Institut für Keramik, Glas- und Baustofftechnik

Improvement of surface properties: Experiences with a new technique

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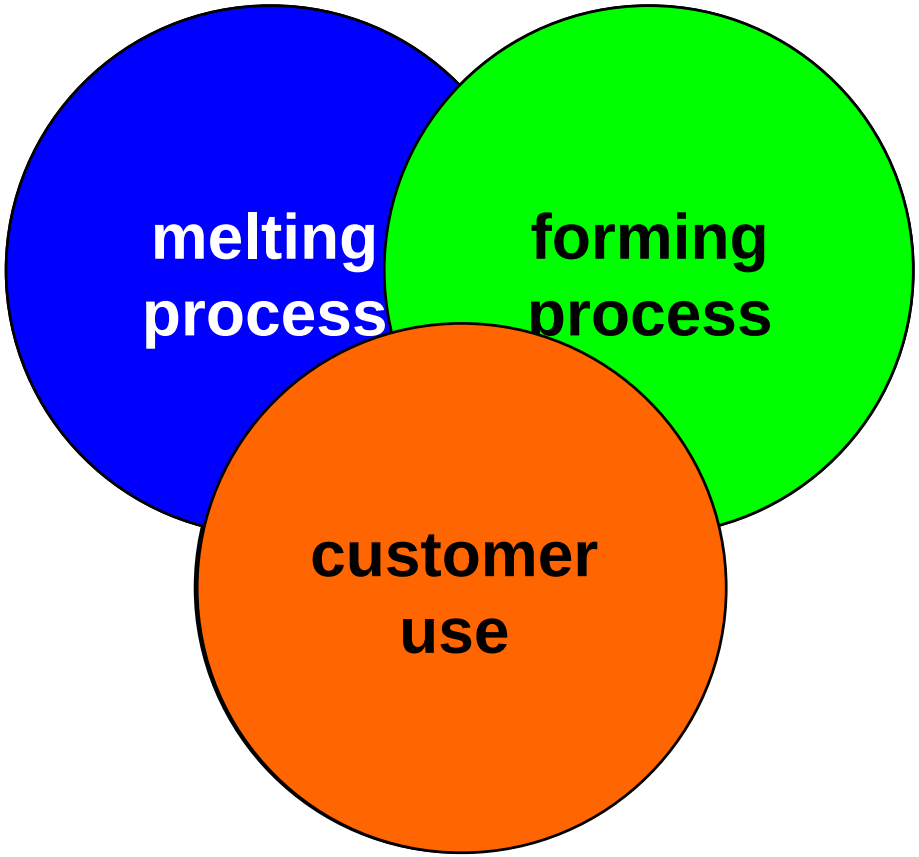
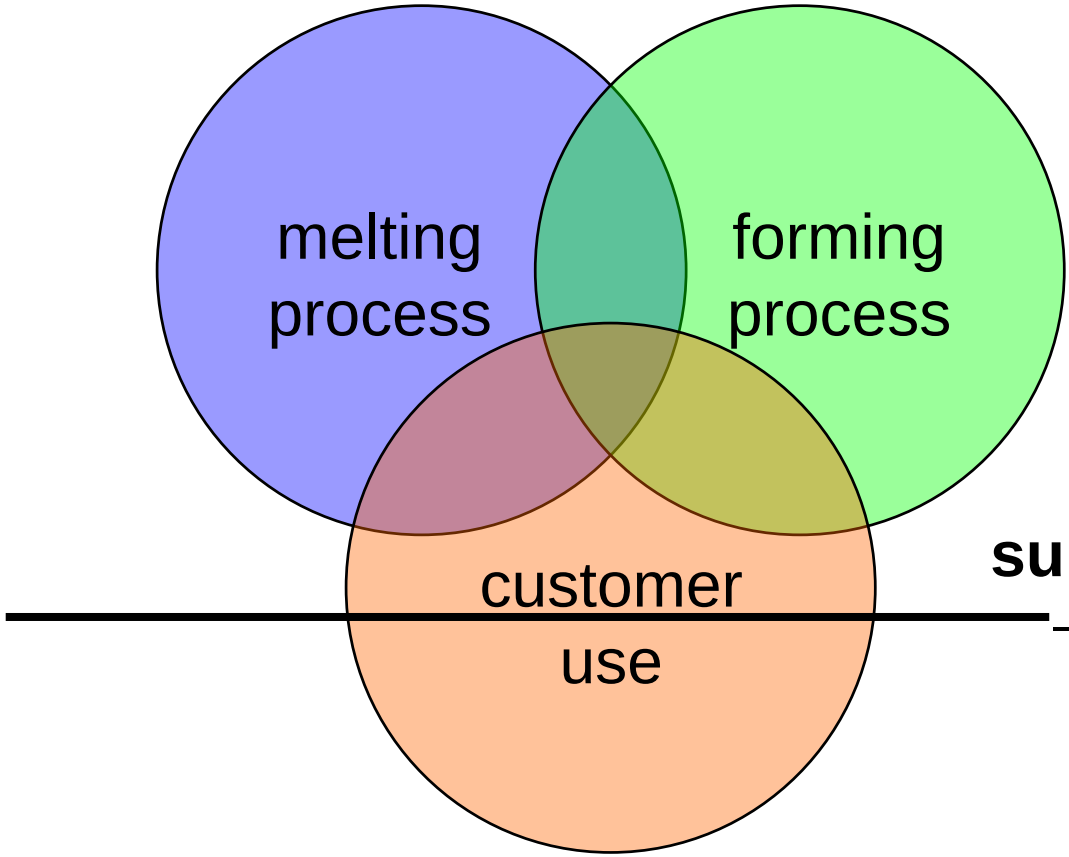
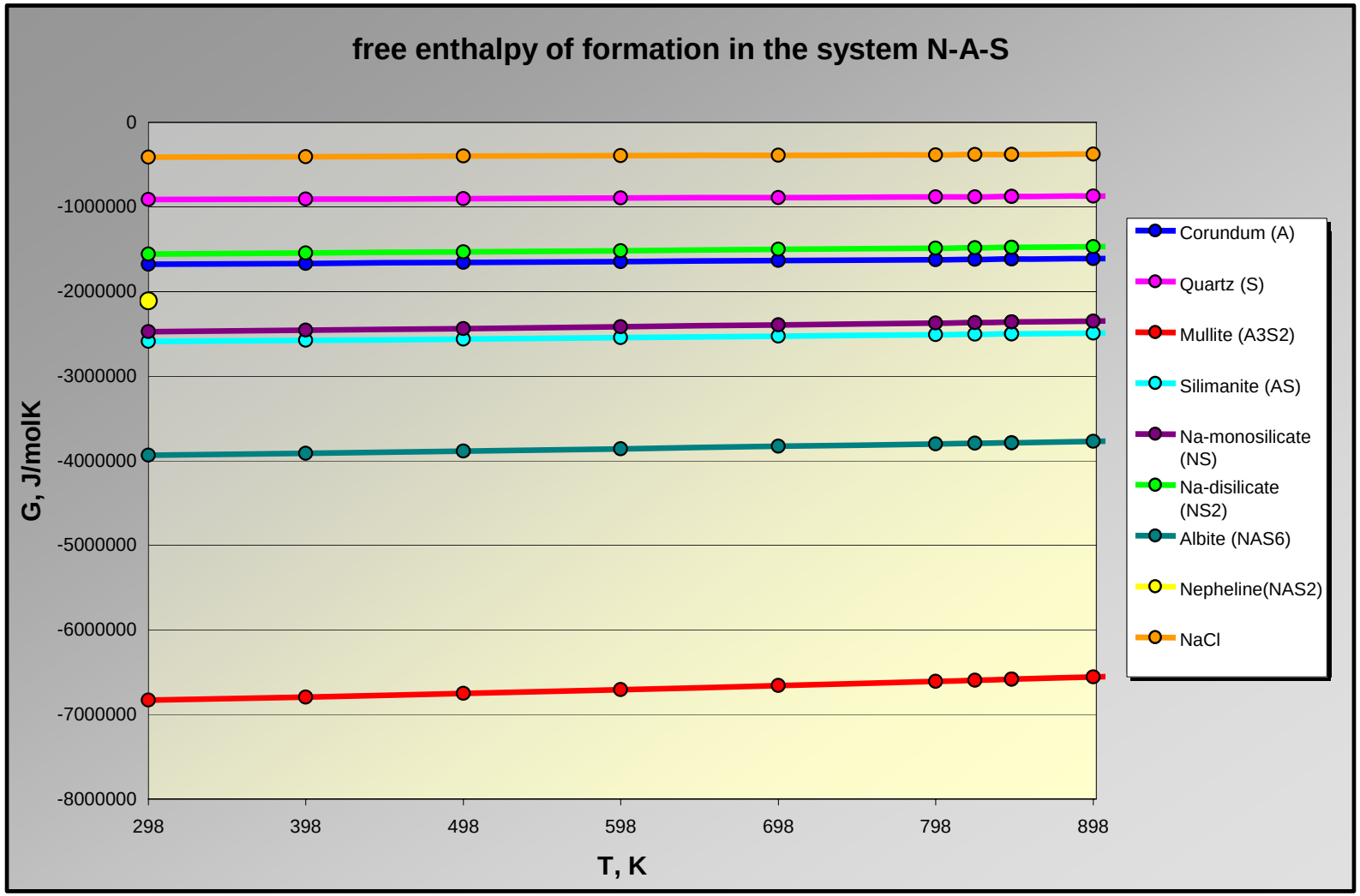


- optical properties
- hydrolytic resistance
- …
- workability
- density
- chemical durability – Pb release to the environment
- mechanical properties
- …
- batch material
- of the glass



surface treatment
– online after the forming process


free enthalpy of formation in the system N-A-S
0
-1000000
-2000000
-3000000
-4000000
-5000000
-6000000
-7000000
-8000000
G, J/molK
298
398
498
598
698
798
898
T, K
Corundum (A)
Quartz (S)
Mullite (A3S2)
Silimanite (AS)
Na-monosilicate (NS)
Na-disilicate (NS2)
Albite (NAS6)
Nepheline(NAS2)
NaCl

With formation of thermodynamically stabile structures are expected:

1. Improvement of mechanical properties
2. Improvement of chemical resistance
3. Higher temperature stability

Possibilities:

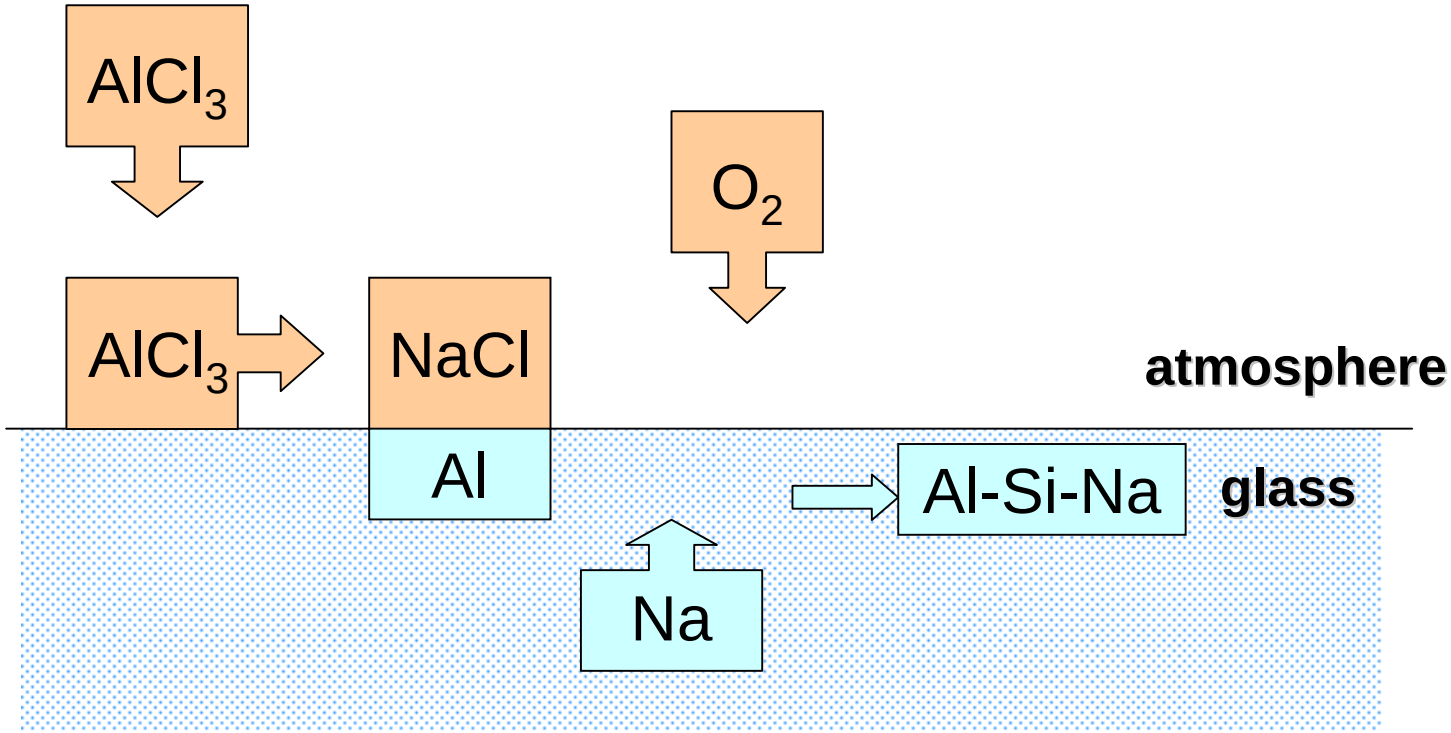
- Al supply from gas phase
- Al supply due to metal contact

Ideal is a hot reactive surface during forming process

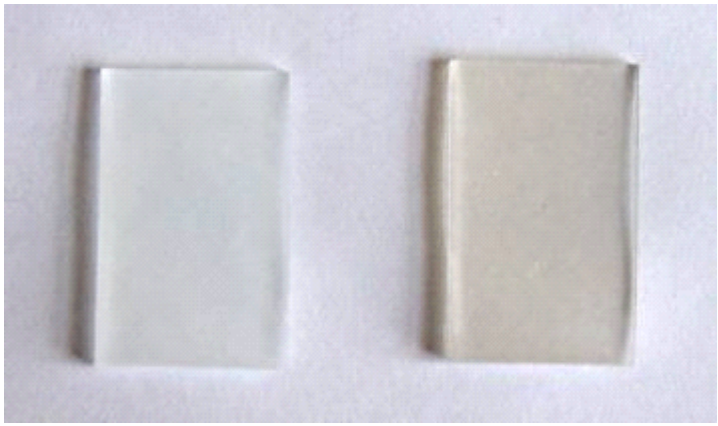
Support of transport processes and reorganisation in the glass surface; application of electrical potentials.

Interaction processes depending on time, temperature and concentration:

possible process flow:



Optical comparison of various glasses untreated and differently treated at T_g

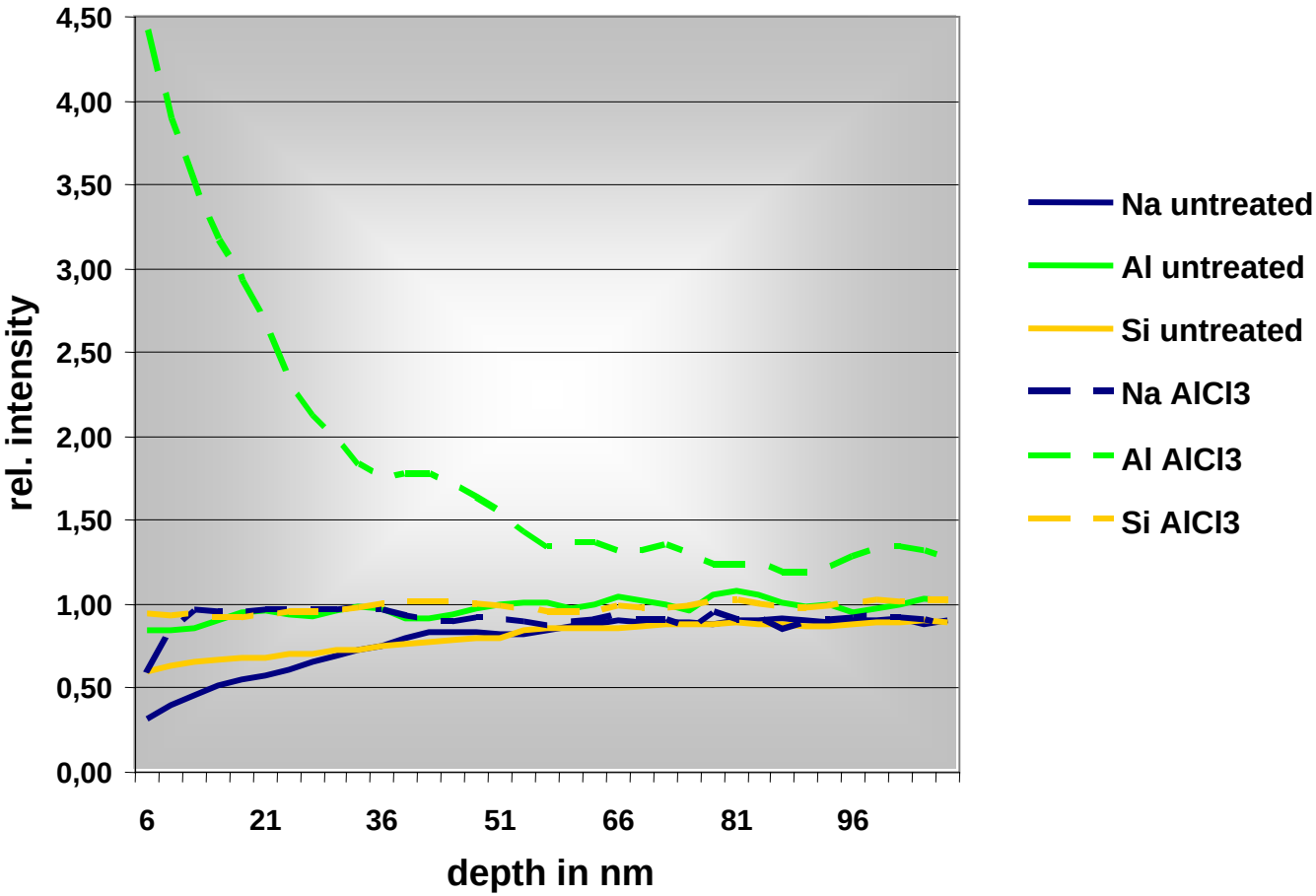


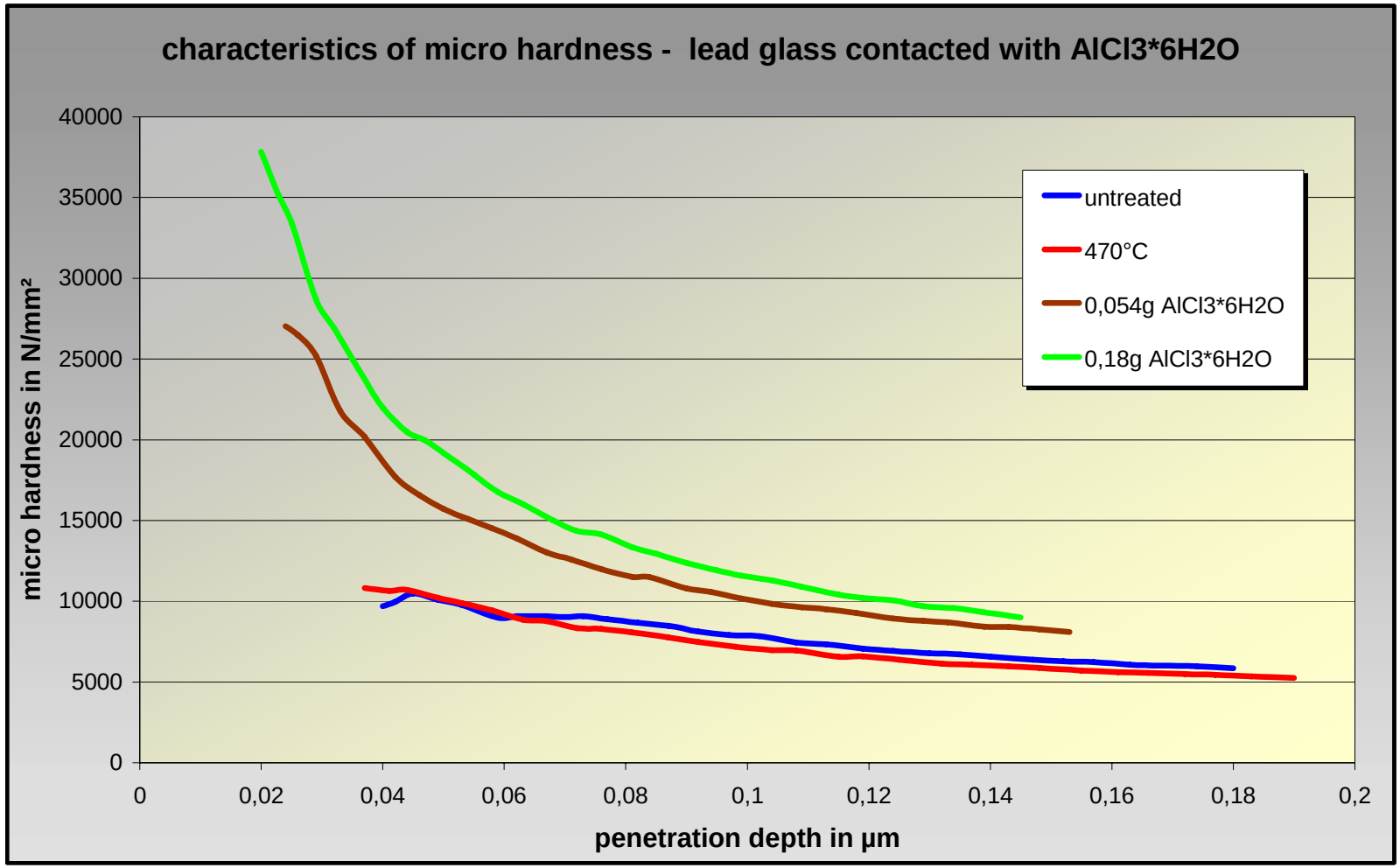
polished float glass

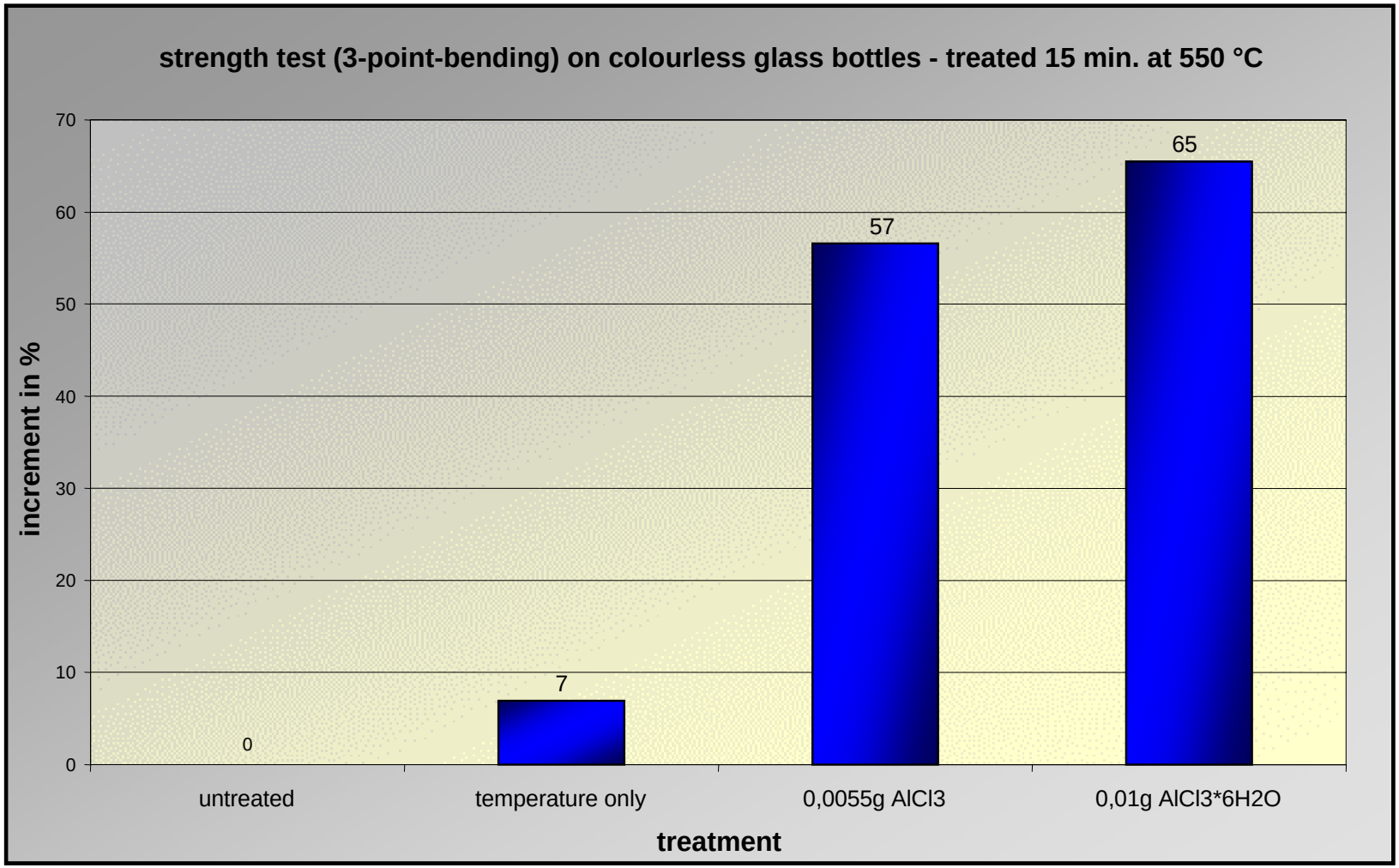
lead crystal glass

lead crystal glass

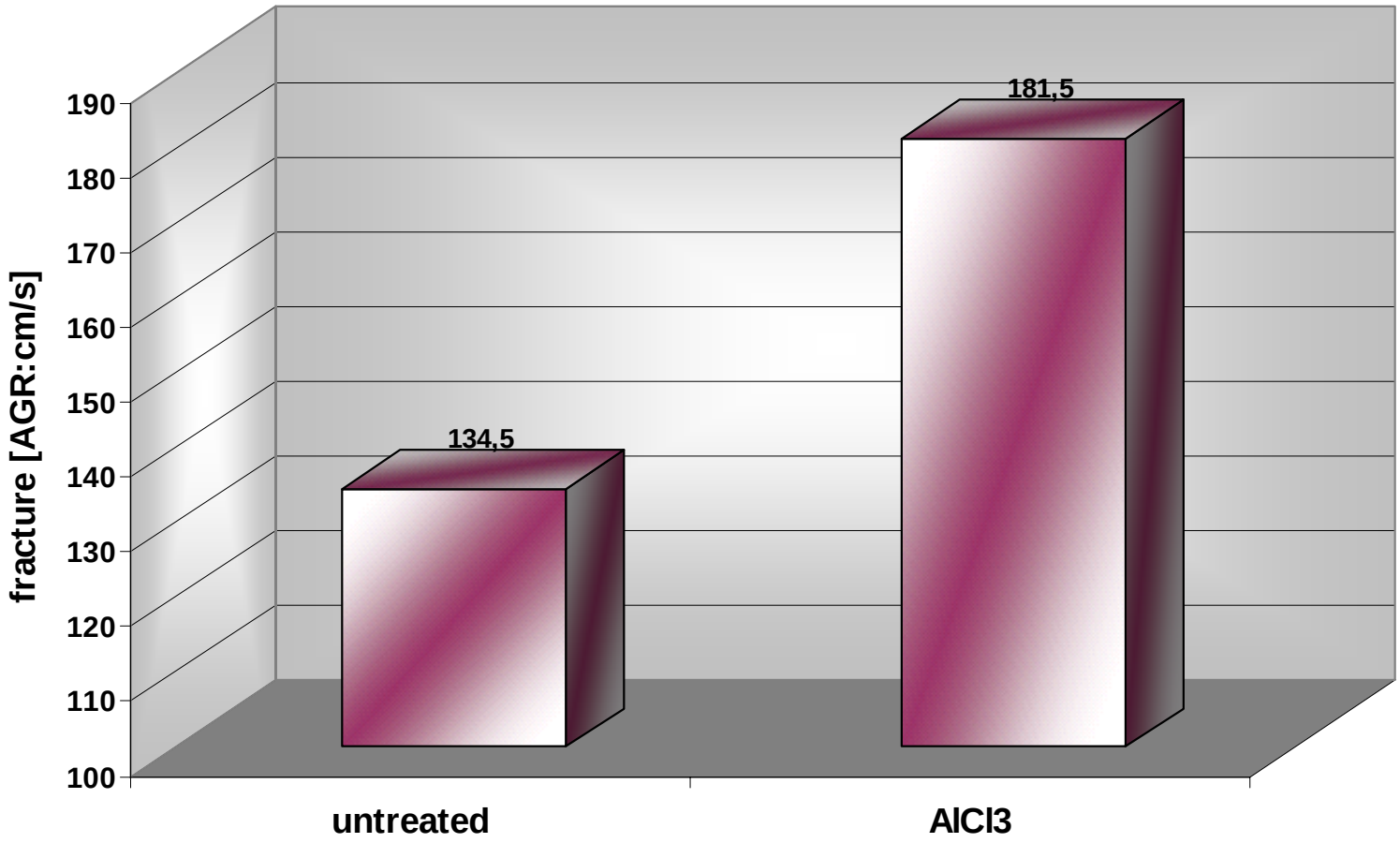
SNMS depth profile of float glass



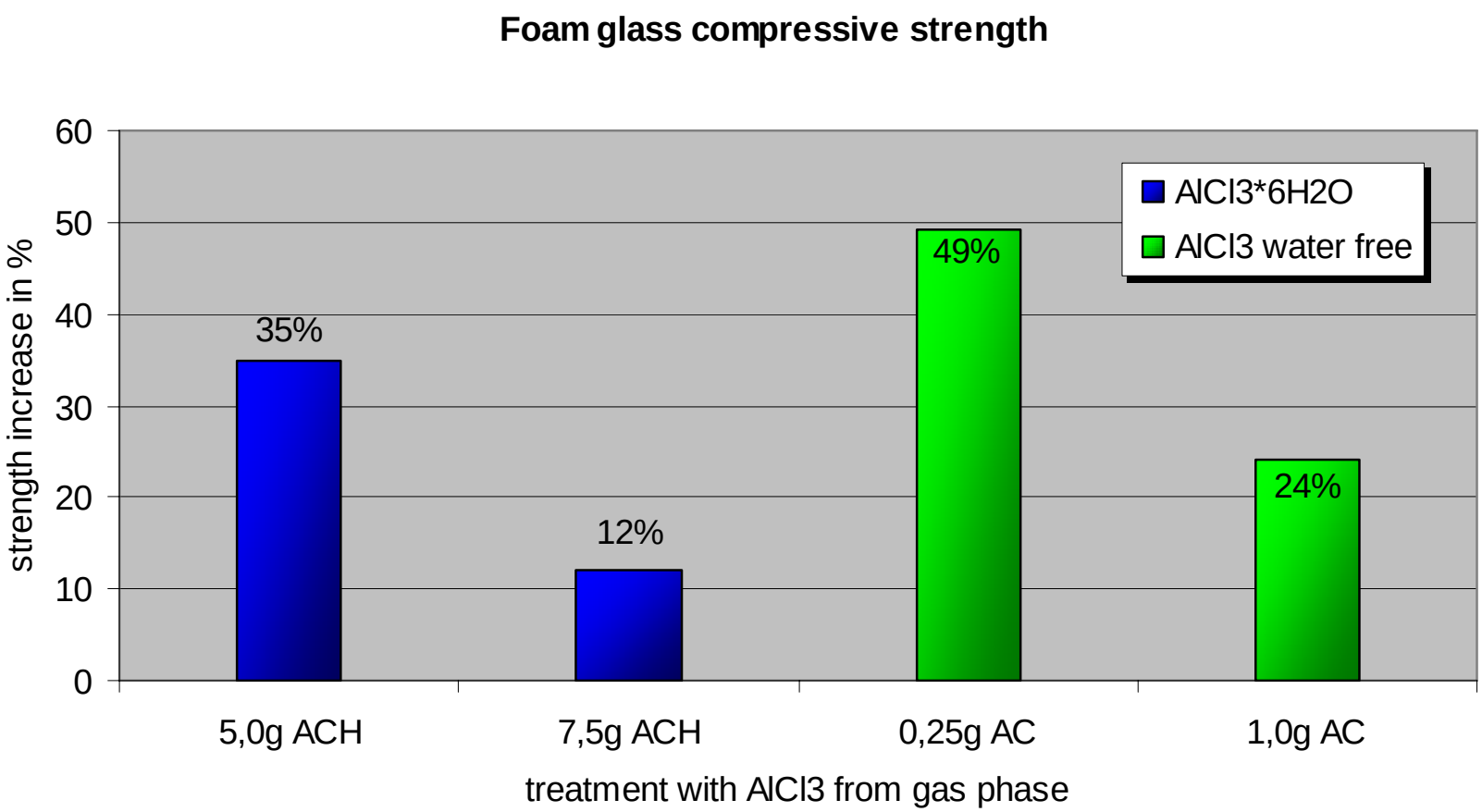

characteristics of micro hardness - lead glass contacted with AlCl3*6H2O
micro hardness in N/mm²
40000
35000
30000
25000
20000
15000
10000
5000
0
0
0,02
0,04
0,06
0,08
0,1
0,12
0,14
0,16
0,18
0,2
penetration depth in µm
untreated
470°C
0,054g AlCl3*6H2O
0,18g AlCl3*6H2O


strength test (3-point-bending) on colourless glass bottles - treated 15 min. at 550 °C
increment in %
70
60
50
40
30
20
10
0
0
7
57
65
untreated
temperature only
0,0055g AlCl3
0,01g AlCl3*6H2O
treatment

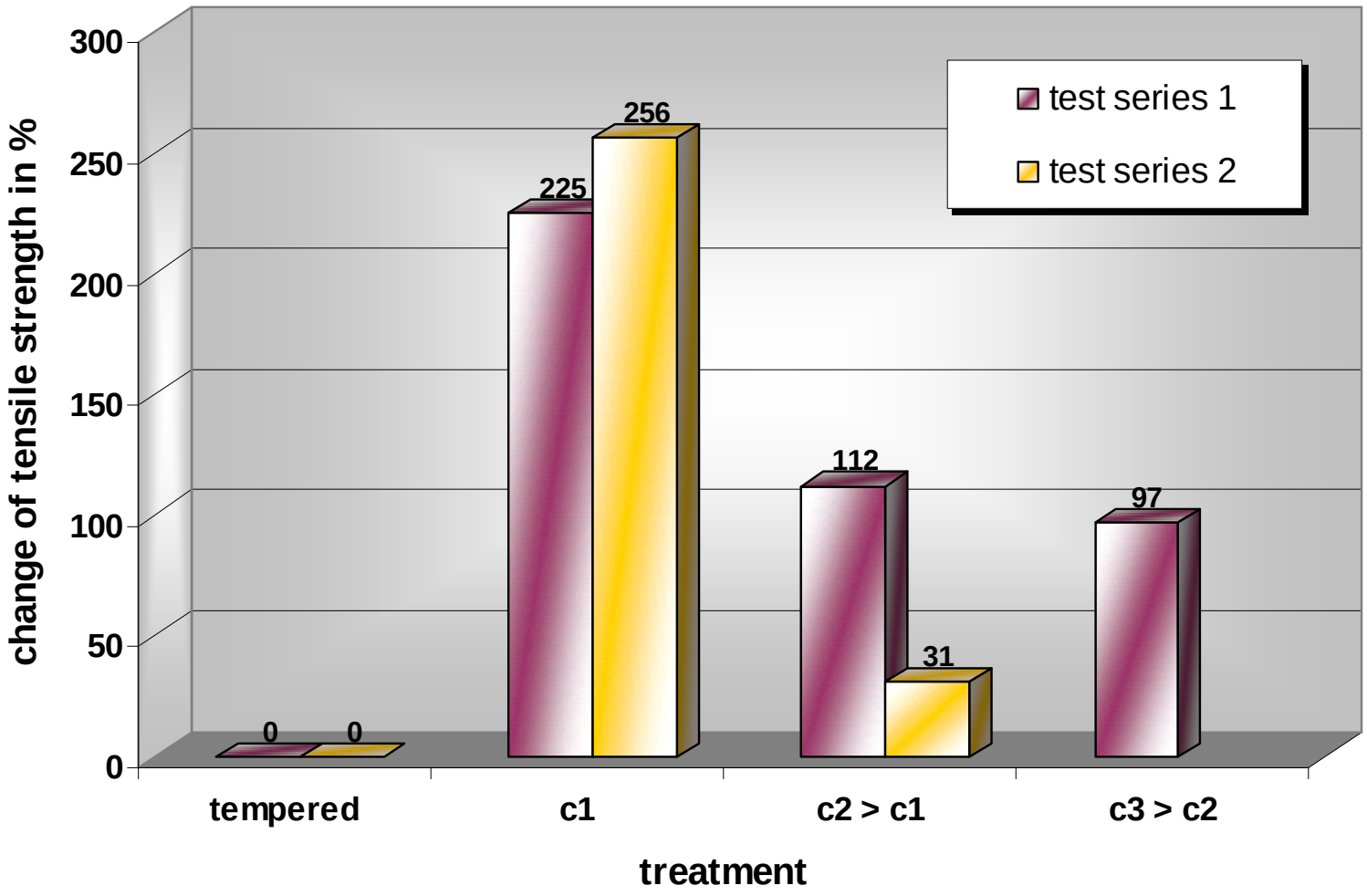
impact strength of container glass: 1st production test



Comparison of the impact strength (AGR) of 720 ml wide neck container glass; AlCl3 treatment in running production

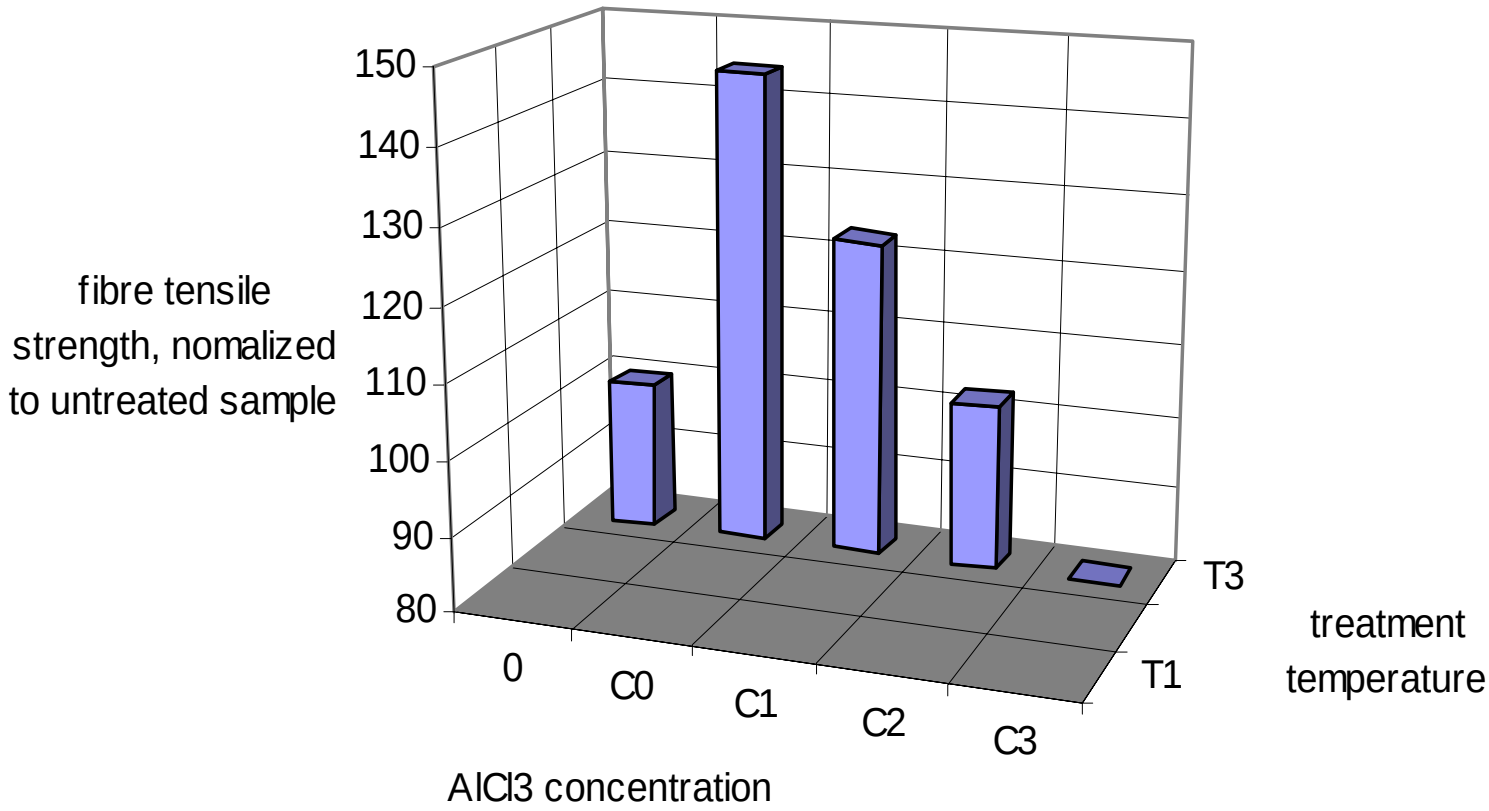

Foam glass compressive strength
60
50
40
30
20
10
0
strength increase in %
AlCl3*6H2O
AlCl3 water free
35%
12%
49%
24%
5,0g ACH
7,5g ACH
0,25g AC
1,0g AC
treatment with AlCl3 from gas phase

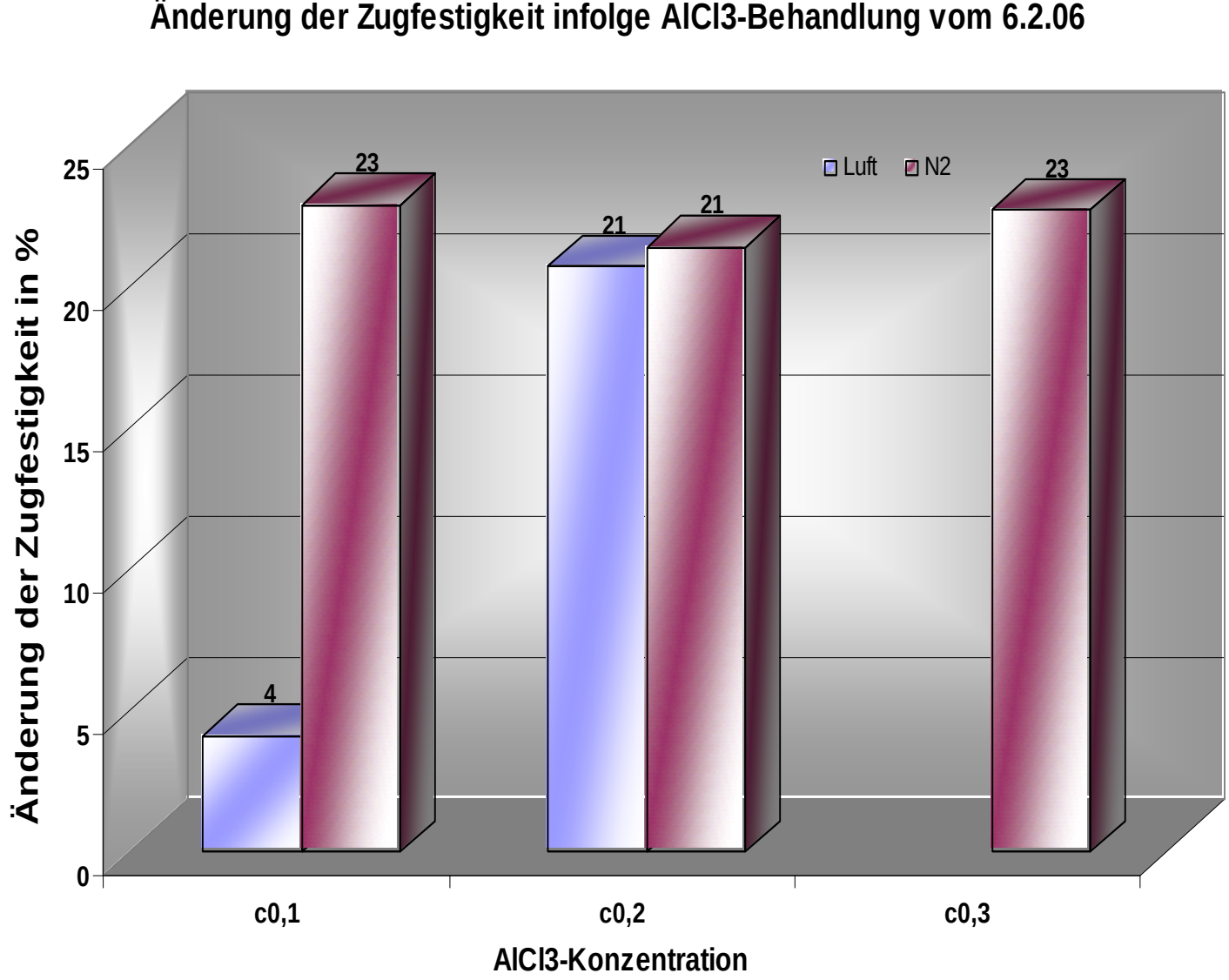
Pukh's group[15] has made interesting strength/composition studies over the years. They found that three sodium alumino silicate glasses with Na = Al and silica concentrations of 50, 67 and 75 mol% all had the same strength and approximately the same as that shown for S-glass, a ternary glass with 15.5 MgO 15.5Al_2O_3 69 mol% SiO_2. While the latter glasses (S-glass and the Na/Al/Si glasses) all have relatively high strengths, on the basis of their Young's modulus values (E ~85–90 GPa), they should all be stronger than silica.

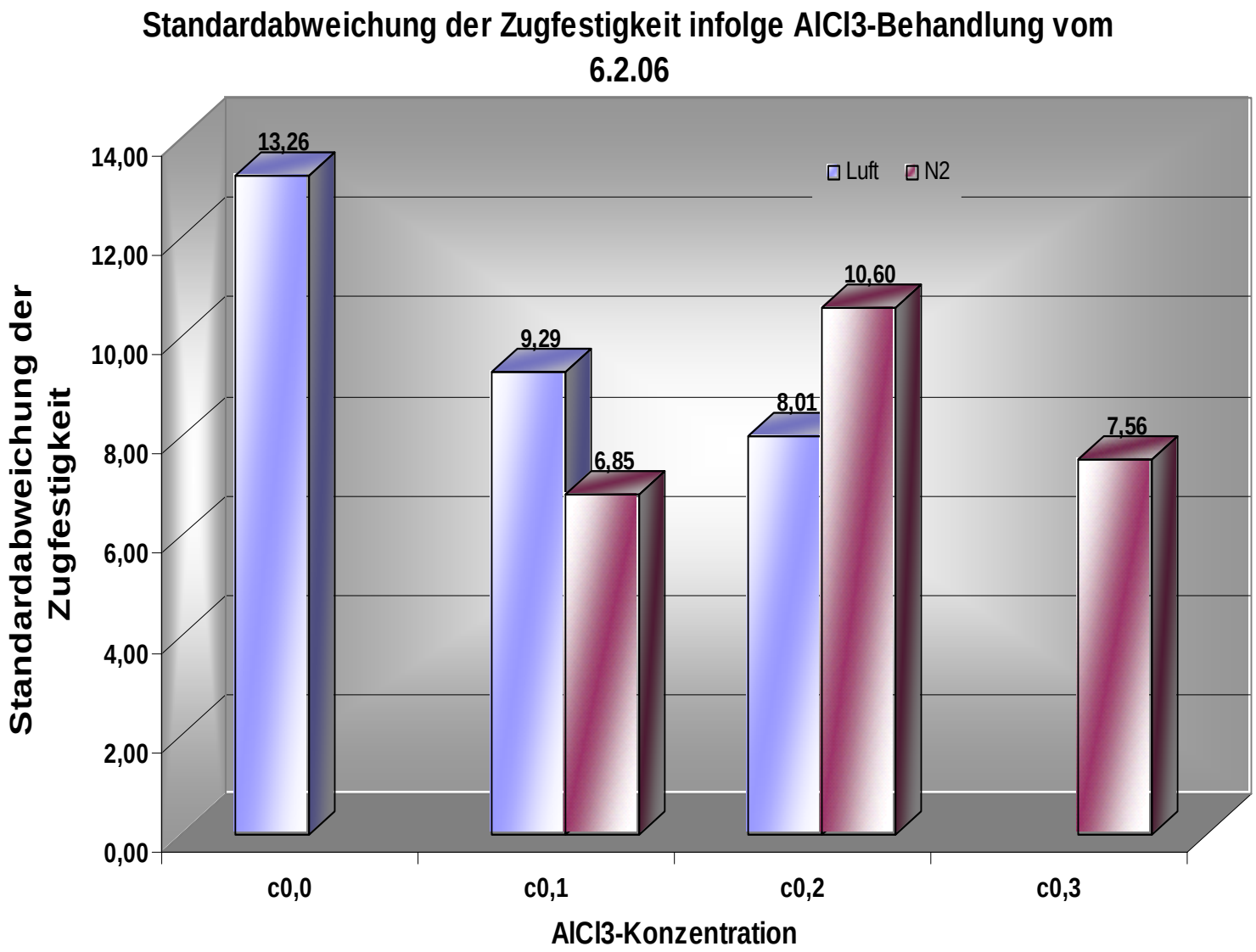


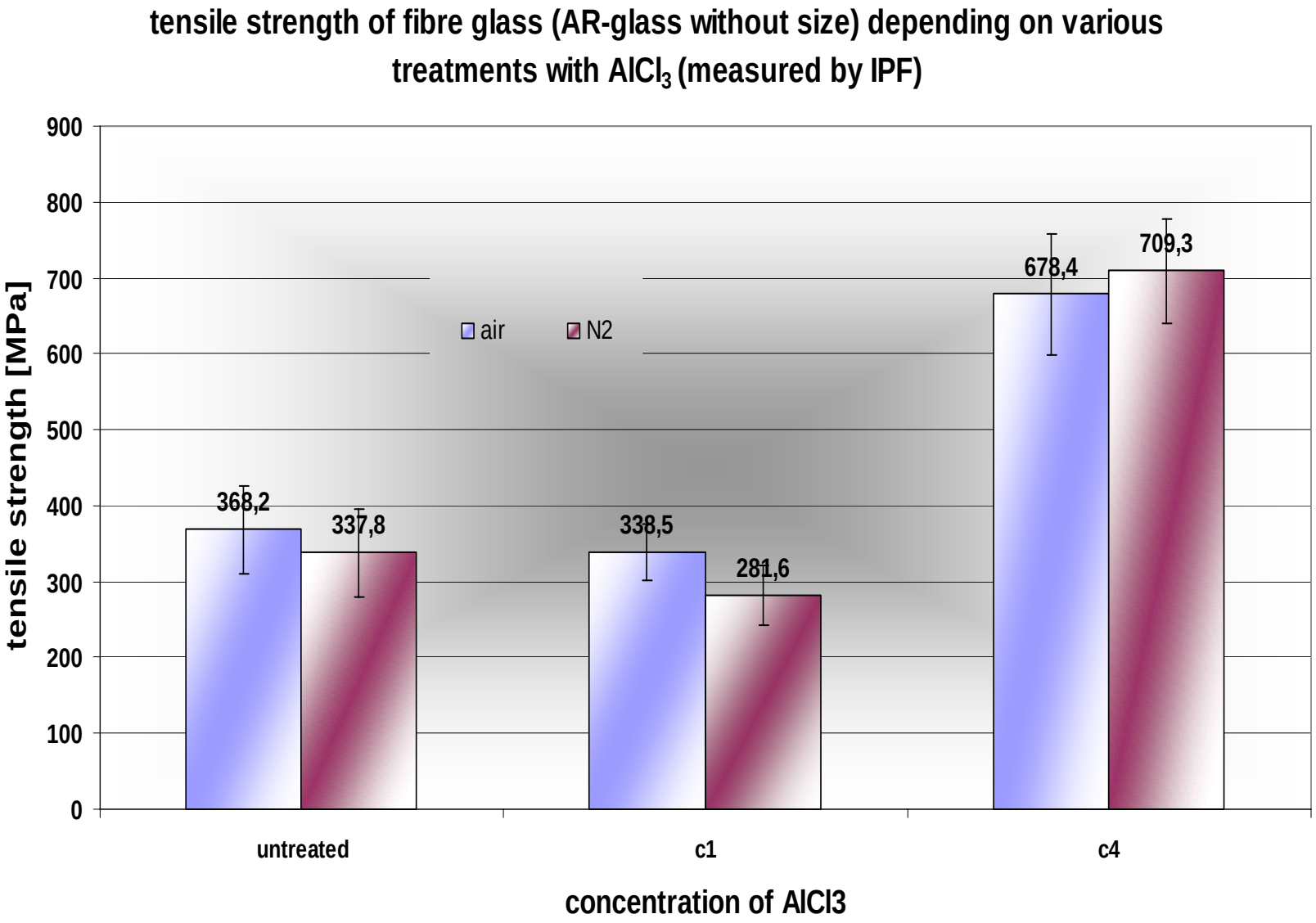
change of tensile strength of c-glass fibres after treatment with $AlCl_3$ (varying concentrations c1-c3)

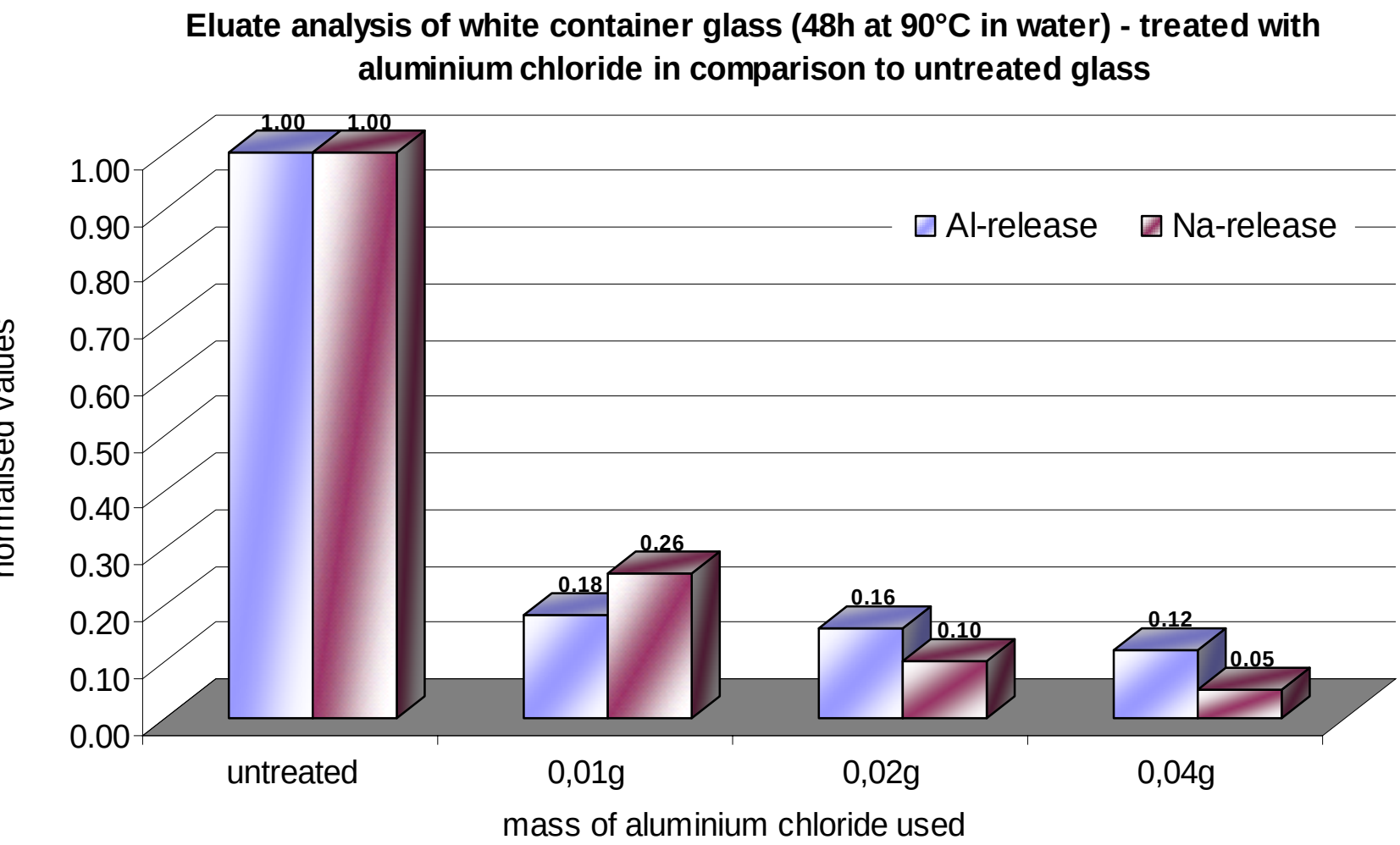
tensile strength of AR-glass (series 01, september 05)




Änderung der Zugfestigkeit infolge AlCl3-Behandlung vom 6.2.06
Änderung der Zugfestigkeit in %
25
20
15
10
5
0
Luft
N2
4
23
21
21
23
c0,1
c0,2
c0,3
AlCl3-Konzentration

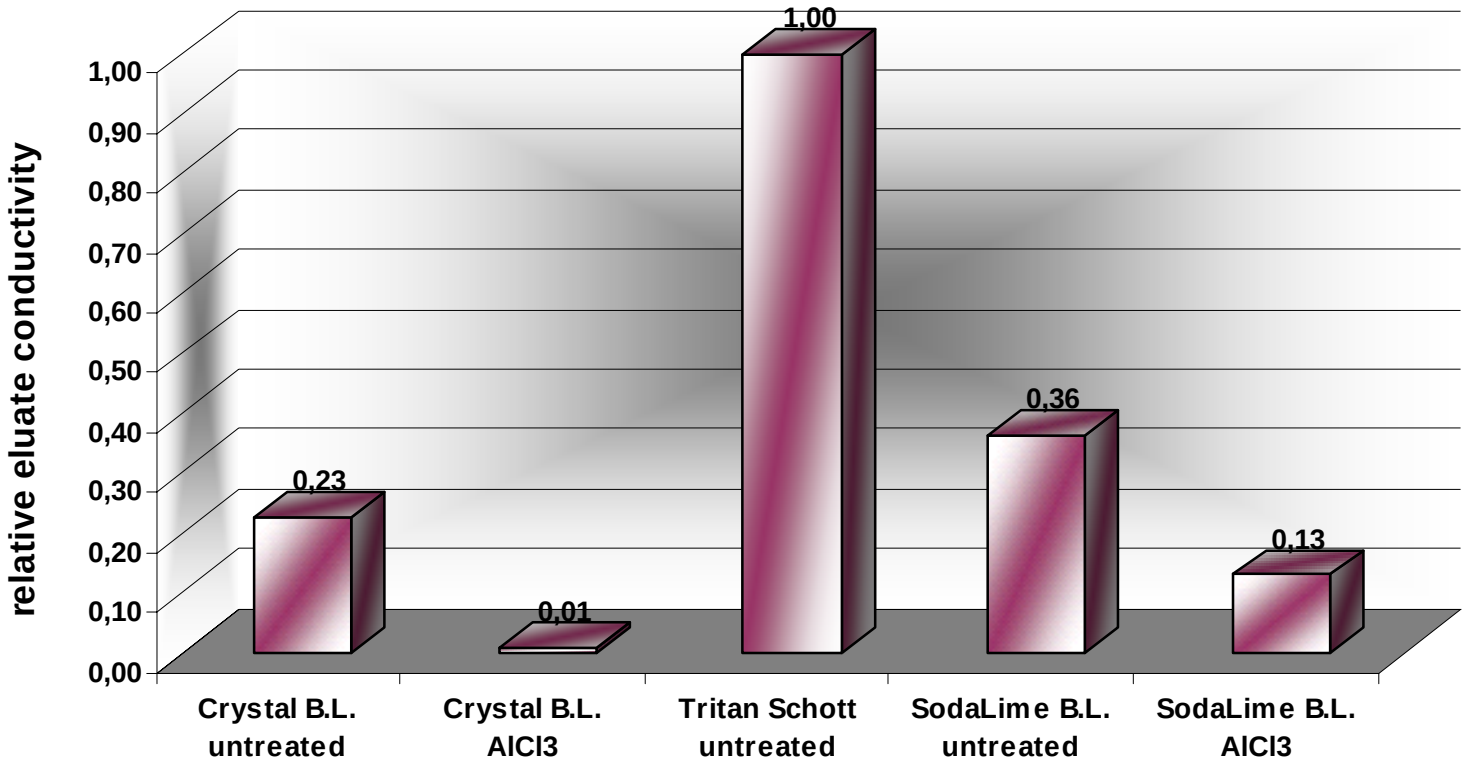

Standardabweichung der Zugfestigkeit infolge AlCl3-Behandlung vom 6.2.06
Standardabweichung der Zugfestigkeit
14,00
12,00
10,00
8,00
6,00
4,00
2,00
0,00
Luft
N2
13,26
9,29
6,85
8,01
10,60
7,56
c0,0
c0,1
c0,2
c0,3
AlCl3-Konzentration


tensile strength of fibre glass (AR-glass without size) depending on various treatments with AlCl3 (measured by IPF)
tensile strength [MPa]
900
800
700
600
500
400
300
200
100
0
air
N2
368,2
337,8
338,5
281,6
678,4
709,3
untreated
c1
c4
concentration of AlCl3

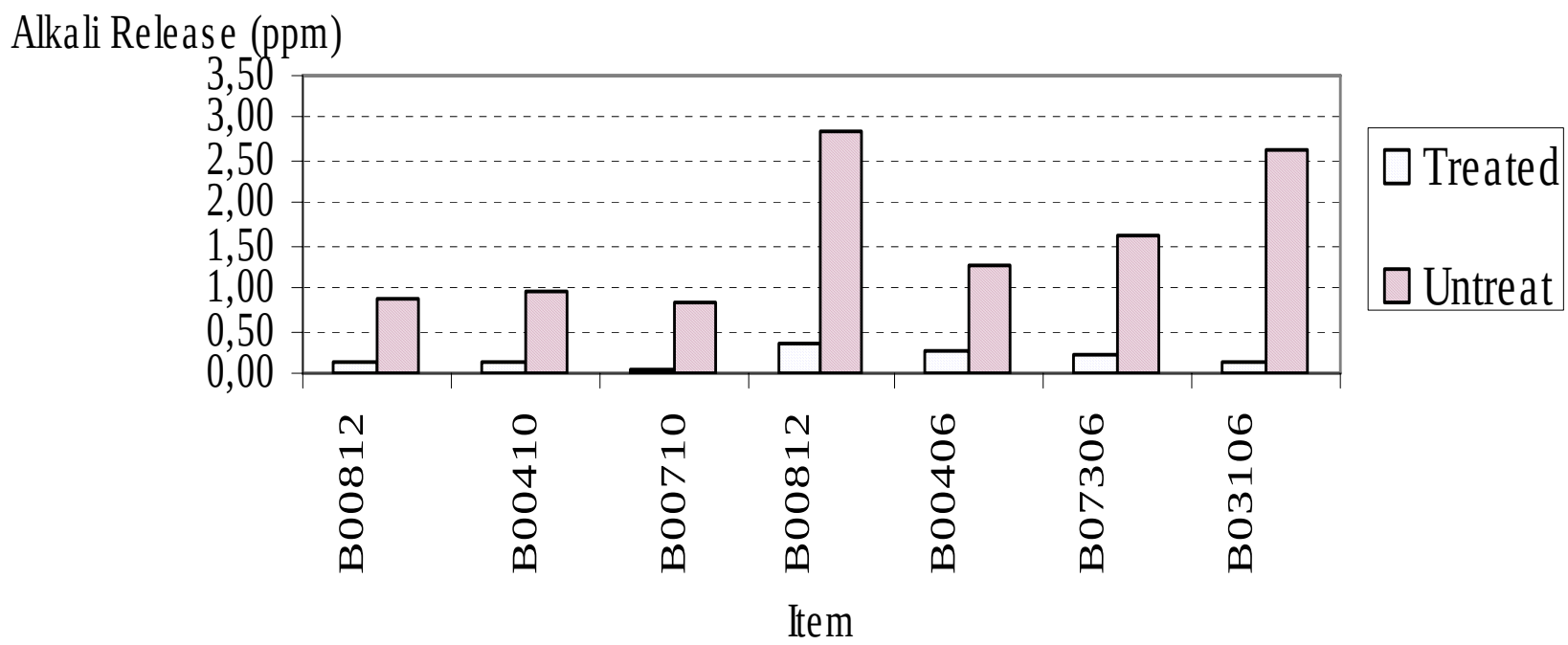

Eluate analysis of white container glass (48h at 90°C in water) - treated with aluminium chloride in comparison to untreated glass
normalised values
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Al-release
Na-release
1.00
1.00
0.18
0.26
0.16
0.10
0.12
0.05
untreated
0,01g
0,02g
0,04g
mass of aluminium chloride used

lead glass – after 72 hours immersion in distilled water at 90 °C; left: untreated; right: treated with $AlCl_3$

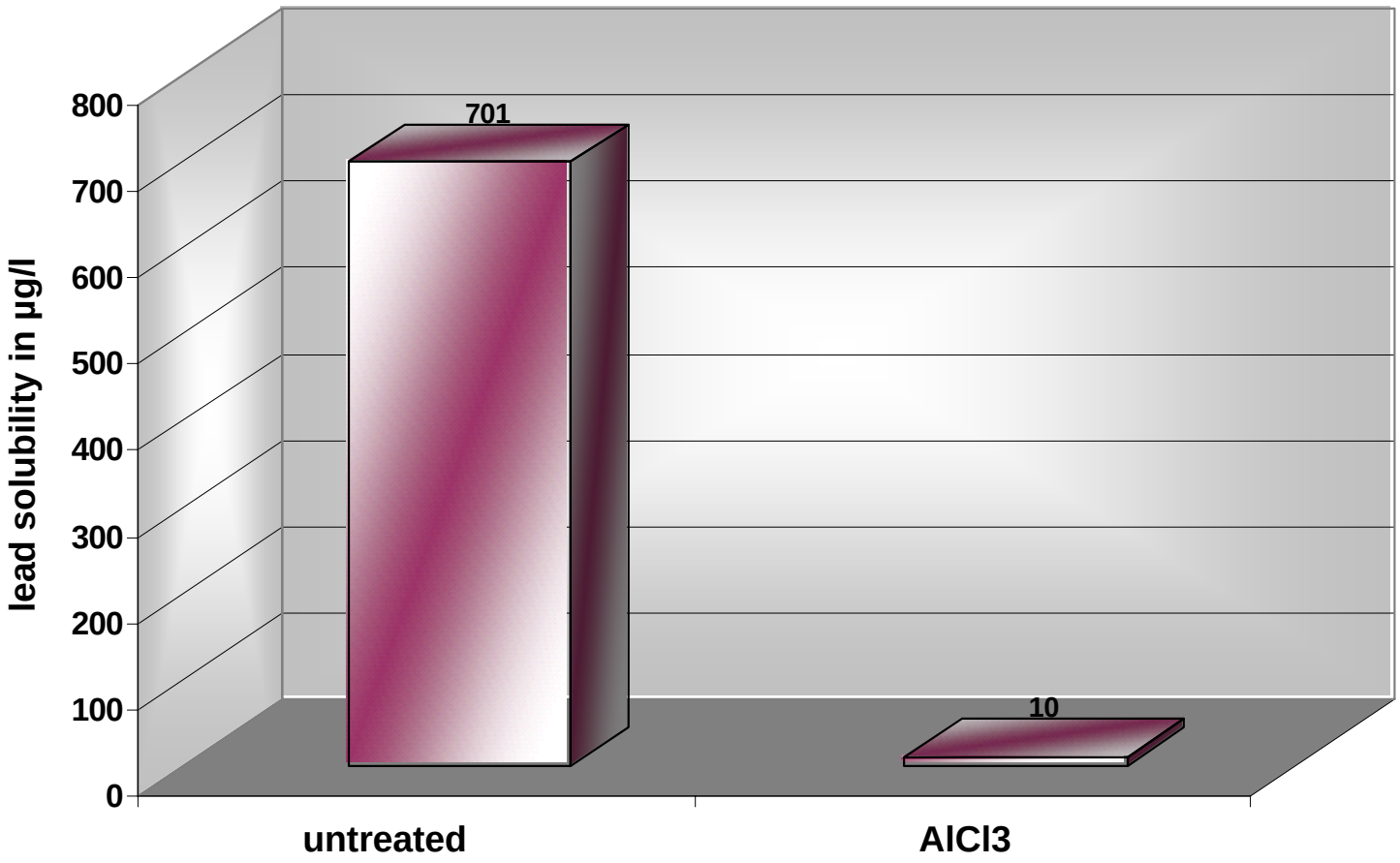
Comparison of the eluate conductivity of different glass systems after a 65 hour water attack at 90 °C (normalized to the value of the Schott glass)

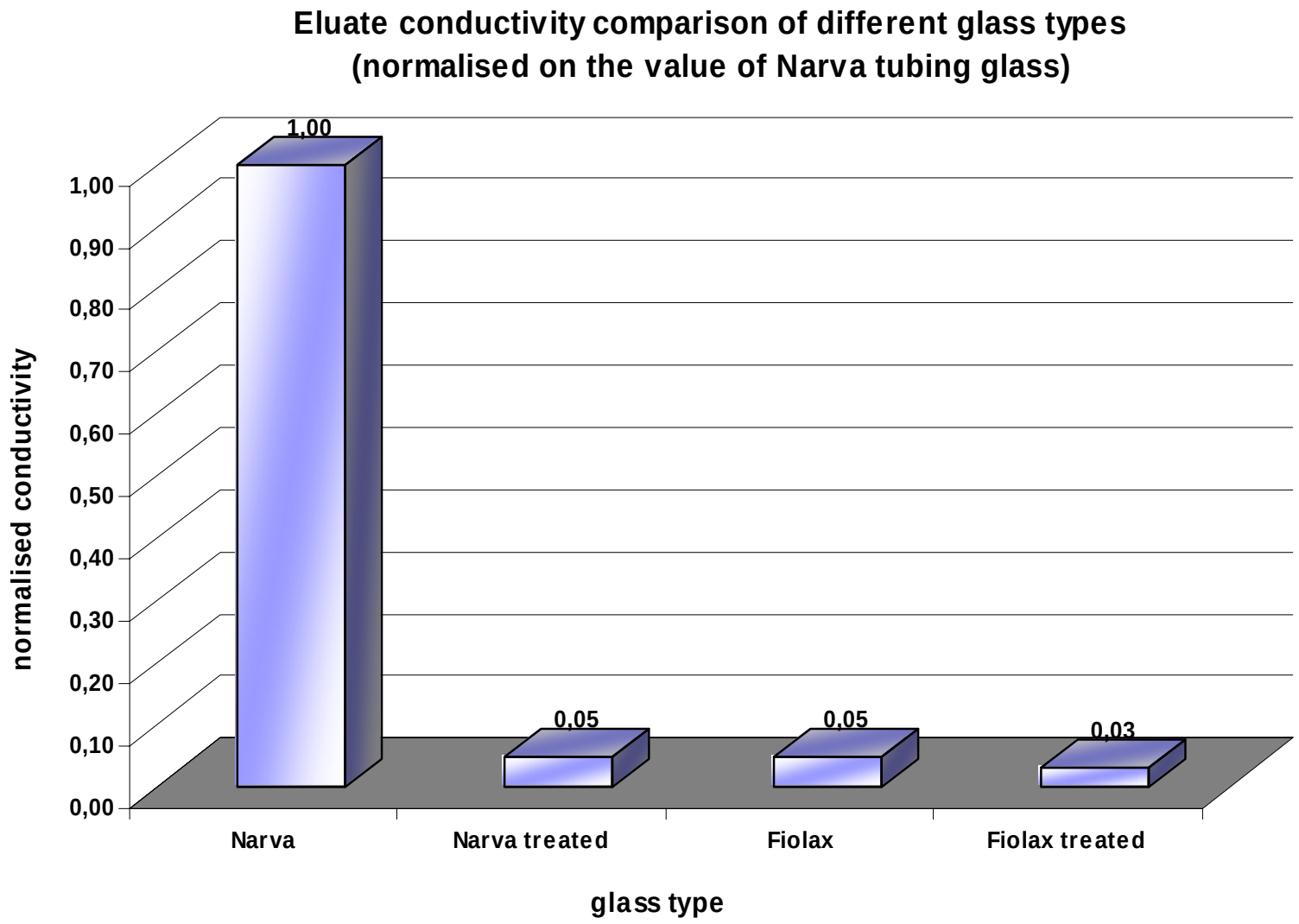


Tableware glass Thailand



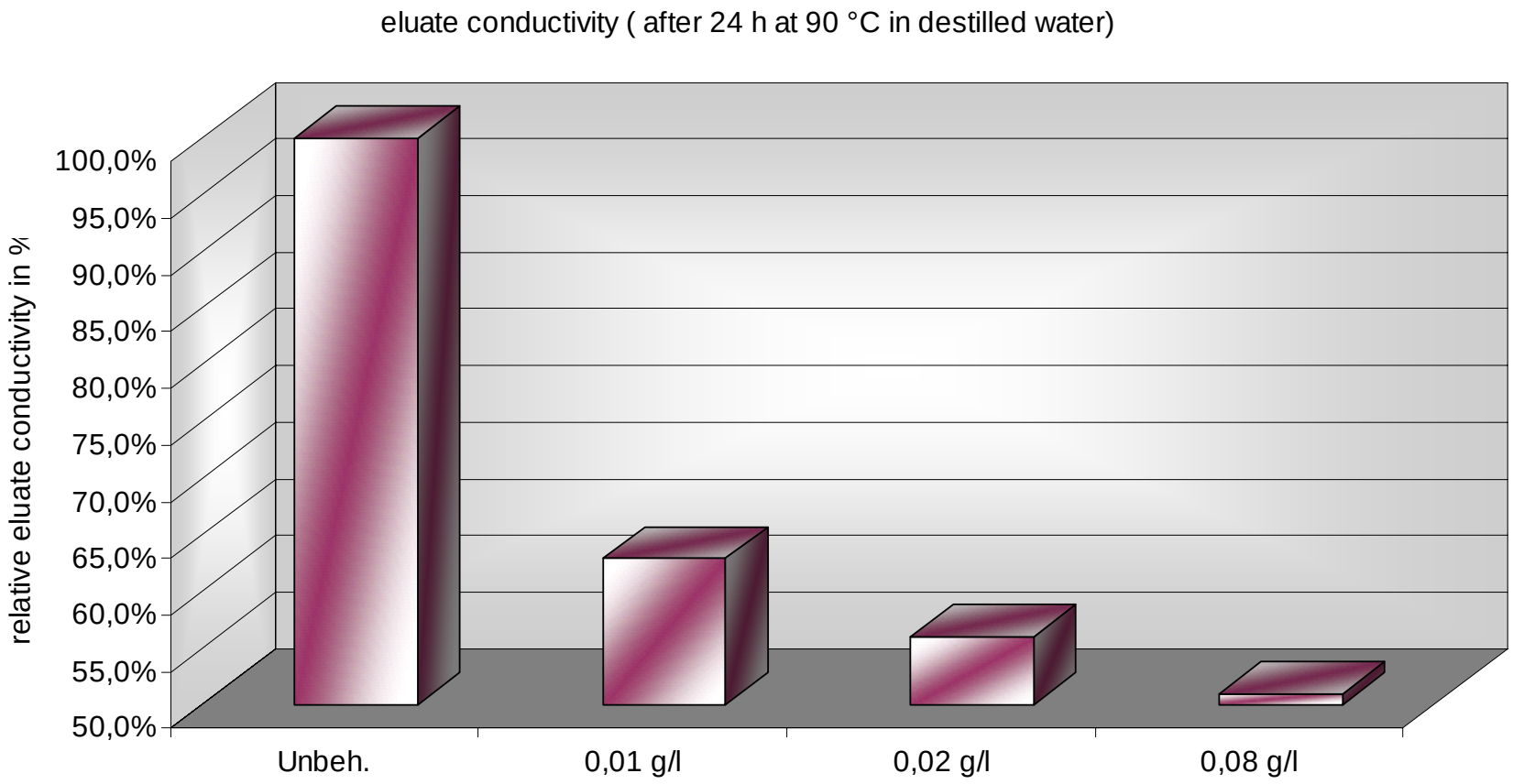
lead glass - lead solubility



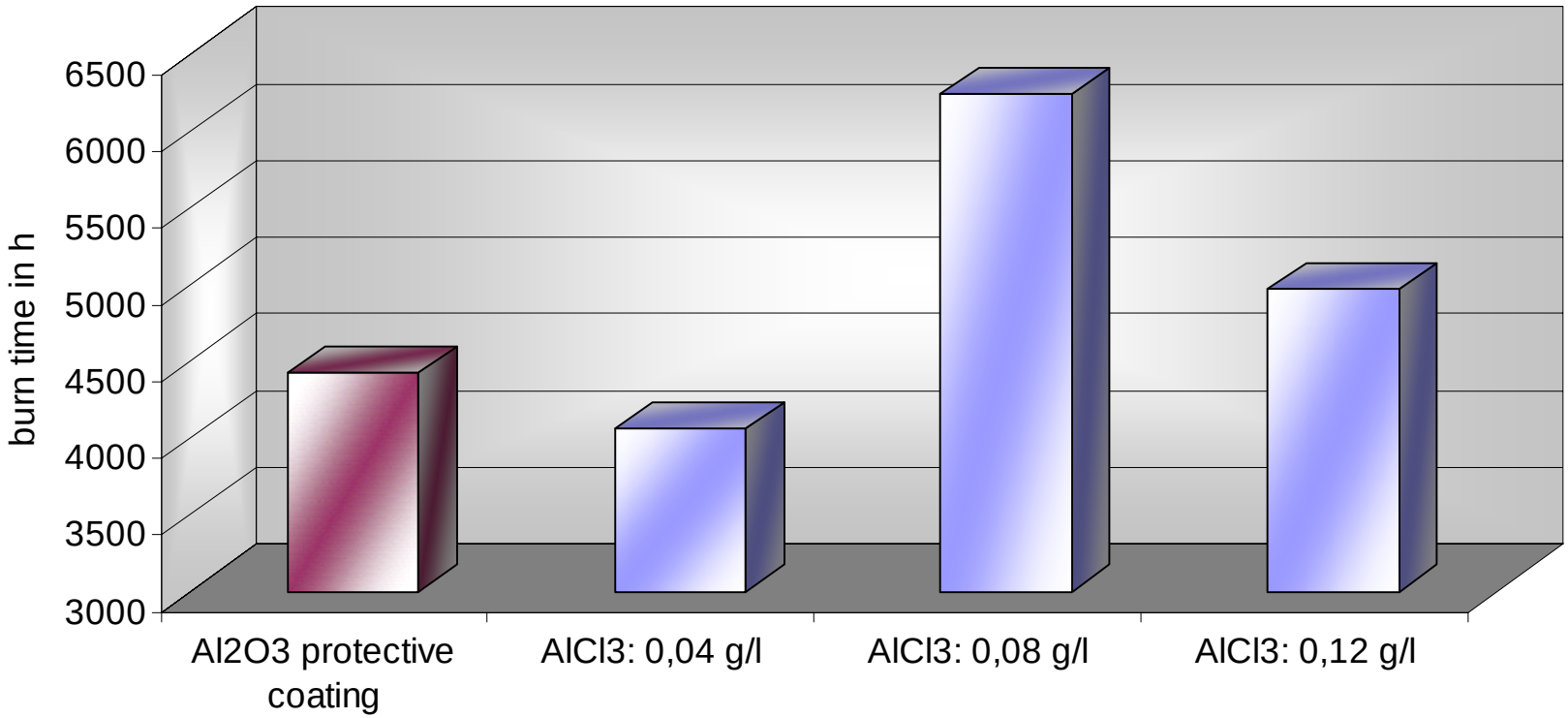

Eluate conductivity comparison of different glass types
(normalised on the value of Narva tubing glass)
normalised conductivity
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
1,00
0,05
0,05
0,03
Narva
Narva treated
Fiolax
Fiolax treated
glass type

eluate conductivity of a tube glass

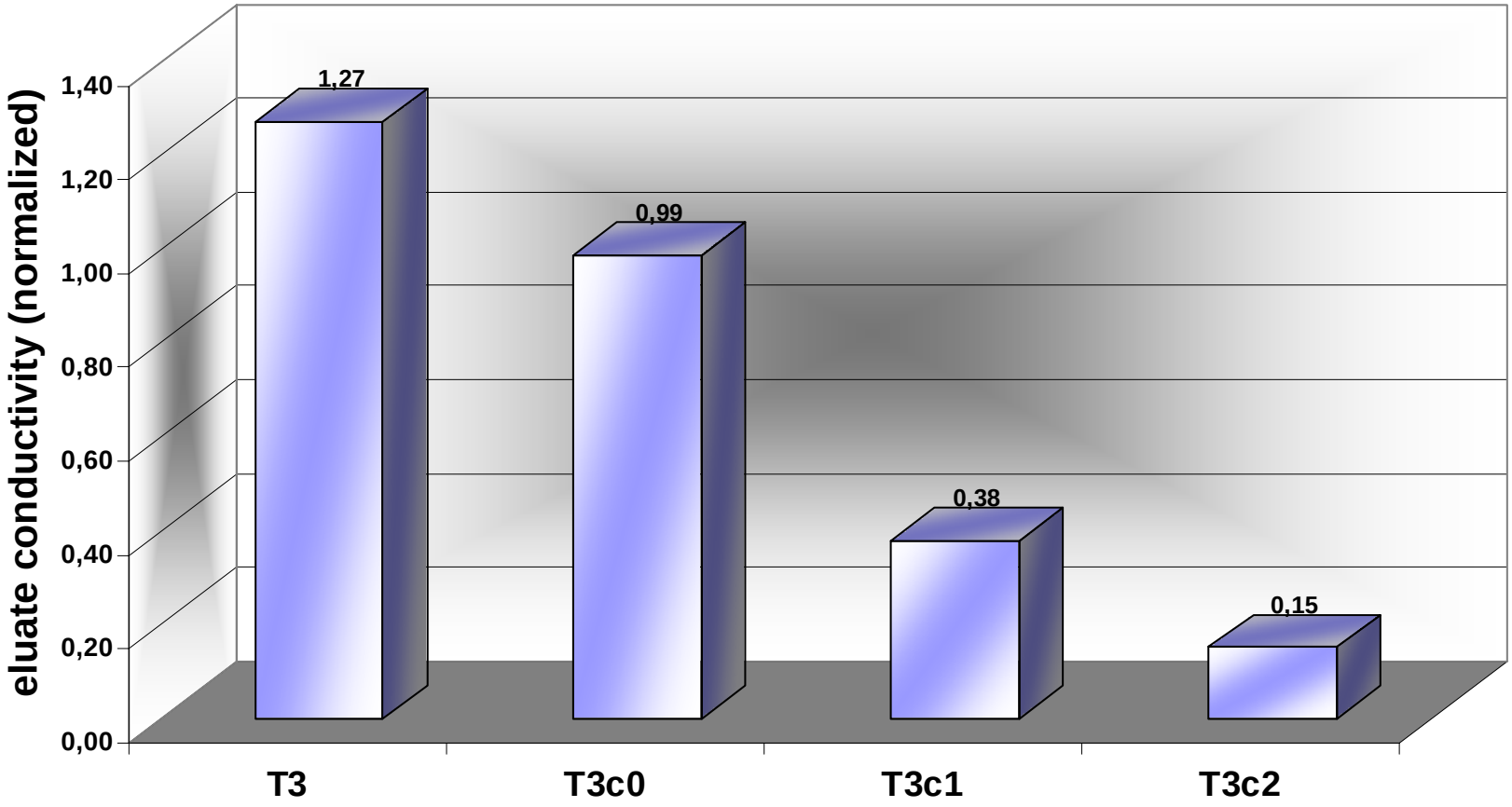
(online treatment of the inner surface with $AlCl_3$ during the production process)



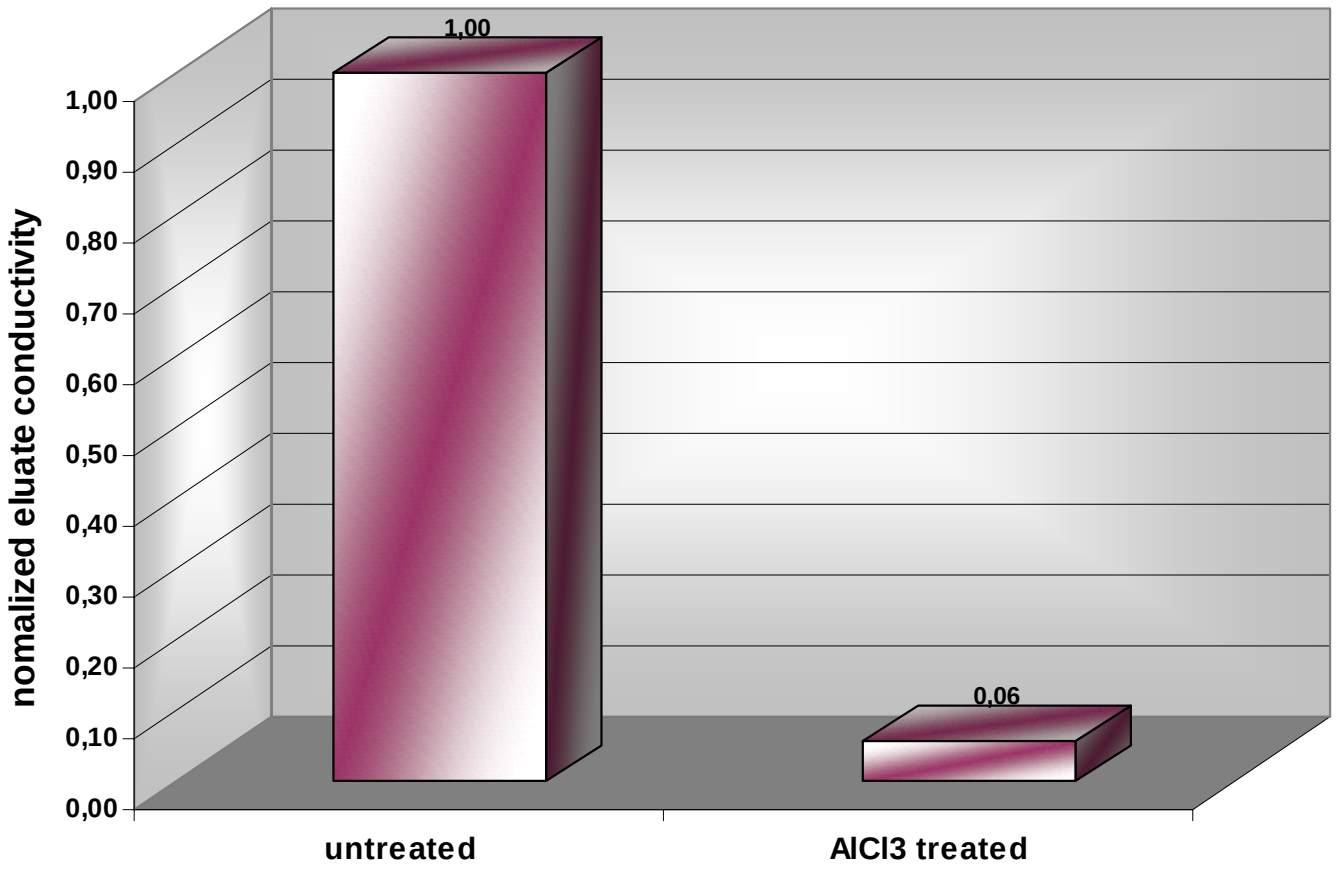
Burn time of fluorescent lamps until a decrease of the luminous flux down to 90 %



eluate conductivity of c-glass fibres (deposited in water at 90 °C) treated with different AlCl3 concentration (normalized to untreated glass)

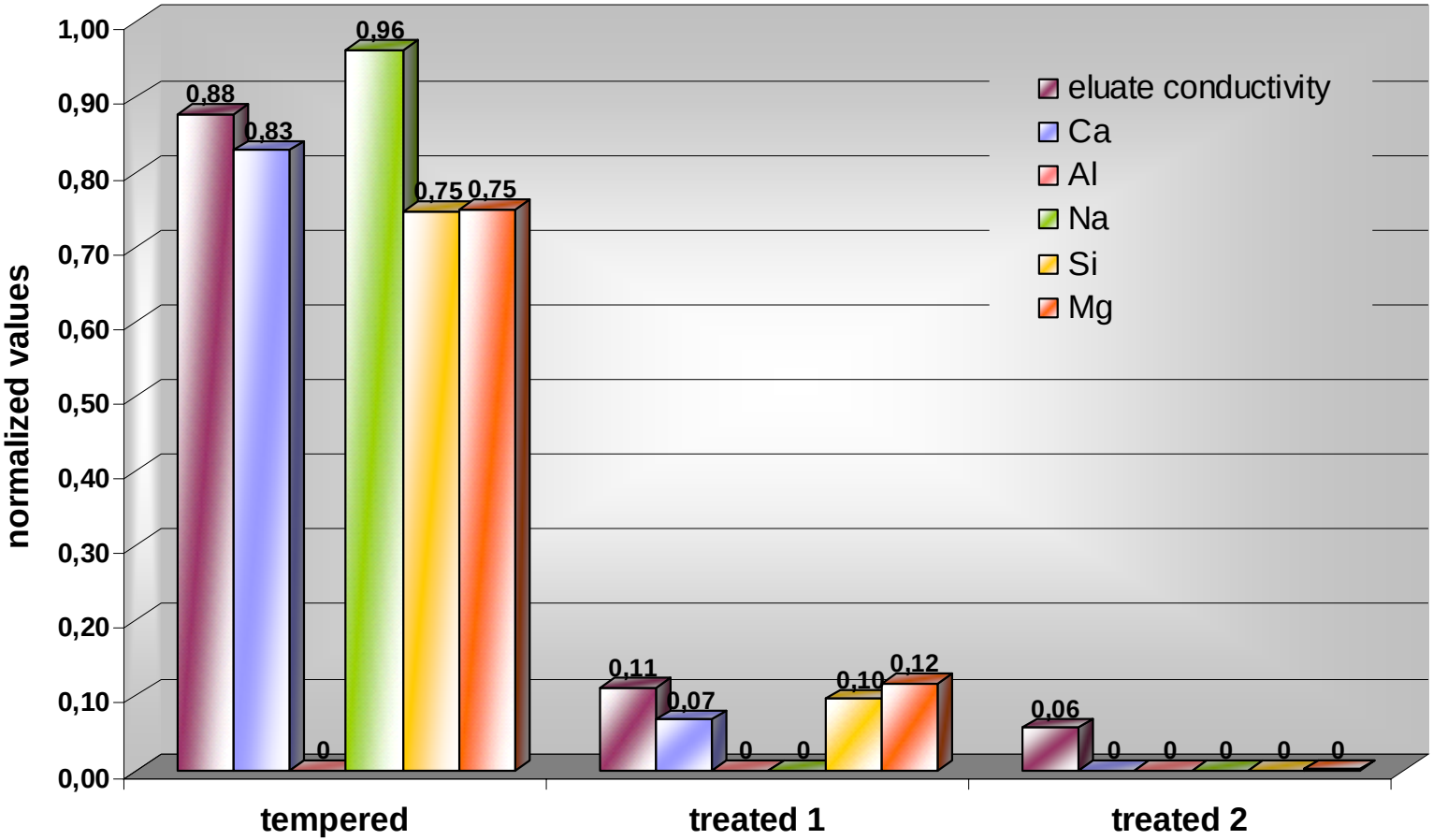


float glass – 1st laboratory phase



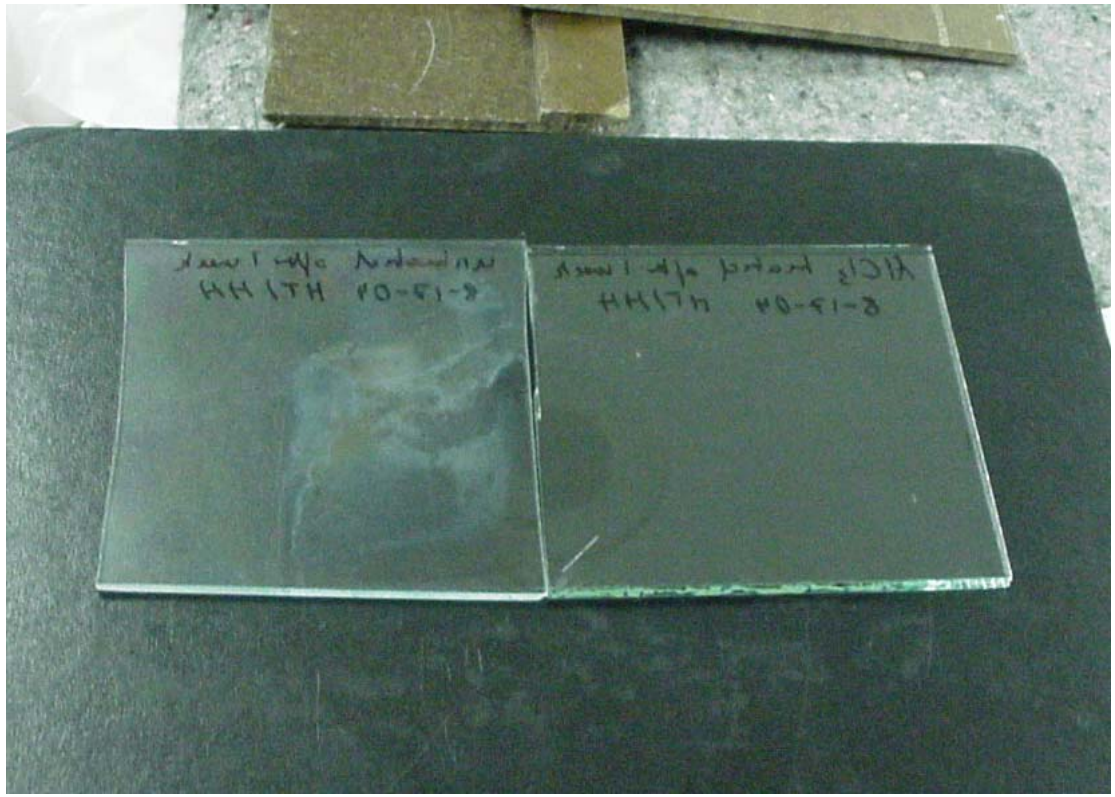
comparison of the eluate conductivity of AlCl3 treated and untreated float glass

Float glass – Coating test phase



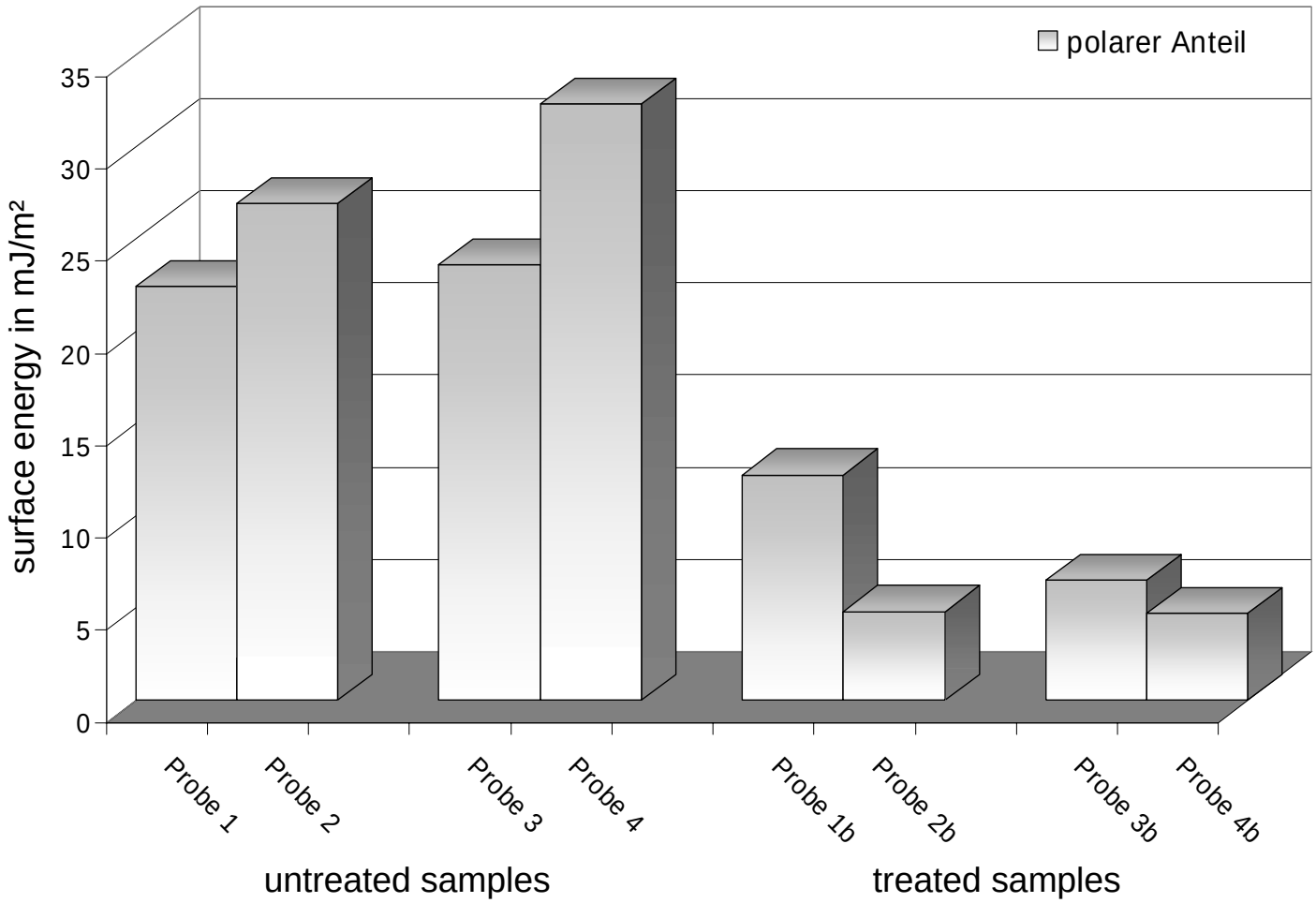
Comparison of the element specific eluate analysis (normalized to untreated glass) of variably treated float glass samples for the coating test phase

Hydrolytic durability - Float glass



comparison of an untreated (left) with a AlCl3-treated float glass sample after deposition in a climatic chamber for 7 days at 60 °C

Decrease of the surface energy due to the treatment with $AlCl_3$



Further aspects:

- Application in the enamel field
- Complete replacement for the hot end coating process
- glazes
- Decrease of interface energy
- silica glass optimization