STUDY OF NITROCELLULOSE SELF-IGNITION TEMPERATURE

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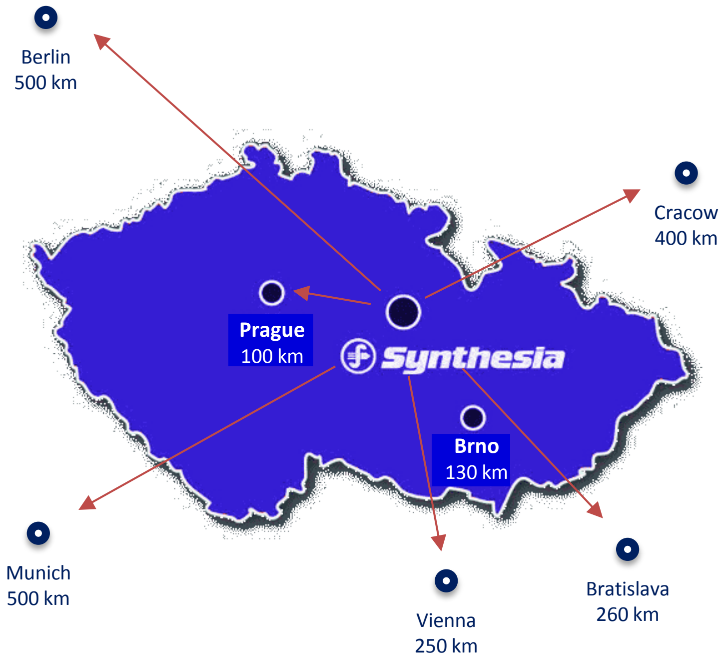


Synthesia & Nitrocellulose

- Nitrocellulose production since 1923
- Current portfolio of “NC related products”:
  - ✓ Energetic nitrocellulose (propellants, dynamites)
  - ✓ Industrial nitrocellulose
  - ✓ Nitric acid, sulphuric acid, mixed acids
  - ✓ Diethyl ether
  - ✓ Propellant stabilizers

NC Self-Ignition Temperature

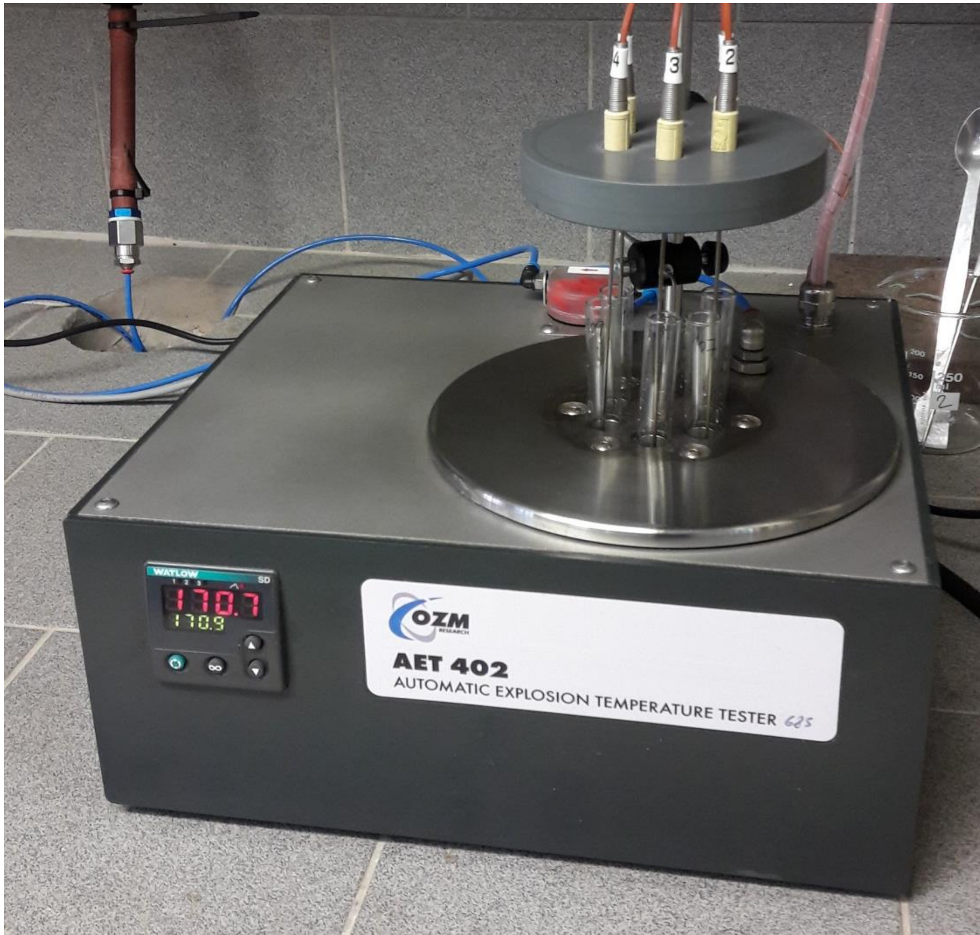
- Measuring method is described in STANAG 4491 [1] or in ADR [2]
- Principle: NC sample is heated from 100°C, at a rate of 5°C/min, until self-ignition occurs. The corresponding temperature is recorded as NC deflagration (self-ignition) temperature
- Typical results of properly stabilized NC are above 180°C
- For particular NC type, the self-ignition typically occurs within ± 1°C, even for different stability results. This is not sufficient for more detailed study
- Slower temperature gradients or even constant temperature levels were used for more detailed study

Testing Instrument

- Automatic Explosion Temperature Tester with five measuring cells and one reference cell was used

- Automatic temperature control with possibility to select
  - Constant temperature
  - Temp. gradient

- Recording of time and temperature data



Influence of Temperature Gradient

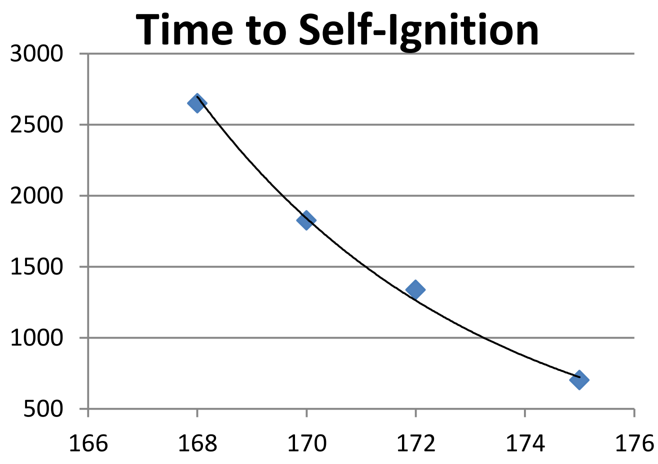
Temperature Gradient [˚C / min]	Initial Temperature [˚C]	NC Self-Ignition Temperature [˚C]	Time to Self-Ignition [s]
5 *	100	184 – 187	1000 - 1050
1	165	177 – 181	700 - 1000
0,5	165	175 – 177	1200 - 1500
0,2	165	171 – 173	2000 - 2500

* Standard method according to STANAG or ADR

- Smaller temperature gradient results in wider time interval
- Temperature gradient has no significant influence to the width of temperature interval

Temperature Influence - Isotherm

Constant temperature [˚C]	Average time to self-ignition [s]	Time to self-ignition [s]
168	2649	2500 – 3000
170	1825	1400 – 2400
172	1336	1100 – 1500
175	701	500 – 900

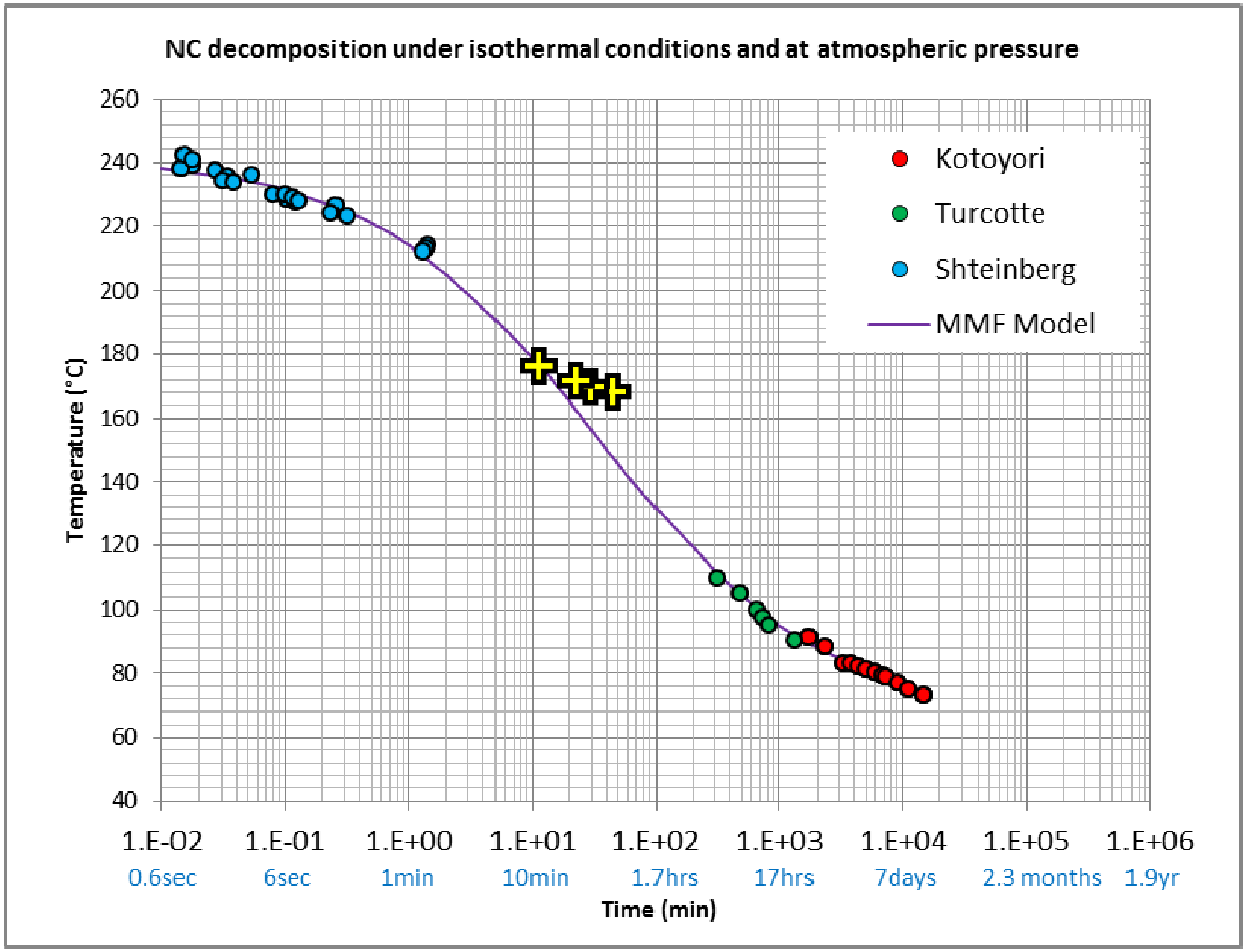


Time to self-ignition strongly depends on selected constant temperature.

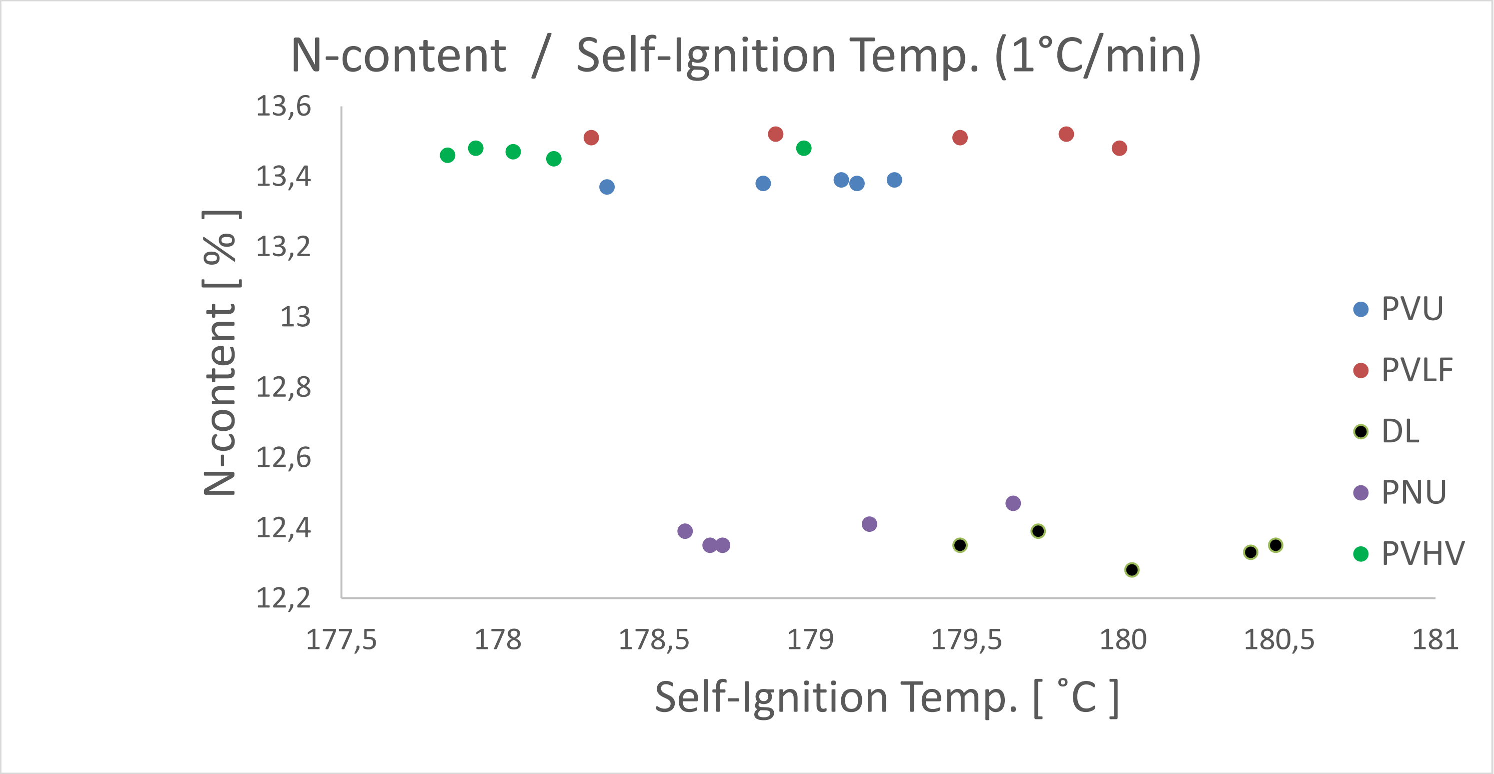
170˚C was chosen for future isothermal experiments

NC Decomposition Time

- Our isothermal experiments shows good conformity with results from work [3]

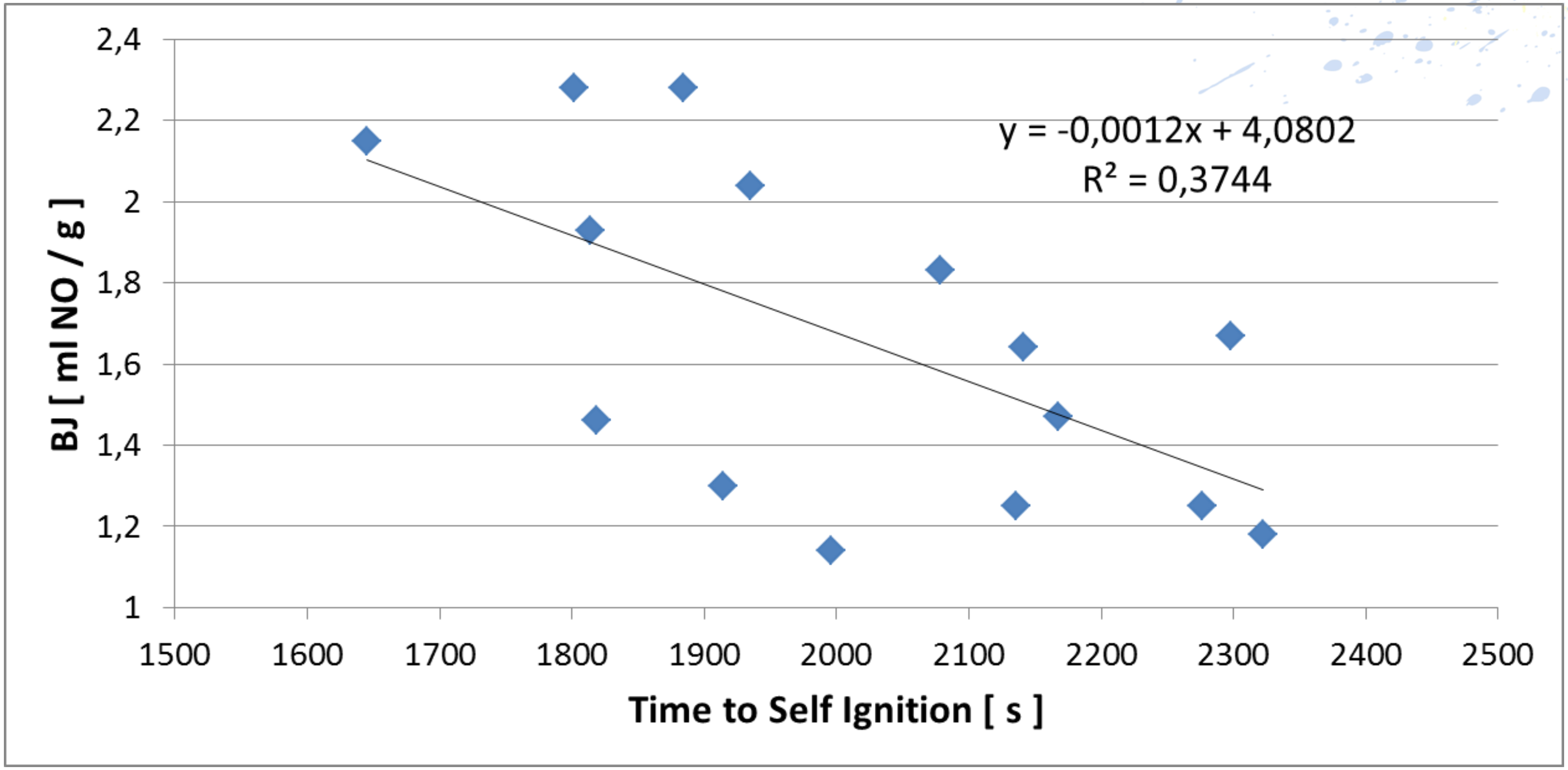


Nitrogen Content Influence



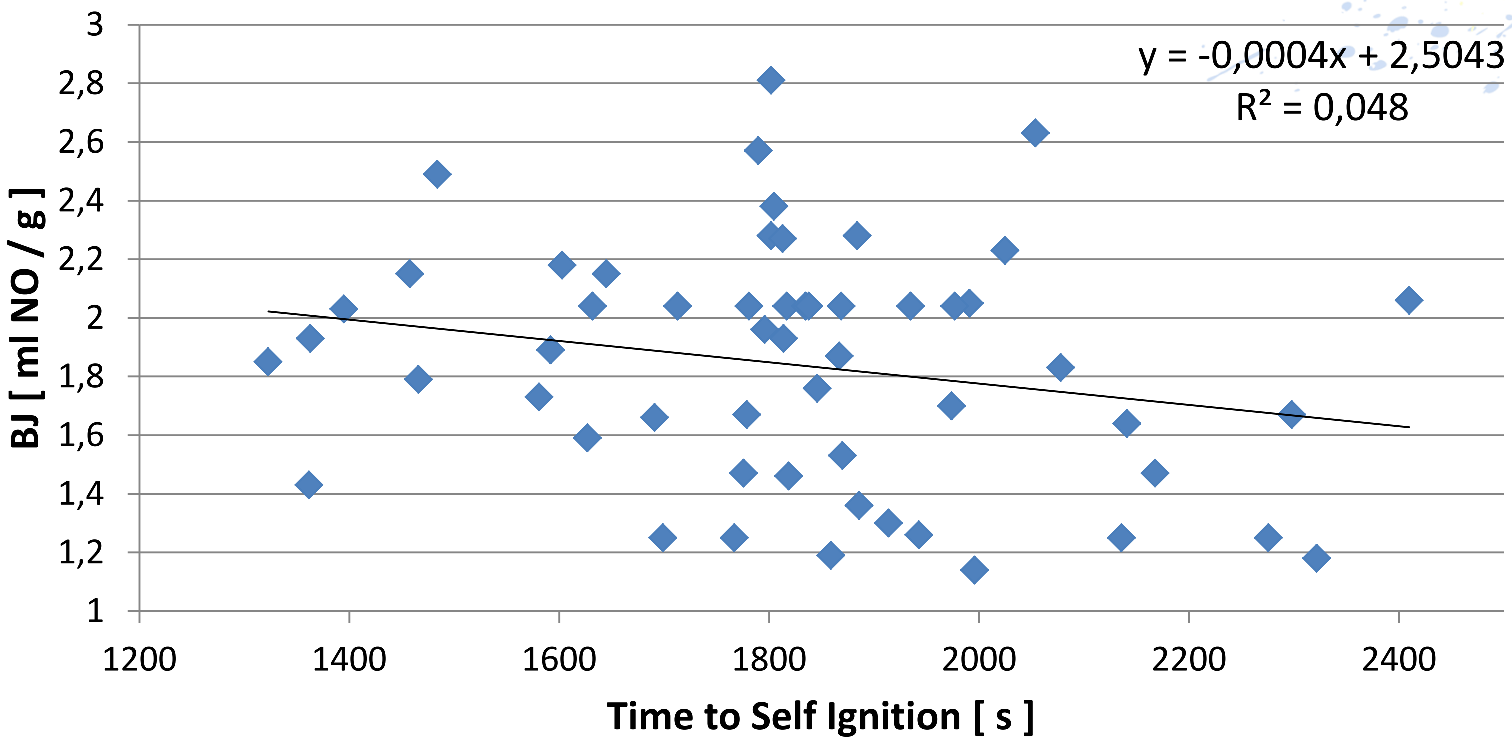
Different results for various NC types, even within the same nitrogen content level.

Bergmann-Junk Test Correlation



Promising results with one NC type, sample taken from the same process step of NC stabilization

Bergmann-Junk Test Correlation



Not satisfactory results for combination of NC types and different sample origin (from different stabilization process steps).

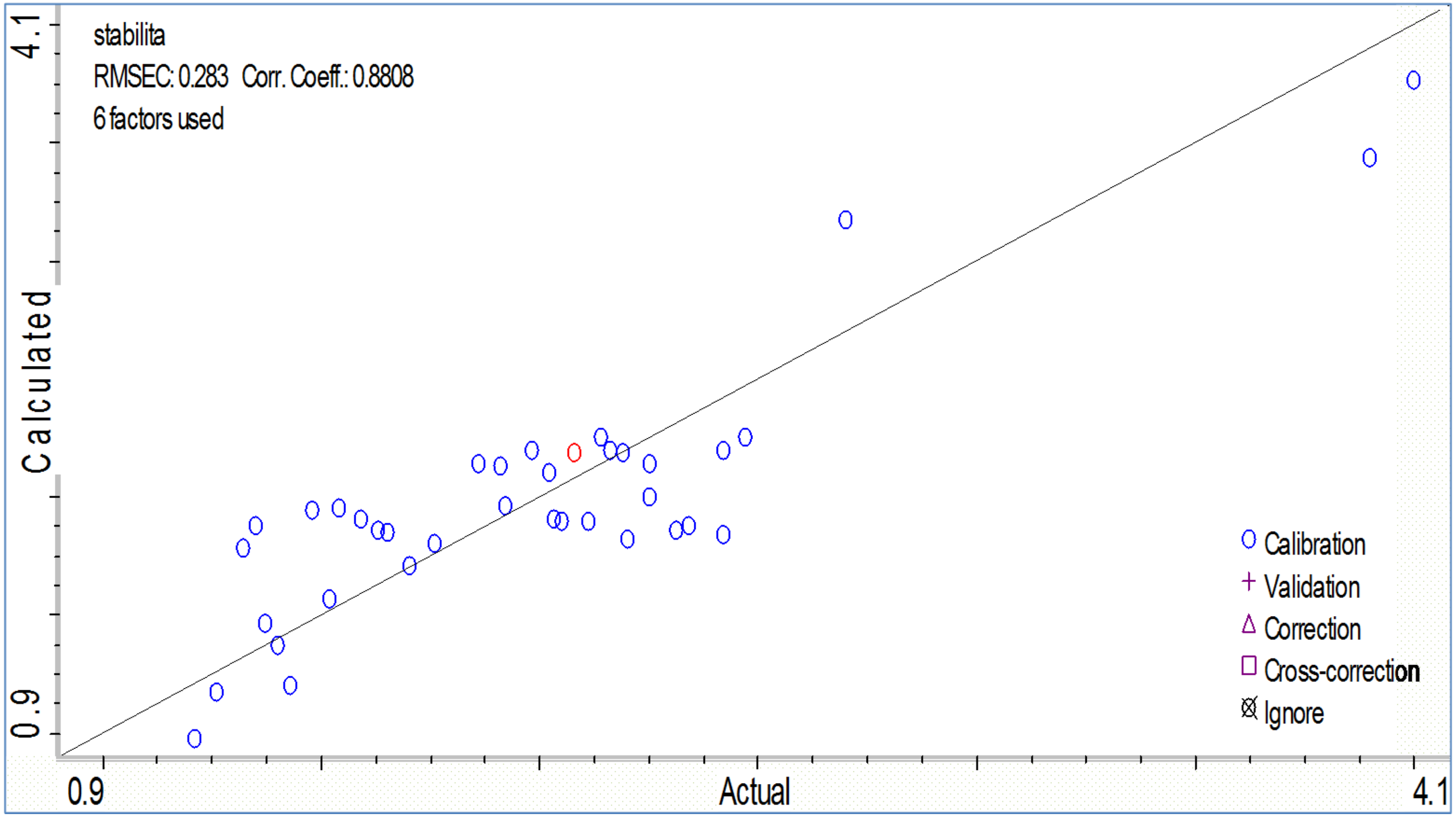
Conclusions

- Influence of nitrogen content of used NC sample
- High sensitivity to the temperature during experiment: small temperature deviations from selected constant temperature or temperature gradient may lead to large deviations in results
- Influence of other NC parameters, possibly physical properties of NC or raw material, may change the heat transfer and obtained results

The method does not represent a suitable alternative to commonly used Bergmann – Junk stability test

Steps Forward

Promising results were achieved using dispersive Raman spectroscopy, but only on a small group of samples.



References

[1] NATO – STANAG 4491, ed. 2. Explosives, thermal sensitiveness and explosiveness tests. North Atlantic Treaty Organization, 2015

[2] European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR 2017), United Nations, 2016.

[3] Mario Paquet: Review of basic concepts related to the thermal decomposition of nitrocellulose. NC Symposium Spiez, 2012.

Thank you for your attention!

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