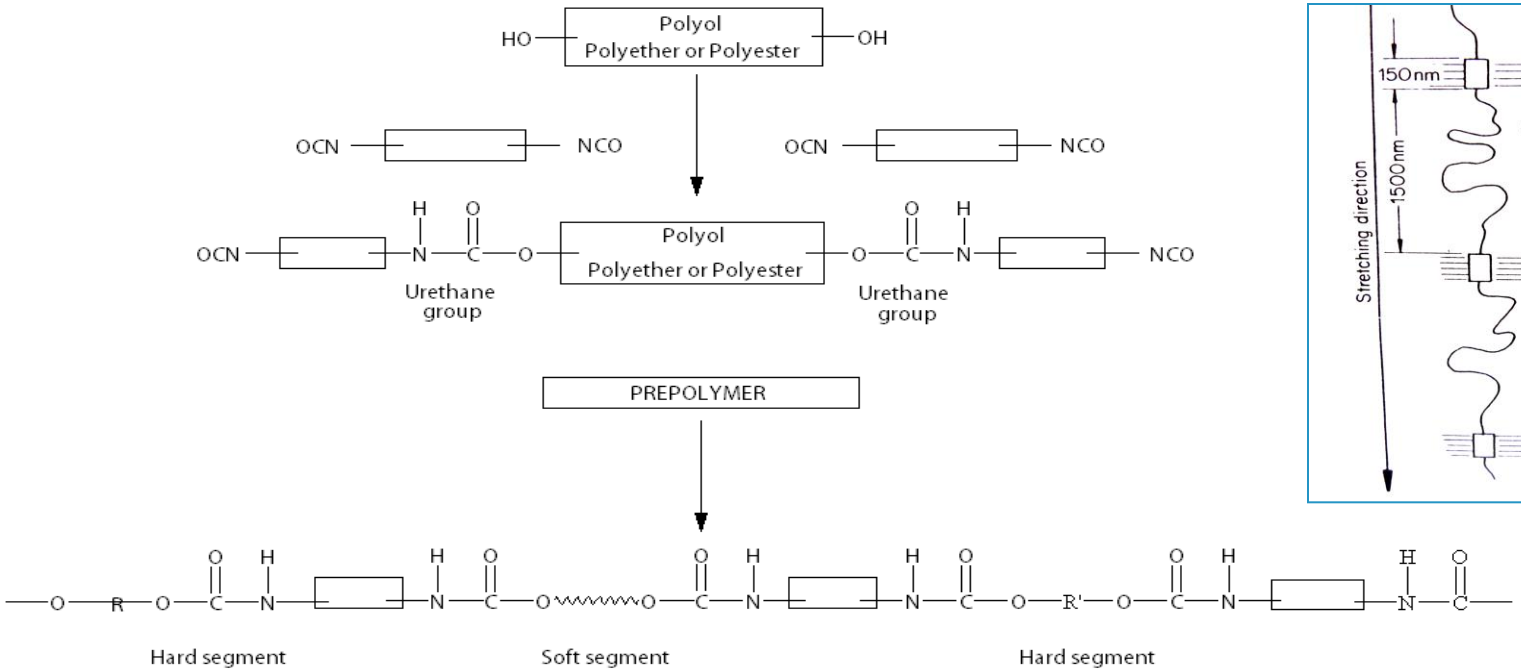


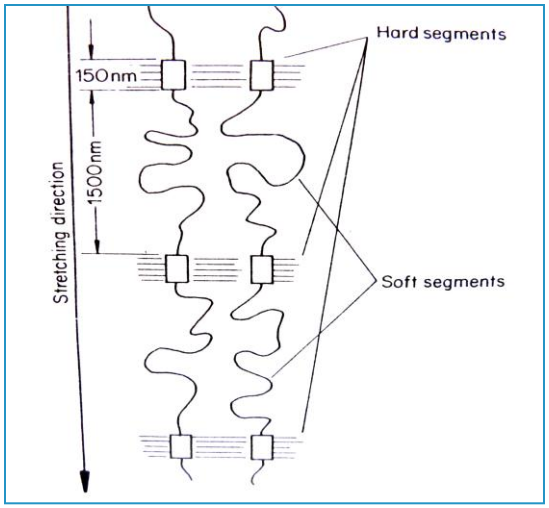
TDI

diisocyanate

PUR ester prepolymer

How is PUR made?

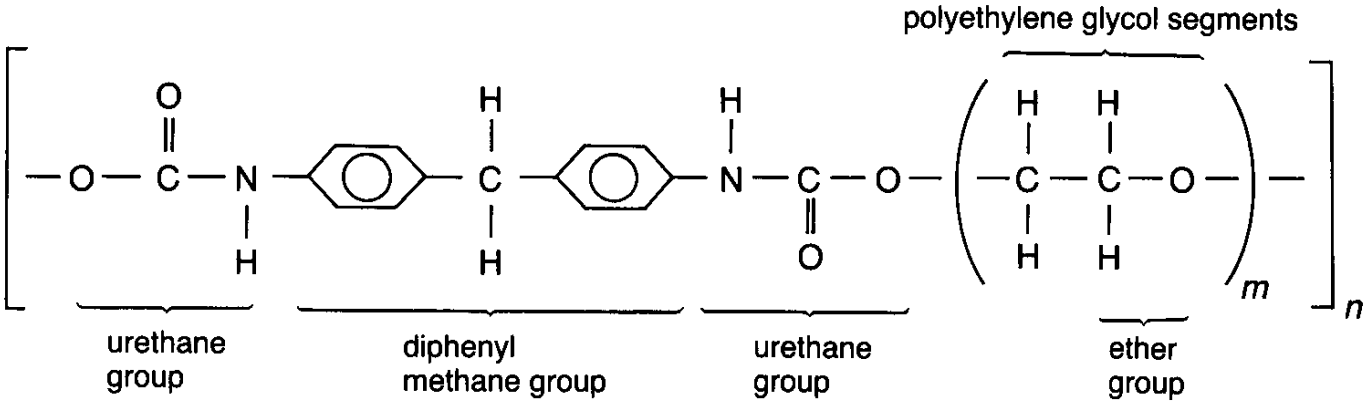




PUR ester elastomers: internally plasticized
(chain extenders) 1,4, butanediol

PUR ester elastomers: externally plasticized:
Phthalate esters

How is PUR ether made?



Vitaflex	Component A	Component B	Shore hardness
10	100	100	10 A
20	100	100	20 A
30	100	100	30 A
40	100	100	40 A

Part A

Toluene Diisocyanate < 1 %

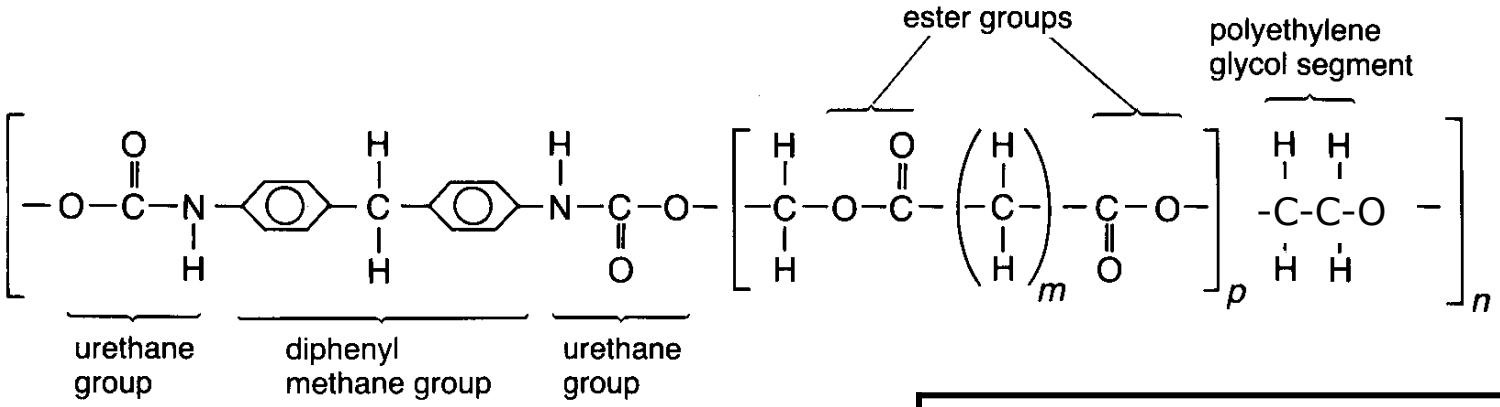
Diisononylphthalate 5-15 %

Part B

Polyol /Plasticizer Blend 90-95%

Diethyltoluenediamine 1-5 %

How is PUR ester made?



Part A:
TDI prepolymer

Part B:
diisocyanate + kaolin

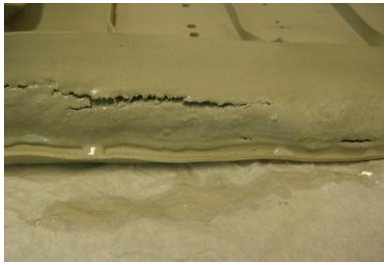
Part C:
Butylbenzyl phthalate

Parts by weight			
Shore hardness	Component A	Component B	Component C
40 A	10	100	0
25 A	10	100	20
15 A	10	100	40
10 A	10	100	60
6 A	10	100	80

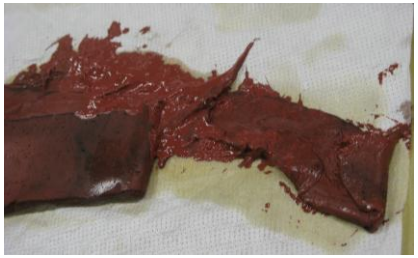
Problems with PUR elastomers

Physical/chemical change

Loris Cecchini, Stage evidence, F*inestre II,* 2000, Private collection **PUR Ester**



Loris Cecchini, Stage evidence, Fotocopiatrice, 2002, Museo de Novecento, Milano **PUR Ester**



Olaf Metzel, 'Wurfeisen und Zwille' 1990, Hamburger kunsthalle, **PUR Ester**

Efflorescence

Saar Oosterhof, Soft Tiles Centraal Museum Utrecht **PUR ether**

PUR ethers oxidize
PUR ester hydrolyze

Mechanical damage

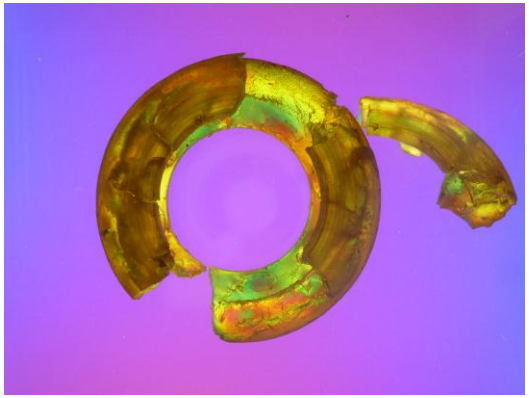
Loris Cecchini, F*inestre II,* 2000 Galleria Continua **PUR Ester**

Hella Jongerius, Soft vase, Private Collection **PUR Ester**

Stress

Skate wheel Bayer 2010

Damaged skate wheel



Broken part Soft Vase

Set up Research

Identification PUR objects:
- FTIR, Py-GCMS

Mimic physical/chemical change:
- find suitable PUR (artist interviews)
- making test samples
- artificial ageing

Measuring physical/chemical change of test samples:
- FTIR
- elasticity test
- shore hardness

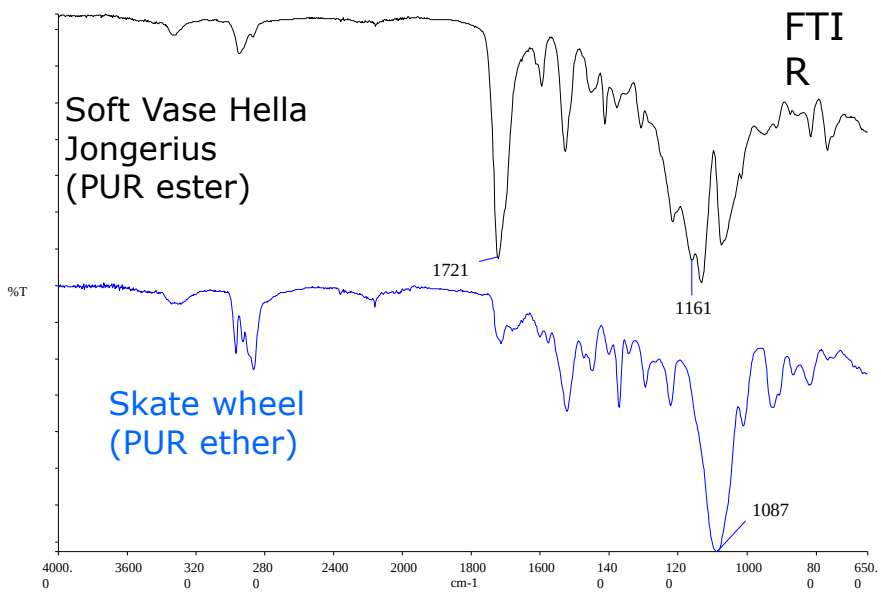
Testing adhesives:
- FTIR
- refractive index
- artificial ageing

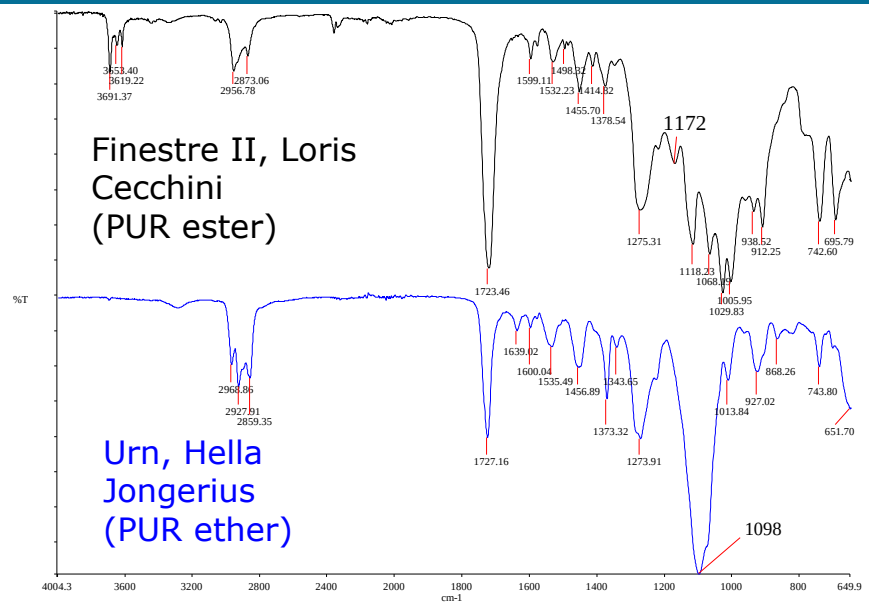
Test samples

Durometer

Light ageing

Identification FTIR





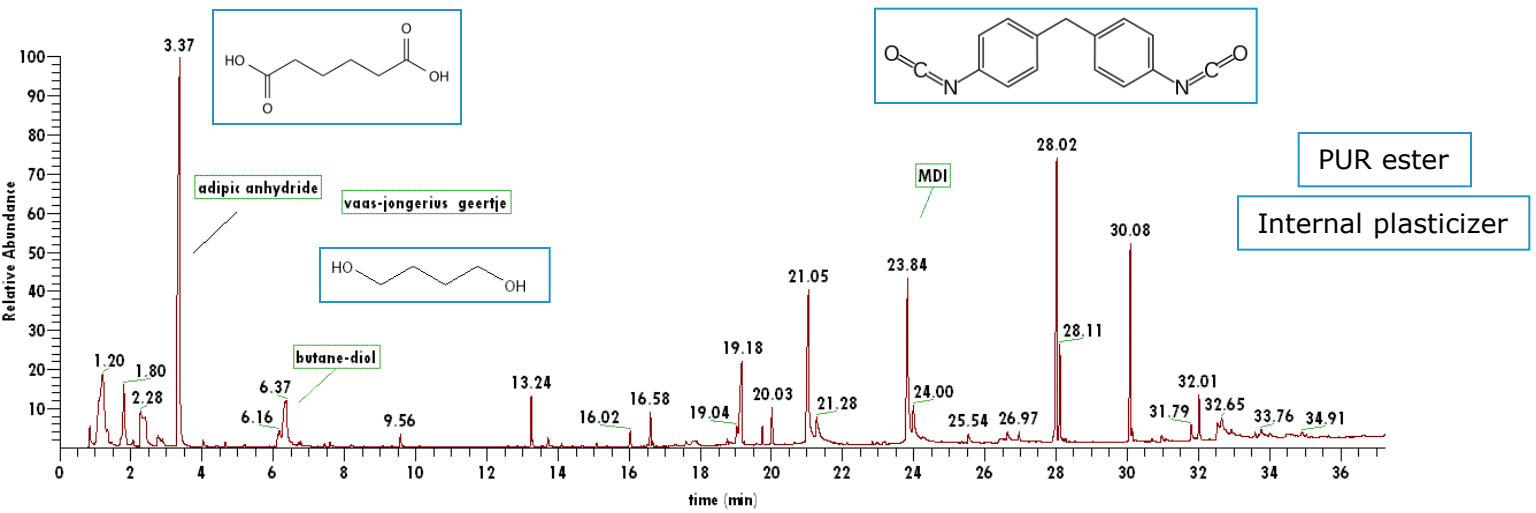
Hella Jongerius,
Soft vase,
Private Collection

Skate wheel

Loris Cecchini, Finestre II,
2000, Private collection

Hella Jongerius, Urn, 1994
Centraal Museum Utrecht

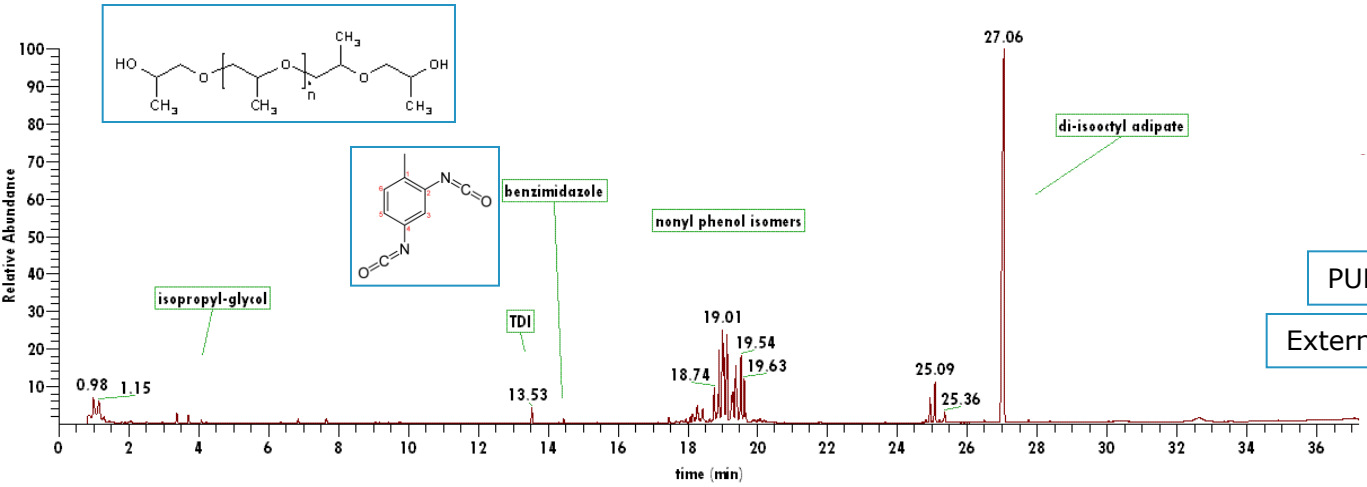
Identification PY-GCMS



PUR ester

Internal plasticizer

Hella Jongerius,
Soft vase, Private Collection

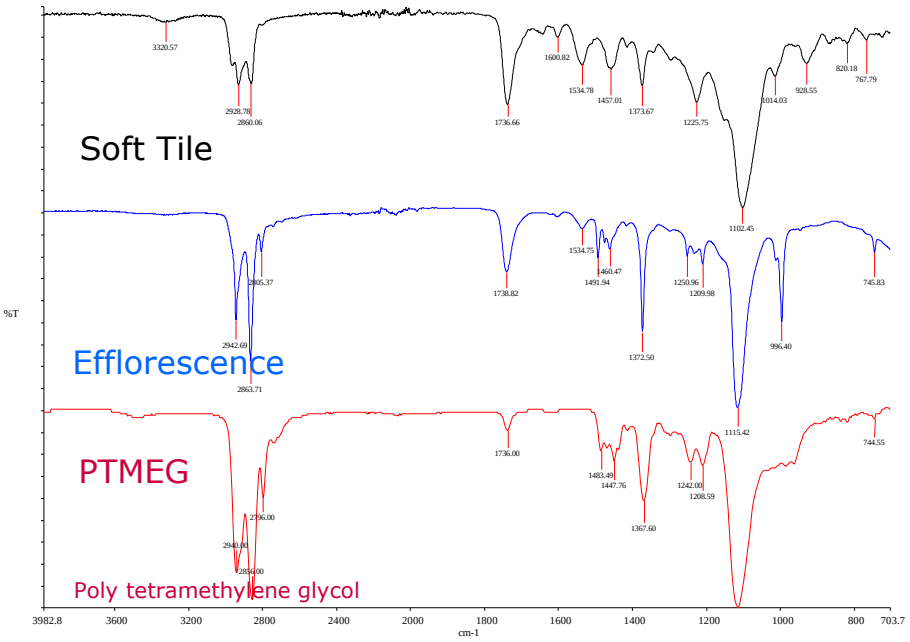


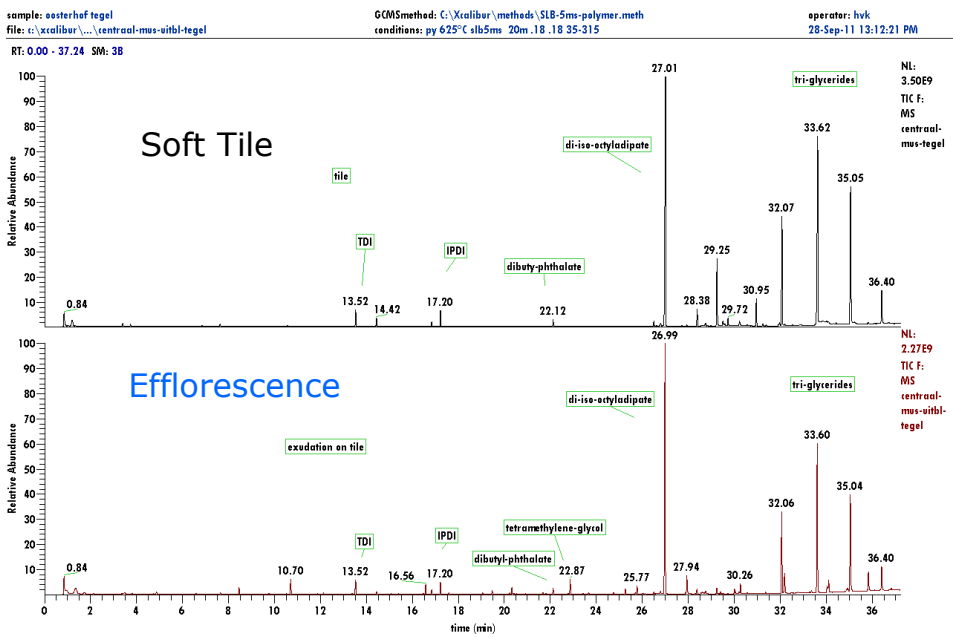
PUR ether

External plasticizer

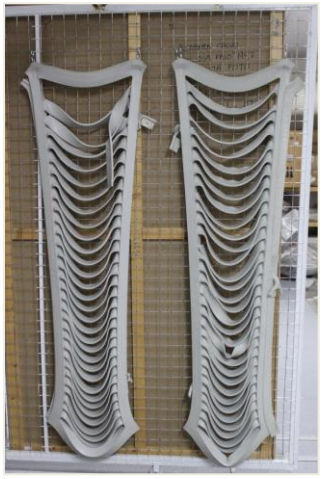
Saar Oosterhof, Table cloth with bowl, 1998, Centraal Museum Utrecht

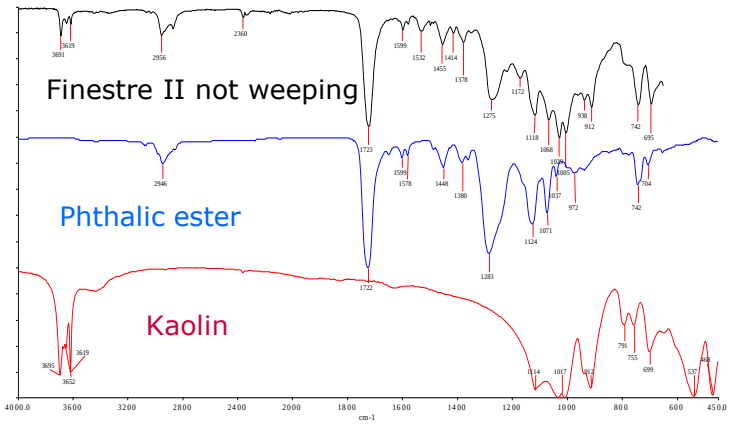
Degradation PUR ether 'Soft Tiles', Saar Oosterhof

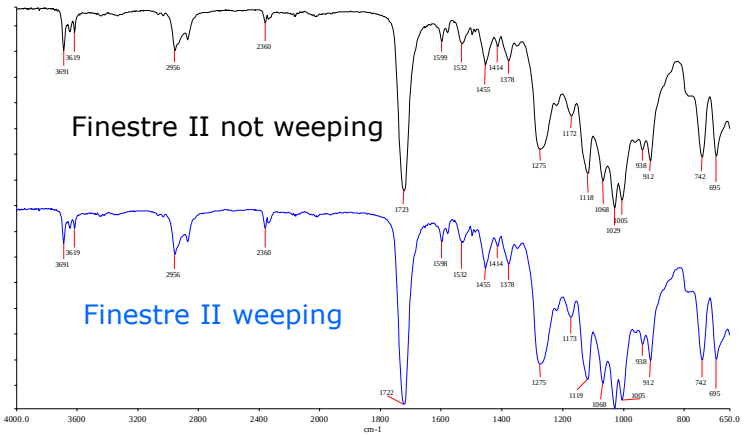




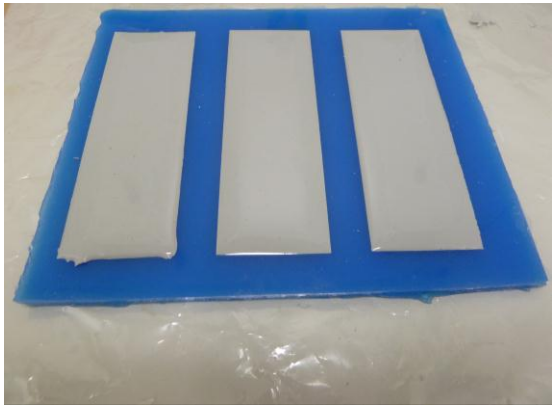
Degradation PUR ester ‘Finestre II’, Loris Cecchini

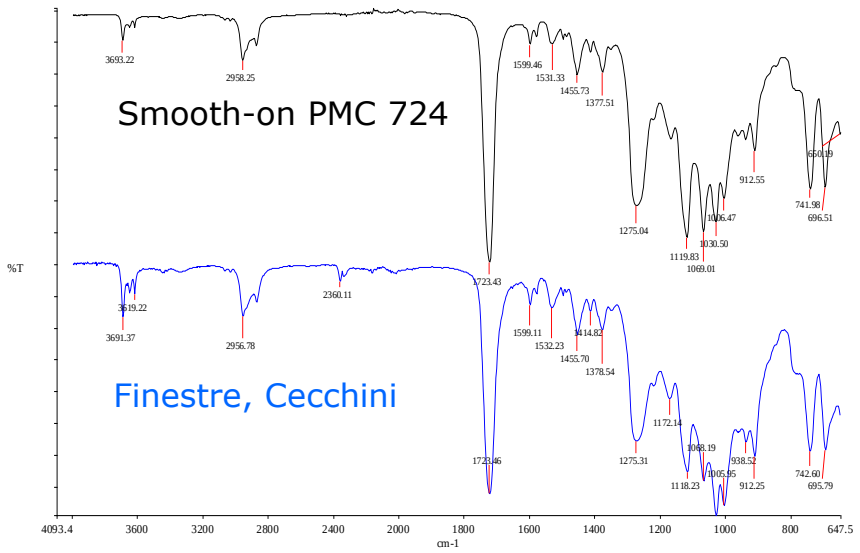


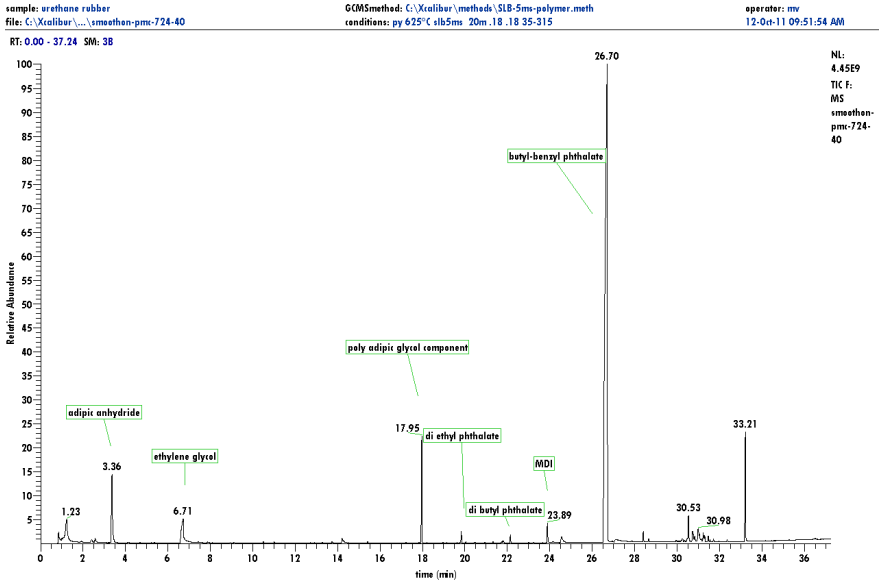




Making PUR ester test samples







Making test samples

Important: This rubber will last and perform in production, often for hundreds of castings (depending on what you are casting into the mold). It also exhibits good physical properties and chemical resistance. But **PMC-724®** does not have a long "library life". Molds will soften and revert to a liquid within 2 – 5 years, depending on exposure to moisture. Smooth-On makes many different mold rubbers that offer a very long library life (25 years and more depending on application). Contact Smooth-On for information about its complete line of silicone and polyurethane mold rubbers.

The table at right indicates the effect of different percentages of Part C on the Shore A hardness of the cured rubber. (Important: Use of 'Part C' to soften the rubber may shorten mold life.) *Shore A Hardness after 72 hours at 73°F/25°C.

Artificial ageing

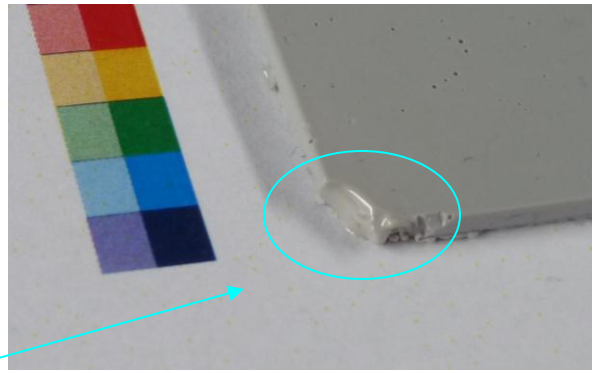
Ageing: 70°C, 30-80% 3 hrs interval for 2 weeks

Physical/mechanical test: Weight 2,5 kg

Smooth-on PMC 724, 25 shore test sample shows sticking soft material (weeping)

Smooth-on PMC 724 25 shore test sample:
20% increase in length

Smooth-on PMC 724 25 shore test sample **AGED**:
70% increase in length

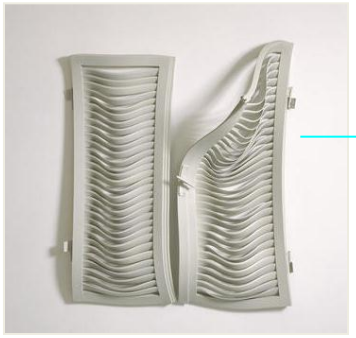


After test:
Both test samples back to original size
Change in elasticity due to artificial ageing

What went wrong?

Loris Cecchini

Stage evidence series, PUR ester urethane



Finestre II
2000, Private Collector

Weeping

Fotocopiatrice
2002, Museo del
Novecento, Milano

Hella Jongerius

Soft vases, PUR ester urethane

Soft vase,
1999, Private Collector

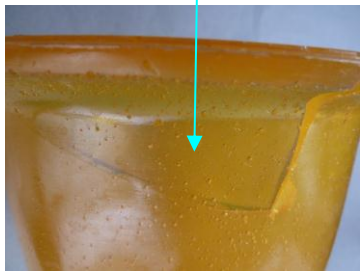
Soft vases, 1994

What can we do?

Research on adhering

Hella Jongerius, Soft vase, 1999, 25 x Ø 19 cm 1,5 / 2 cm thickness

Crack



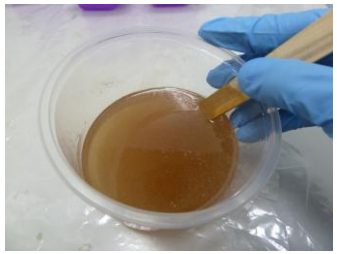
Broken parts

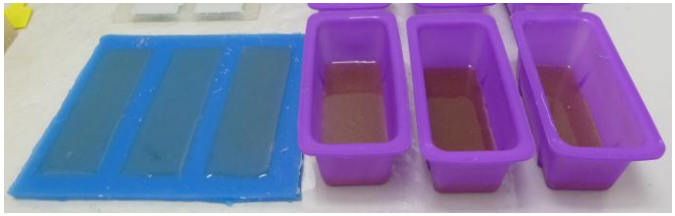
Shore hardness 20A

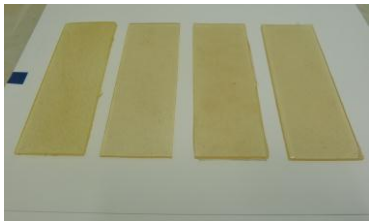
Bubbles

Making test samples and dummies

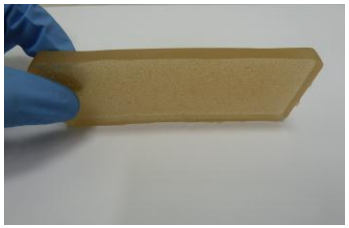
- PUR ether elastomer (VytaFlex® 20 – Smooth on)
- Colour (Amber)
- Translucency
- Shore hardness



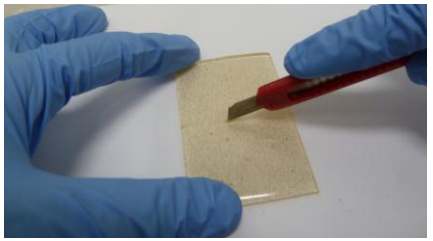


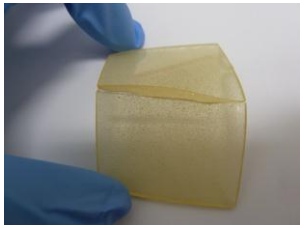


Test samples



Thick test samples 1,5 cm





Mimic mechanical damages

Selecting adhesives

- the ability to adhere polyurethane elastomers
- comparable optical properties
- comparable refractive index,
- the ability to make a flexible bond
- enough strength suitable working time to adhere large surfaces,
- preferably not yellowing,
- appropriately viscosity,
- chemical and physical stable
- preferably reversible.

ADHESIVES	Composition
Bison Rubber repair	Polyester/polyether-urethane dispersion of aliphatic isocyanate
Bison Soft plastic adhesive	Polyester urethane
Bison kit transparent	Polyester urethane
Bison Kombi power	Polyester urethane (filled)
Bison stick Universal	Polyester urethane
Smooth-on Vitaflex 20	Polyether urethane
Bison Universal kit	Siliconated acrylate dispersion
Bison Alleslijm	Polyvinylacetate
Paraloid F10	Butylacrylate in mineral spirit
Plextol D 360	Acrylic Aqueous dispersion
Plextol B 500	Acrylic Aqueous dispersion
Plextol D 498	Acrylic Aqueous dispersion

Testing adhesives

Research include:

- Identifying all the adhesives using Fourier Transform Infrared spectroscopy

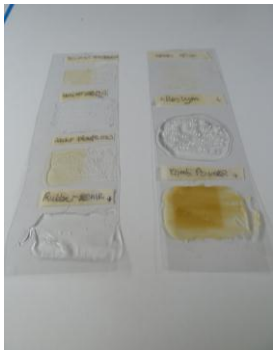
- Light aging of the adhesives using a Xenon 160 hours of artificial light equals 40 years at museum condition at 200 lux.

- Measuring the refractive index of the adhesives and the polyurethane objects

- Testing bond strength.

6 adhesives selected:
Plextol B500,
Plextol D480,
Plextol D360,
Bison soft plastic adhesive,
Bison Rubber repair
VytaFlex®20

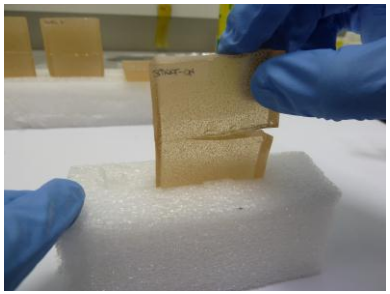
Xenotest, Alpha High Energy (Atlas®)

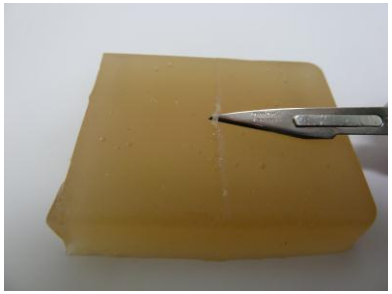


Adhesives after light ageing

Rayner illuminated Dialdex refractometer

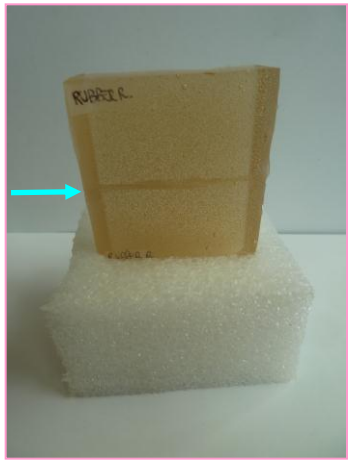
Testing applicability

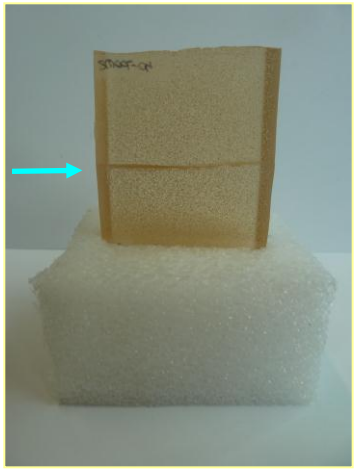




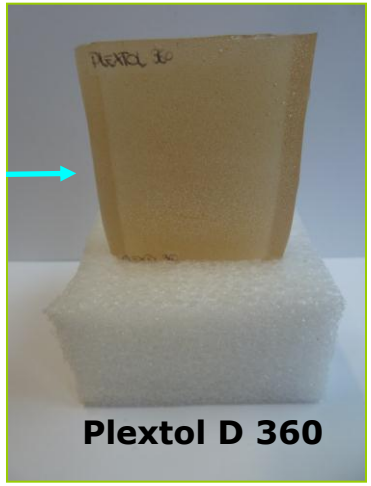
Testing appearance

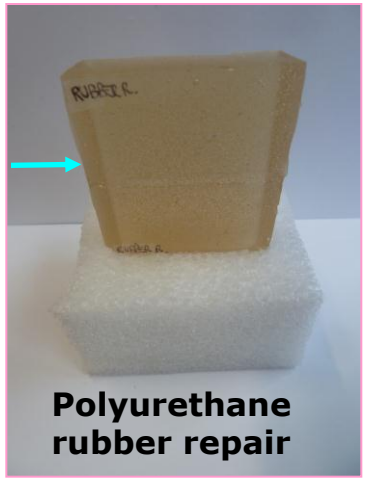
BEFORE ADHERING





AFTER ADHERING





Conclusions

✓It was possible to mimic the weeping of soft sticky material and loss in elasticity as in Finestre II

✓PUR ester elastomer casting materials with external plasticizers turn to soft sticky material within 5 years(as nowadays mentioned in the datasheet) due to materials composition

✓Preliminary good results were obtained with adhering PUR ethers elastomers

Ongoing research

o Adhering tests on translucent PUR ester elastomers based on the experience with PUR ether elastomers

o Strength tests for the selected adhesives

o Test consolidents on test samples and perform E-modulus tests after artificial ageing using heat and humidity

Acknowledgements

- Nathalie Dubois, Centraal Museum Utrecht
- Geertje Huisman, RCE
- Theresa Mom
- Loris Cecchini
- Hella Jongerius’s studio
- Anthony Sgard, Form-X
- Julia Langenbacher