MACHEREY-NAGEL

pH-Testing – a no brainer?

Rapid Tests

Dr. Christian Prokisch, 31.10.2020

Agenda

Company

pH-testing experience

pH uncertainty

pH buffering

Summary

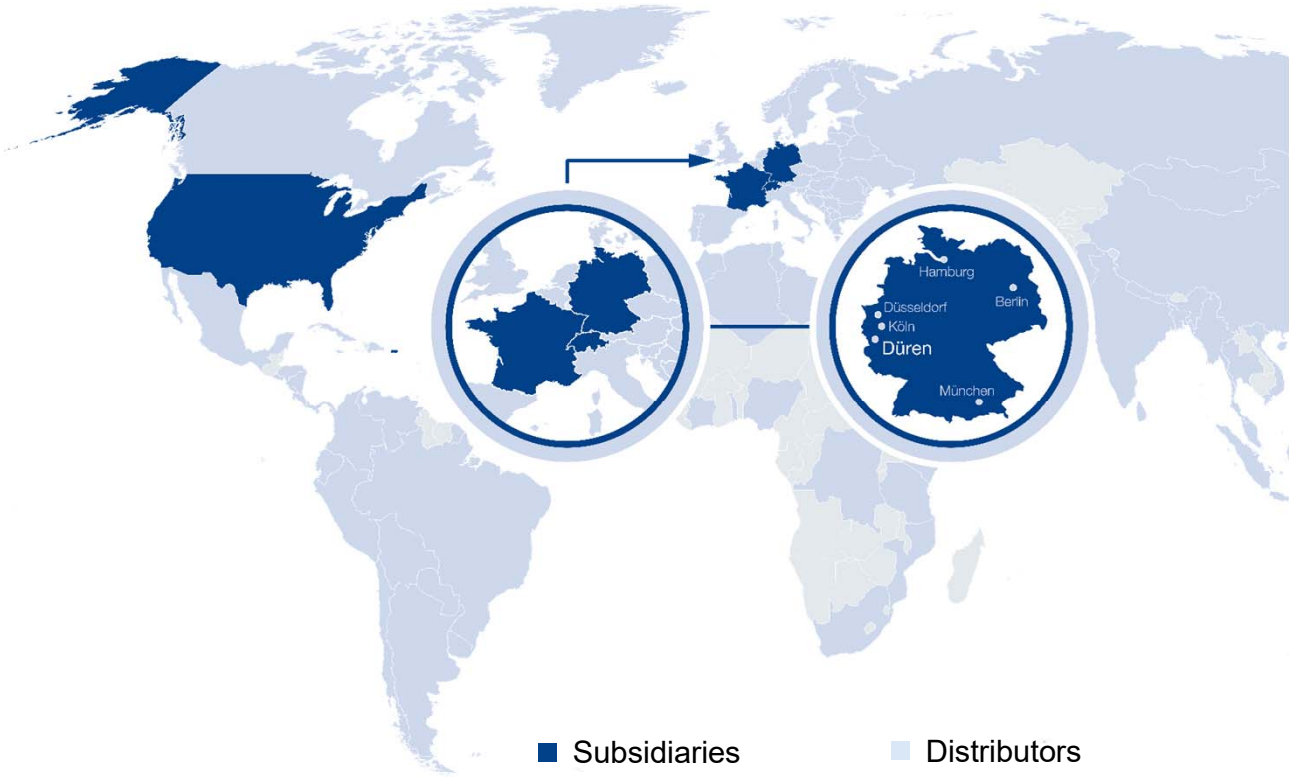
Company

MN Water Analysis

Company

MN today

- 4th Generation family owned
- More than 700 employees
- More than 25.000 products
- Turnover 120 Mio. €



Company

Business units

1911

Filtration

1959

Rapid Tests

1961

Chromatography

1970

Water Analysis

1989

Bioanalysis

Company – MN Water Analysis

Safe and easy *NANOCOLOR*® Tube Tests

- Barcoded tubes
- Color coded labels
- EPA compliant POTW parameter tests

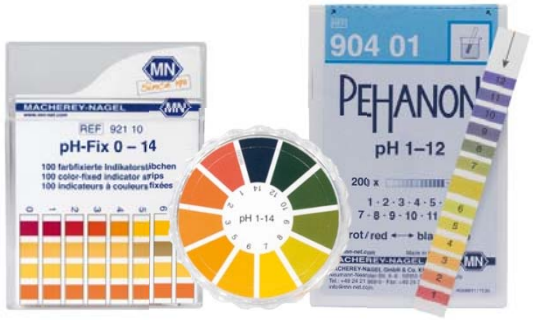
Company – MN Water Analysis

Water Analysis

Rapid and reliable dip & read tests

Qualitative test papers

pH-tests



Semi-quantitative test strips

Company – MN Water Analysis

Water Analysis

QUANTOFIX® Relax – Automated reader for test strips

- Easy use
- Objective readings
- QUANTOFIX® and pH-Fix test strips
- Data export via data export software

pH testing experience

pH testing experience

Water sample preserved at pH=2

- In general: correct reading
- pH 1 and pH 3 can easily be distinguished
  - Reliable results
  - Easy to use
  - …

pH testing experience

Rain water

Type / Brand	Strip read-off
a	5
b	6
c	7

- Different strips give different results
- Solution:
  - Take the one that best meets your expectations?

pH testing experience

Desalted water

pH	Read-off A	Read-off B
5	5.5	6.5
5.5	5.5	6.5
6	5.5	6.5
6.5	5.5	6.5
7	5.5	6.5

- Both are reliable manufacturers, well known brands
- Which brand is the best?
- Solution:
  - Take the one that best meets your expectations?

pH testing experience

Urine

pH	Read-off A	Read-off B
5.5	5.5	5.5
6.0	5.0	5.0
6.5	6.5	6.5
7.0	7.0	7.0
7.5	7.5	7.5

- Both are reliable manufacturers, well known brands
- Which brand is the best?
- Solution:
  - You may take either

pH testing experience

Summary

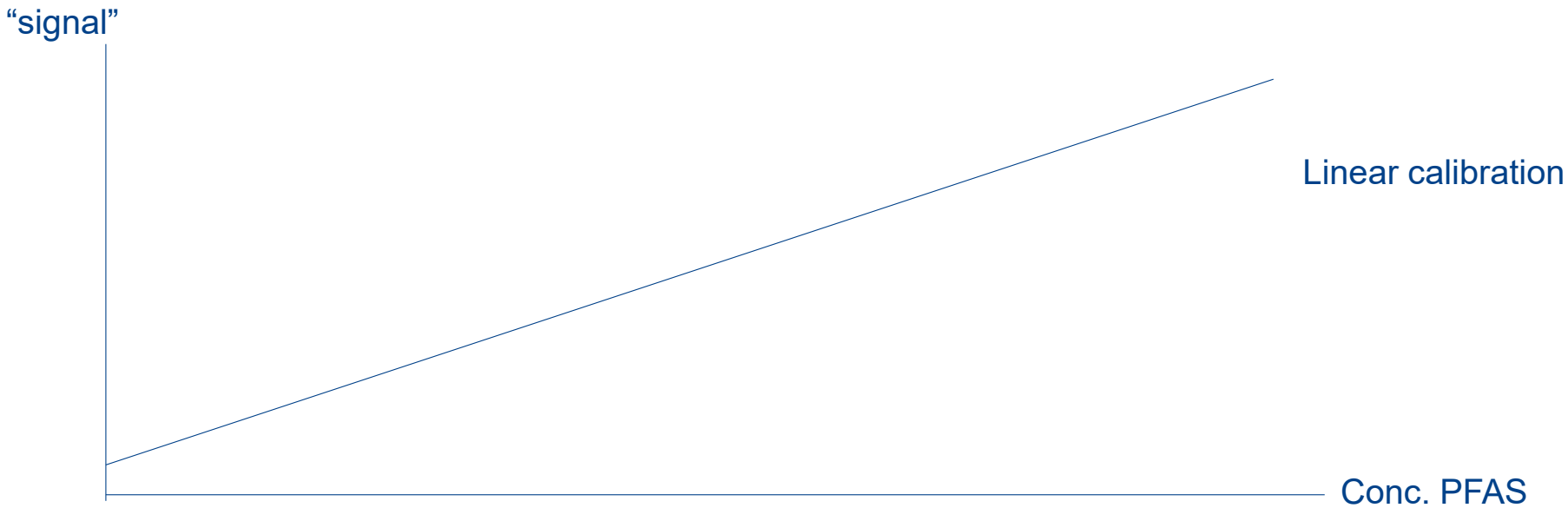
- Both are reliable manufacturers, well known brands
- Both behave very similar

pH	Brand A	Brand B
pH 2 preserved sample	good	good
Rainwater	Not good	Not good
Desalted water	Not good	Not good
Urine	good	good

pH – uncertainty

pH uncertainty

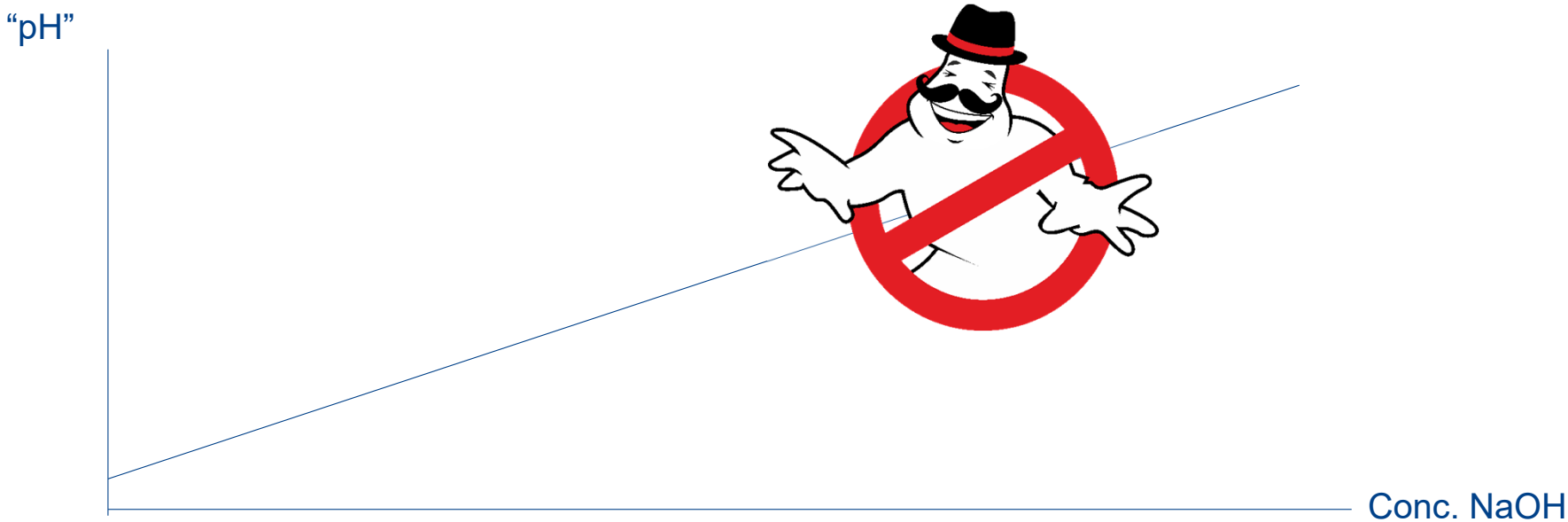
Typical calibration



Uncertainty lowest in the middle of the range

pH uncertainty

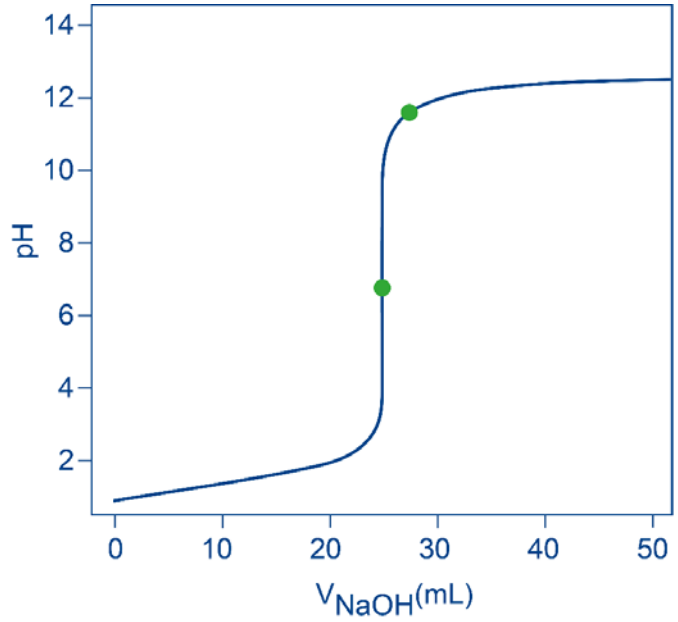
pH – intuitive expectation



pH different from most other analytes

pH uncertainty

Titration curve



Uncertainty highest in the middle of the range (pH = 7)

pH uncertainty

pH understanding

- Basic definition
  - pH = $-\log_{10}([H_3O^+])$…
  - [H3O+]*[OH-]=10^{-14}
- Logarithmic relationship
  - Like exponential relationships very difficult to “feel”
- “Concentration” lowest in the middle of range…

pH uncertainty

Concentration of analyte

- “Analyte” concentration in this case:
  - [H3O+] + [OH-]

pH	$[H_3O^+]$	$[OH^-]$	$[H_3O^+] + [OH^-]$
1	10^{-1}	10^{-13}	10^{-1}
2	10^{-2}	10^{-12}	10^{-2}
7	**10^{-7}**	**10^{-7}**	**$2*10^{-7}$**
13	10^{-13}	10^{-1}	10^{-1}

← Concentration lowest in the middle of the range

pH uncertainty

Capability of test strips

- Example, Nitrate
  - Detection limit: 10 mg/L
  - Molar weight: 62 g/mol
  - => 1,6 * 10^{-3} mol/L
- Rule of thumb for test strip detection limits:
  - Regular = about 10^{-3} mol/L
  - High performance = about 10^{-4} mol/L
- Exceptions apply

pH uncertainty

What does it mean for pH-strips?

- Similar limits apply
- In pure (!) water
  - pH test papers should NOT be used in the range pH 4-9
  - Between pH = 4 and pH = 9 papers show a value that is a property of the strip rather than a property of the sample

pH	$[H_3O^+]$	$[OH^-]$	$[H_3O^+] + [OH^-]$
1	10^{-1}	10^{-13}	10^{-1}
3	10^{-3}	10^{-11}	10^{-3}
5	10^{-5}	10^{-9}	10^{-5}
7	10^{-7}	10^{-7}	$2*10^{-7}$
9	10^{-9}	10^{-5}	10^{-5}
11	10^{-11}	10^{-3}	10^{-3}
13	10^{-13}	10^{-1}	10^{-1}

pH uncertainty

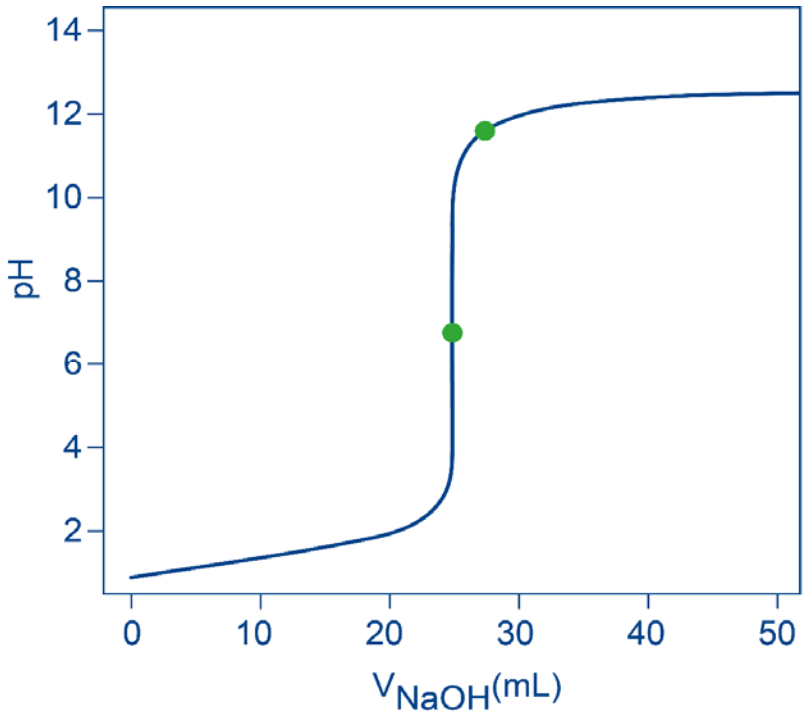
What we saw before…

pH	Brand A	Brand B	
pH 2 preserved sample	good	good	← Understood
Rainwater	Not good	Not good	← **Understood** (pH between 4 and 9)
Desalted water	Not good	Not good	← **Understood** (pH between 4 and 9)
Urine	good	good	← **Why does this work?**

pH buffering

pH buffering

If we only had this…



pH buffering

…nature would be different

- Most processes in nature require a pH of 4-8
- pH 4-8 very difficult to maintain only with strong acids and bases
- Nature provides weak acids and buffer substances
  - Acetic acid / acetate (pH 4.7)
  - Hydrogenphoshate /Dihydrogenphosphate (pH 7.2)
  - Citrict acid / citrate (pH 4.2)
  - …

pH buffering

What we saw before…

pH	Brand A	Brand B		
pH 2 preserved sample	good	good	←	Understood
Rainwater	Not good	Not good	←	Understood (pH between 4 and 9)
Desalted water	Not good	Not good	←	Understood (pH between 4 and 9)
Urine	good	good	←	**Understood** (buffering)

Summary

Summary

pH test strips

- pH strips
  - Widely used
  - Reliable results
  - Easy to use
- Be aware of pH-active substance concentrations ≤ 10^{-3} mol/L
- ASTM standard is in preparation

MACHEREY-NAGEL

Thank you for your attention!

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