

The background is a teal color with a complex network of thin lines. A dense grid of yellow lines is visible in the upper right quadrant, while the rest of the image is filled with a web of black lines that curve and flow across the frame.

NETZSCH

Proven Excellence.

**REDUCING DEFECTS AND CYCLE TIME: CERAMIC DEBINDING &
SINTERING OPTIMIZATION WITH KINETICS NEO SOFTWARE**

Erich NETZSCH GmbH & Co. Holding KG



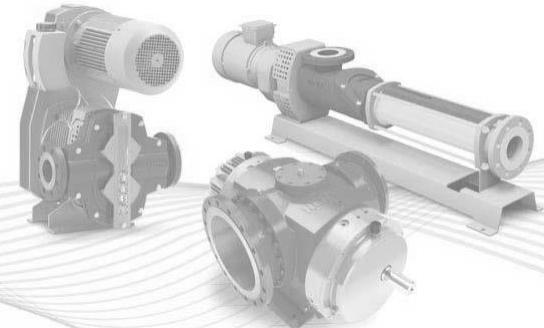
Analyzing & Testing

Devices for thermal analysis, determining thermophysical properties and rheology as well as fire testing systems



Grinding & Dispersing

Extensive range of machines for wet and dry grinding, mixing, dispersing, homogenizing and separating



Pumps & Systems

Always the right positive displacement pump for your application

Products and services for applications in the low and high temperature range from -260°C to 2800°C



Thermal Analysis

Determination of dimensional and mass changes, phase transitions and enthalpies as a function of temperature



Thermophysical Properties

Determination of thermal diffusivity and thermal conductivity, specific heat capacity and thermal expansion coefficients



Adiabatic Calorimetry

Analysis of decomposition processes and reaction processes with regard to temperatures, released heat quantities and pressure curves



Rheology

Measurement of rheological properties of non-Newtonian fluids and soft solids - from formulation to product use



Fire Testing Devices

Determination of the fire behavior of products in the automotive, construction, electronics and polymer sectors; classification into "European fire classes"



>150M €

Sales



>700

Employees worldwide



>10

Laboratories worldwide



6

International
production sites



> 50

Sales and service
locations worldwide

NETZSCH Analyzing & Testing - worldwide presence

NETZSCH

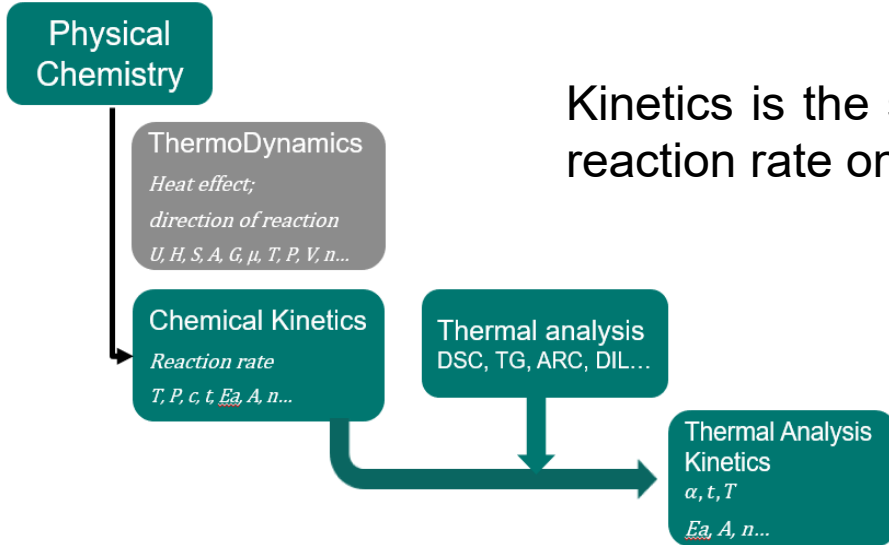
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- 1. Overview of Solid-State Kinetics and Kinetics Neo**
- 2. Debinding Process Optimization**
- 3. Sintering Process Optimization**
- 4. Live Demonstration of Kinetics Neo Software**
- 5. Key Takeaways**

1

Overview of Solid-State Kinetics and Kinetics Neo



Kinetics is the study of the dependents of a chemical reaction rate on time and temperature.

General equation

$$\frac{d\alpha}{dt} = k(T) \cdot f(\alpha)$$

Arrhenius dependence

$$k(T) = A \cdot \exp\left(\frac{-E_a}{RT}\right)$$

$$\frac{d\alpha}{dt} = A \cdot \exp\left(\frac{-E_a}{RT}\right) \cdot f(\alpha)$$

α : conversion

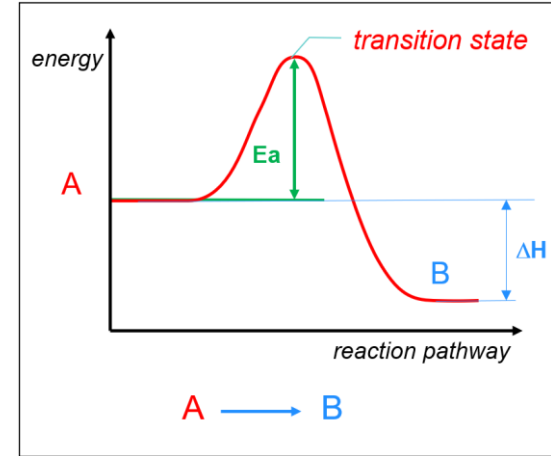
A: pre-exponential factor [1/s]

E_a : activation energy [kJ/mol]

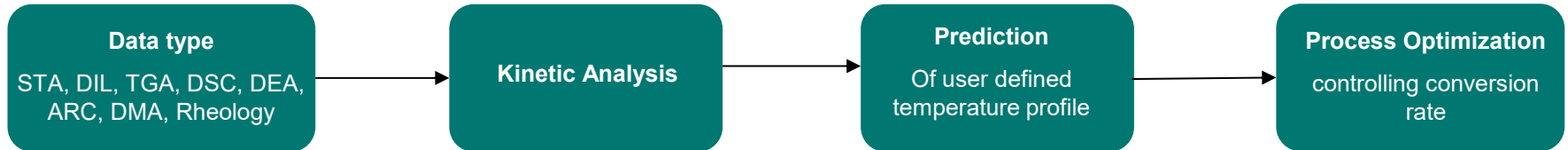
R: gas constant 8.31 [J/(mol.K)]

T: absolute temperature [K]

$$T[\text{K}] = T[^\circ\text{C}] + 273.15$$



- **Fitting Experimental Data by using Mathematical models:** Mathematical models enable the fitting of experimental data to theoretical equations, which helps in determining kinetic parameters like **Activation energy**, **Pre-exponential factor, $f(\alpha)$** and **Coefficient of determination R^2** .
- **Kinetics Neo software** can simulate and **predict** the behavior of chemical processes under various temperature conditions, such as isothermal, dynamic, and adiabatic profiles.
- **Kinetics Neo Software** allows users to **optimize** temperature programs.



Supported Measurement Types

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DIL



ARC / MMC



Rheology



DMA



- NETZSCH and non-NETZSCH data
- ASCII text files like TXT or CSV
- Data Columns (Temperature, Time and Signal)



DEA



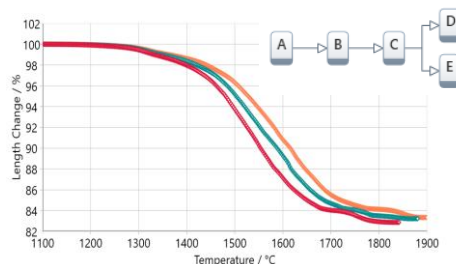
DSC



STA

2. Kinetics Analysis

mg, uniform known temperature, measurement impossible



1. Laboratory measurements

mg, known temperature



STA

Thermal stability and decomposition behavior, can be coupled with: FT-IR or Mass-Spectro-meter for gas analysis



DIL

Expansion and sintering behavior

- **STA (TG + DSC)**
- **DIL**

Debinding and sintering are processes based on time and temperature functions. If not well-chosen, they can result in microcracks and high production costs.



STA

Below 700°C: Debinding

A thermobalance provides you information on binder burnout



DIL

Above 700°C:
Sintering/Densification

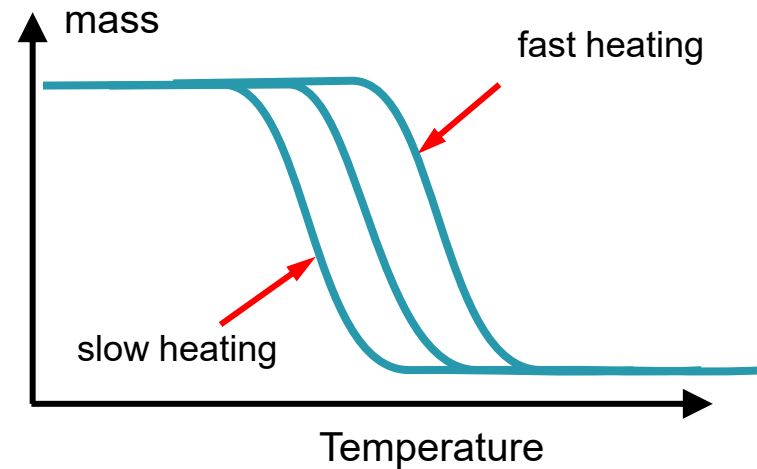
A dilatometer provides you information on sintering shrinkage and thermal expansion

2

Debinding Process Optimization

- Mass sample **10 mg**
- At least 3 measurements at **different heating rates with R^2 value greater than 0.995**
- Heating rates of **0.5, 1, 2 and 5 K/min.**
- **Reproducibility**

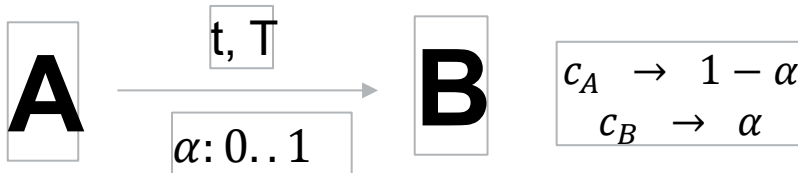
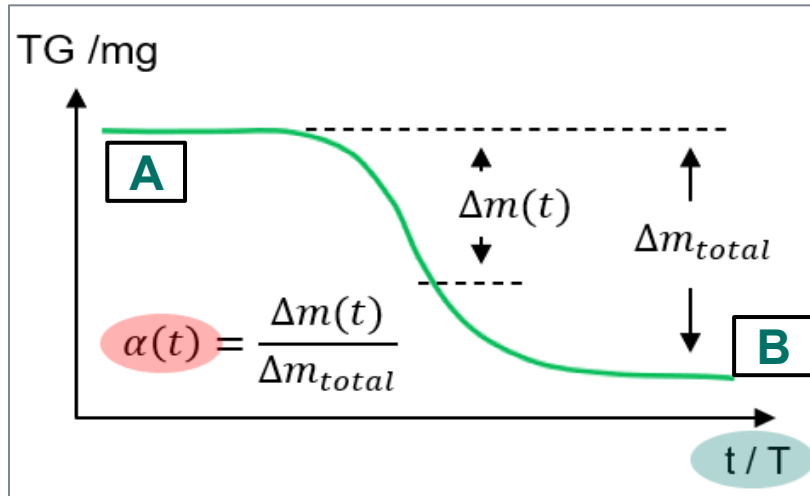
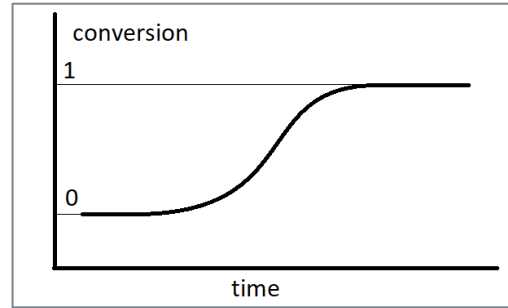
STA 509 Jupiter Select



Simultaneous Thermal Analysis : mass change is measured during heating

Conversion $\alpha(t)$ for TGA data

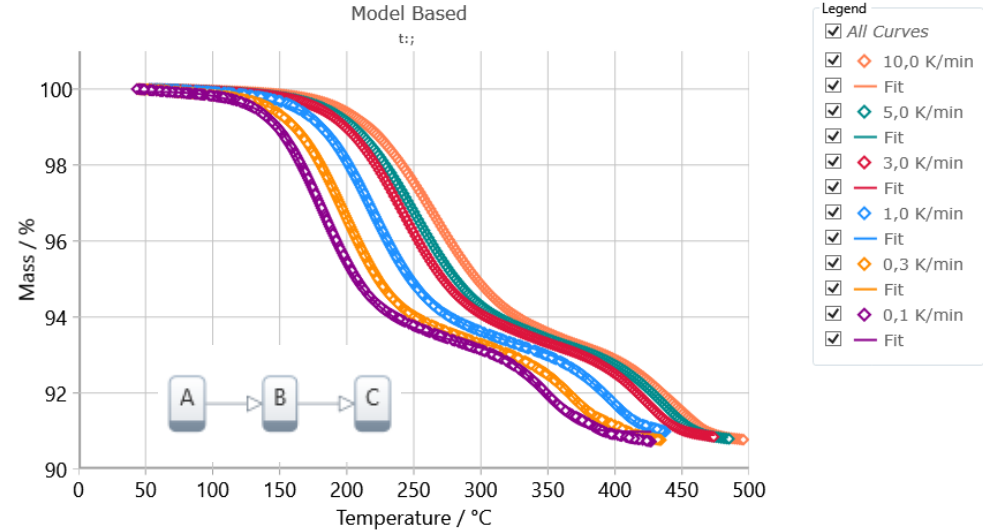
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- $\alpha(t)$: Conversion is the ratio of the partial mass loss at given time point to the total mass loss at the final time point

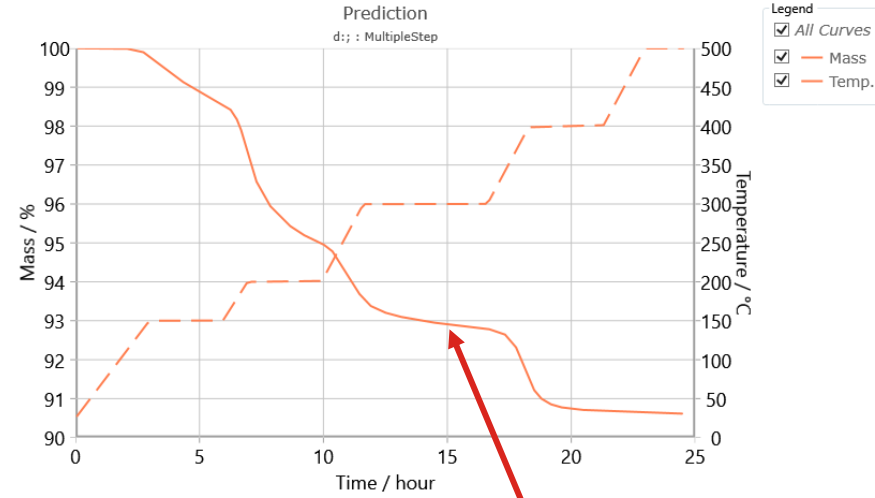
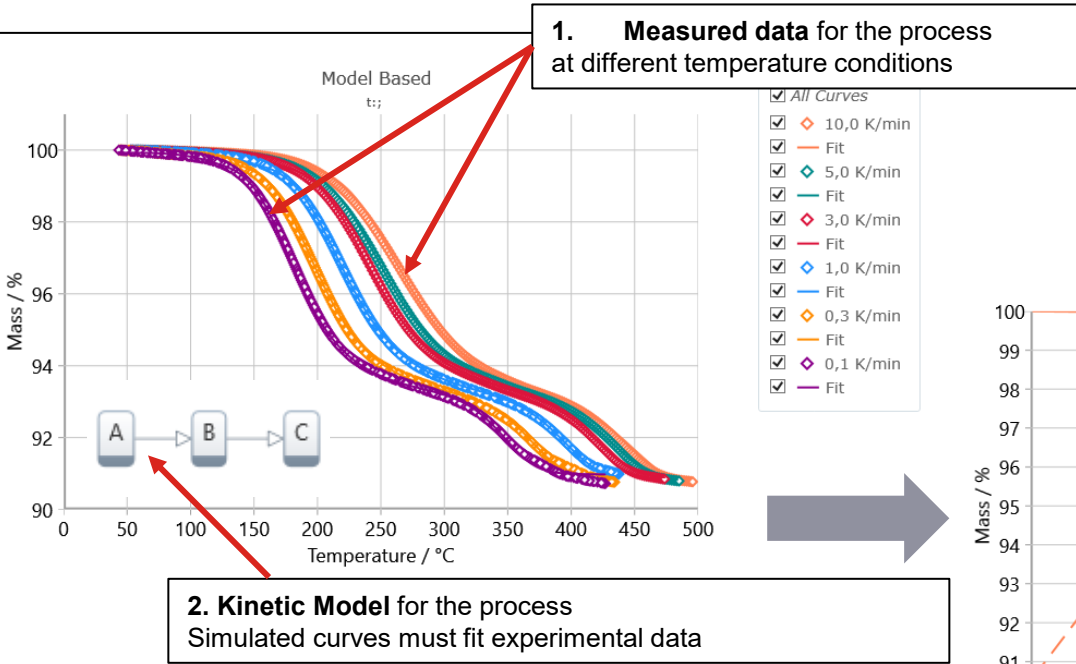


STA 509 Jupiter Select



One kinetic model with two steps can fit all measurements

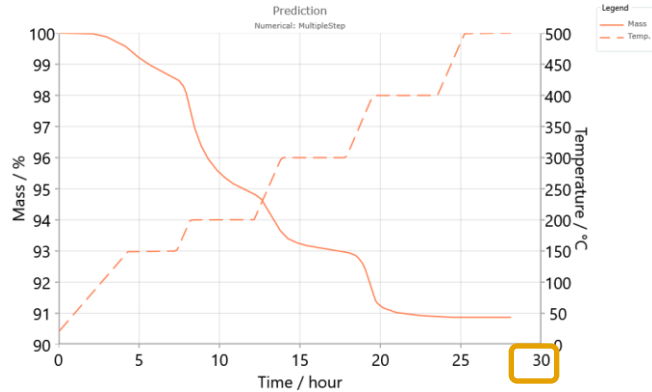
Theory: one Kinetic Model is used for predictions at any temperature



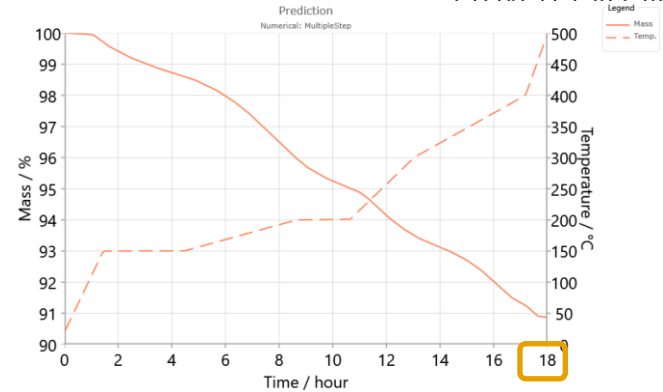
- One kinetic model can fit all measurements at different temperature conditions
- This model will be used for prediction at any temperature
- For any temperature program the result is calculated immediately

Debinding Process Optimization based on TGA data

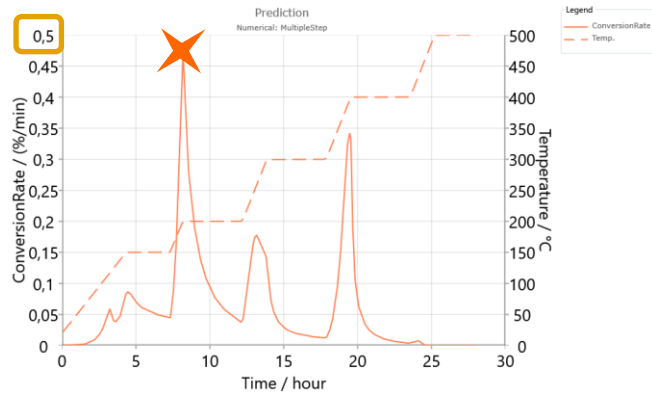
(A)



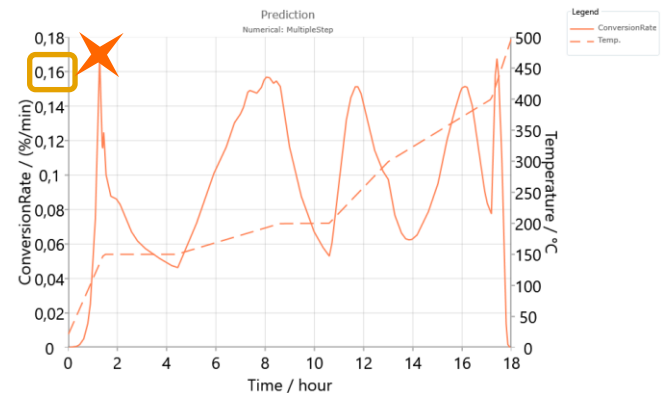
(D)



(B)



(C)



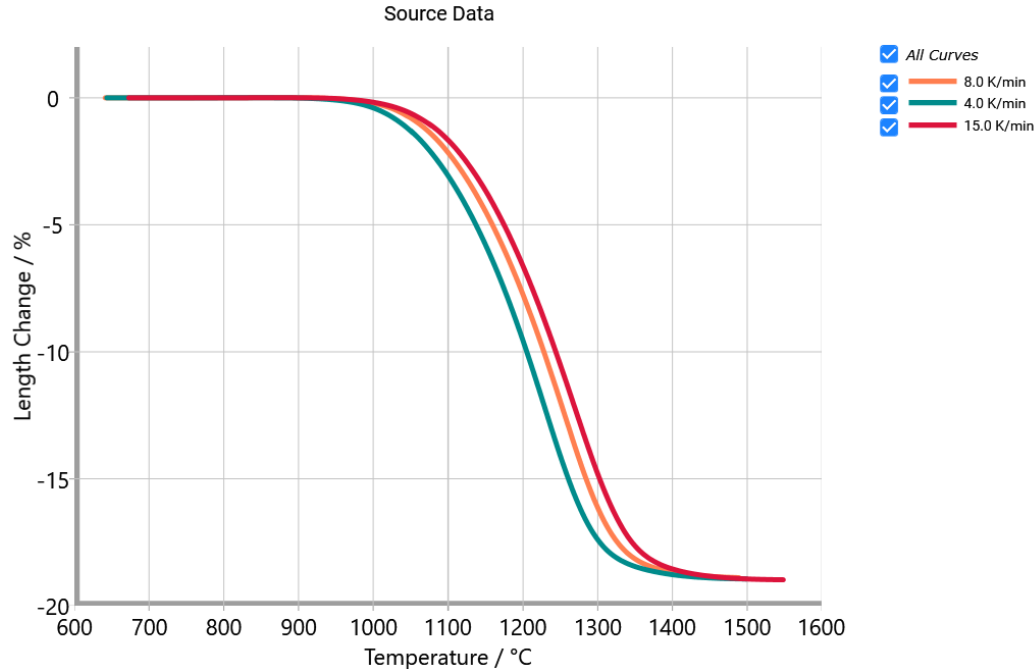
Non-optimized **29 hrs**, max **0.5%/min**

Optimized **18 hrs**, max **0.16 %/min**

3

Sintering Process Optimization

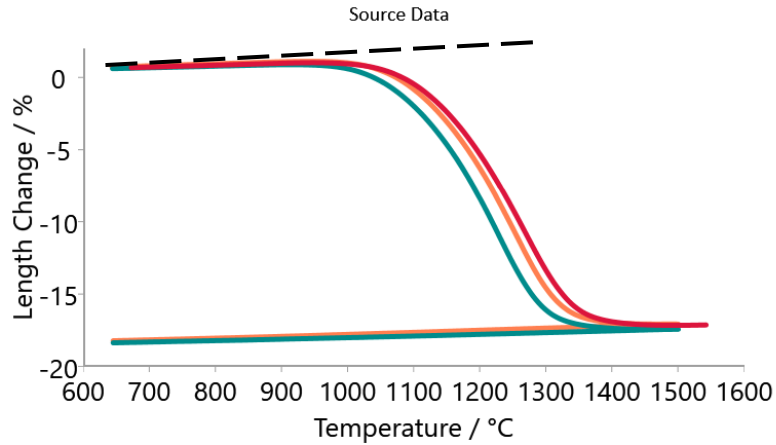
Dilatometer measurements of the zirconia green body



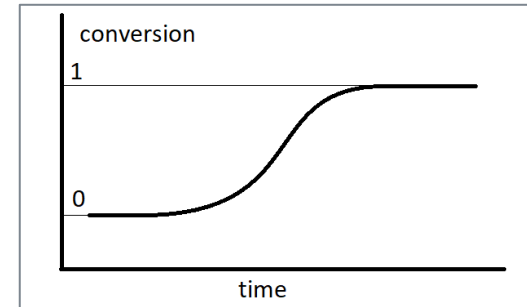
DIL

Sample holder: Al_2O_3
Temperature range: RT to 1500°C
Heating rate: 4/8/15 K/min
Atmosphere: 50 ml/min Air
Sample length: ~10 mm

- Dilatometer measurements of the zirconia green body at heating rates of 4, 8, and 15 K/min

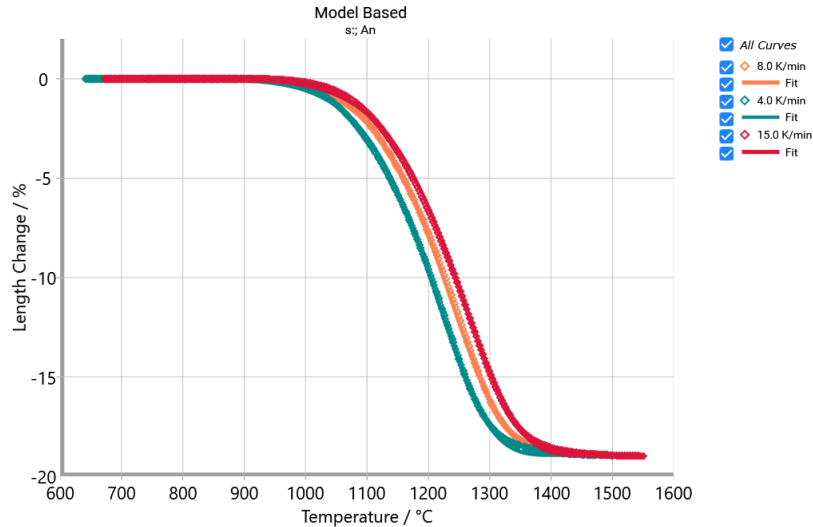


DIL



- $\alpha(t)$: where $\Delta L(T)$ is the partial length change of the DIL up to temperature T and $\Delta L(\text{total})$ is the total length change.
- This assumes all solids react the same way and the sintering rate depends on temperature only.

Optimization of the Sintering Process of Zirconia Ceramics for Dental Applications



- Dilatometer measurements (rhombus symbols) and kinetic model (solid lines) of sintering for zirconia green body at heating rates of 4, 8, and 15 K/min

Reaction step	A → B
Reaction type	An*
Activation energy [kJ/mol]	573.75
Log (Pre- Exp) [Log (1/s)]	17.349
Dimension n	0,4
Contribution	1
Coefficient of determination (R ²)	0.9999

*An: n-dimensional nucleation according to Avrami-Erofeev

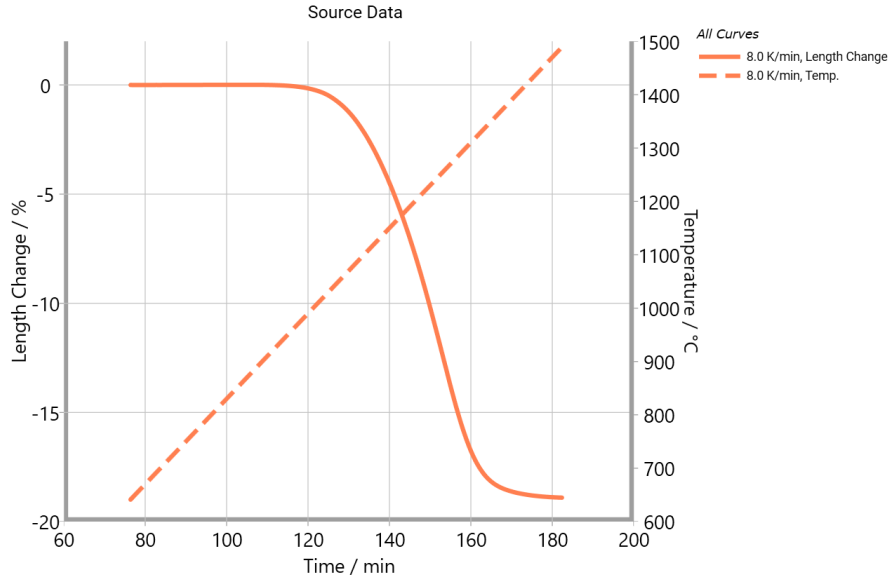
APPLICATION NOTE

Ceramics – Dilatometry/Kinetic Analysis

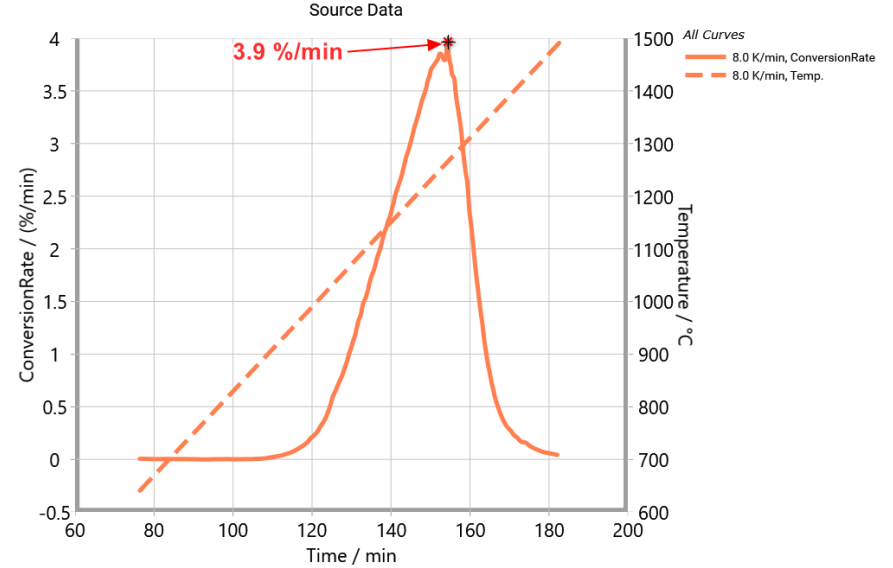
Optimization of the Sintering Process of Zirconia Ceramics for Dental Applications Using Dilatometry and Kinetic Analysis

Dr. Mohammed Bouzbib, Software Neo Business Field, Doreen Rapp, Applications Laboratory, and Dr. Elena Moukhina, Software Neo Business Field Manager

Optimization of the Sintering Process of Zirconia Ceramics for Dental Applications

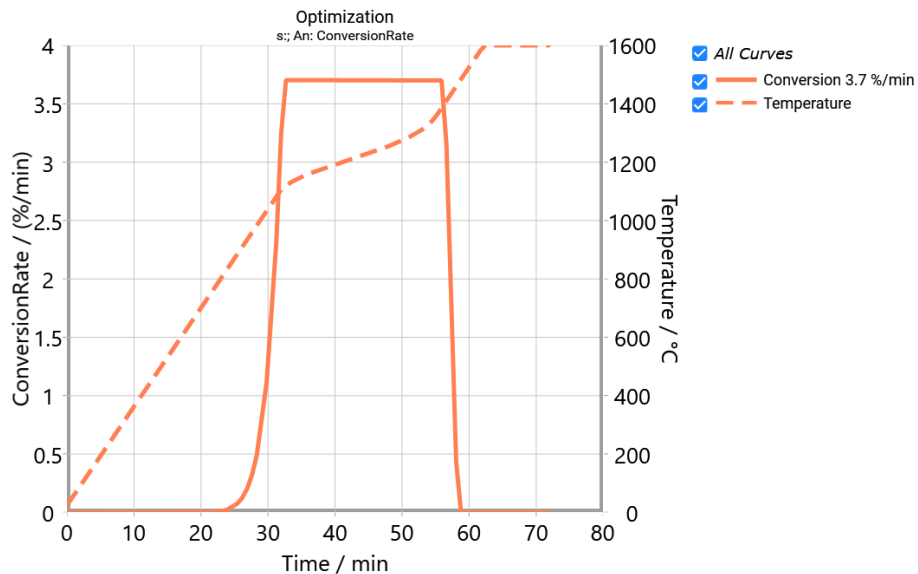


- Non-optimized temperature profile (dashed line) at 8 K/min for ceramic sintering and the appertaining dilatometer measurement (solid curve).

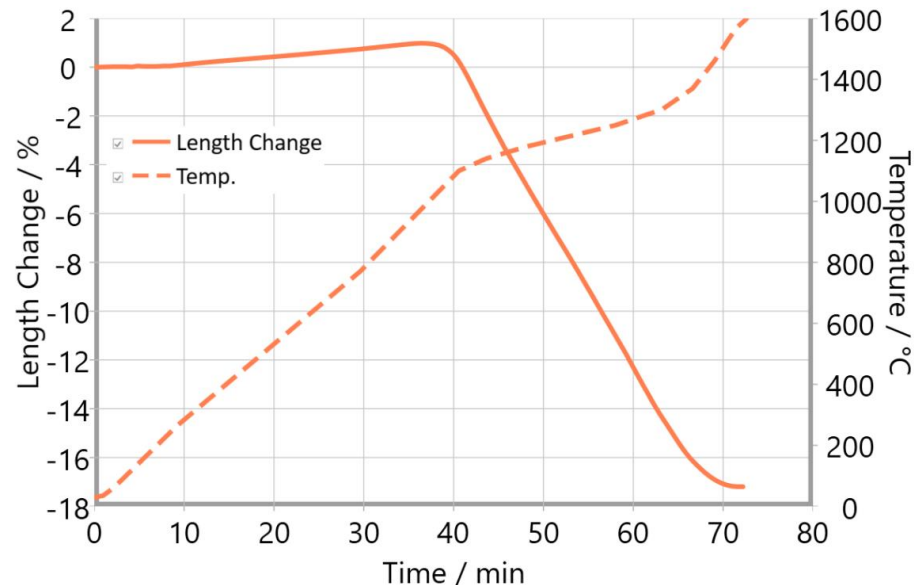


- Optimized temperature profile for ceramic sintering (dashed curve) and simulated conversion rate (solid curve).

Optimization of the Sintering Process of Zirconia Ceramics for Dental Applications



- Optimized temperature profile for ceramic sintering (dashed curve) and simulated conversion rate (solid curve)



- Optimized temperature profile for ceramic sintering (dashed curve) and measured length change (solid curve) **for verification purposes.**



4

Software Demonstration

- ❑ **Kinetic Parameters:** Determined activation energy (E_a) and pre-exponential factor (A) using Kinetics Neo software for effective process control.
- ❑ **Debinding Optimization:**
 - Used TGA + Kinetics Neo to model multi-step reactions.
 - Process time reduced by ~38%.
- ❑ **Sintering Optimization:**
 - Used Dilatometer (DIL) data with Kinetics Neo to track shrinkage & thermal expansion.
 - Process time reduced by ~60%.
- ❑ **Academic Advantage:**
 - Understand thermal behavior, debinding, and sintering; accelerates experiments and publications.
 - By optimizing conversion rates, stress in multilayer ceramics is minimized.



ICTAC: International Confederation for Thermal Analysis and Calorimetry

- Model free analysis
- Multi-step model-fitting (model based)
- Deconvolution analysis (sum of peaks)



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Review

ICTAC Kinetics Committee recommendations for analysis of multi-step kinetics

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- Go to: <https://kinetics.netzsch.com>
- Trial Version: 30 days
- Email (Software Neo Team): kinetics.neo@netzsch.com
- Kinetics as a Service

The screenshot shows the Kinetics Neo website interface. The navigation menu includes 'What is New', 'Features', 'Learn', 'Applications', 'Documents', 'F.A.Q', and 'Contact, Service, Support'. The 'Learn' button is highlighted with a red box and a '2' next to it. Below the navigation, there are two buttons: 'Request Trial Version' (highlighted with a red box and a '1' next to it) and 'Request a Quote'. The main content area features the heading 'Kinetics Neo', a description of the software, and a 'News' section with two webinar announcements.

Kinetics Neo

Software for kinetic analysis of thermoanalytical data for chemical processes.
Prediction of process behaviour and temperature optimization based on kinetics analysis.

Kinetics Neo software fully supports mandatory rules for kinetic analysis: ["ICTAC Kinetics Committee recommendations for analysis of multi-step kinetics". doi.org/10.1016/j.tca.2020.178597](https://doi.org/10.1016/j.tca.2020.178597).

News

December 11, 2025 Webinar "Reducing Defects and Cycle Time: Ceramic Debinding & Sintering Optimization with Kinetics Neo Software" In this webinar, we presented practical solutions for optimizing the debinding and sintering processes in ceramic materials to achieve the highest quality at the lowest cost using Kinetics Neo software.
Registration: [here](#)

November 18, 2025 Webinar "Cure with Confidence: Tools and Models for Resin Process Control", Claire Strasser spoke about comparative use of DSC, DEA and oscillatory rheometry in thermoset cure characterization, kinetic modeling approaches for curing processes and the role of vitrification as a critical parameter in cure analysis.

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Thank you for your attention!

Dr. Mohammed Bouzbib
Chemist

For further questions please contact

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