

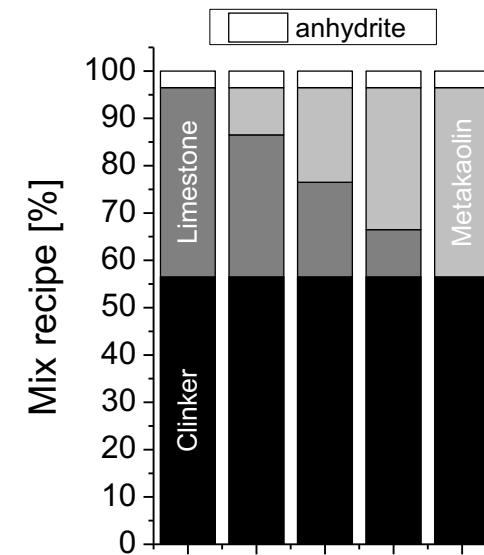
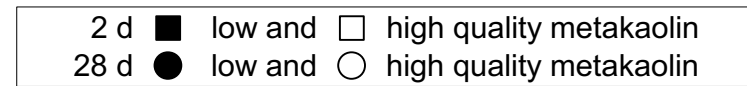
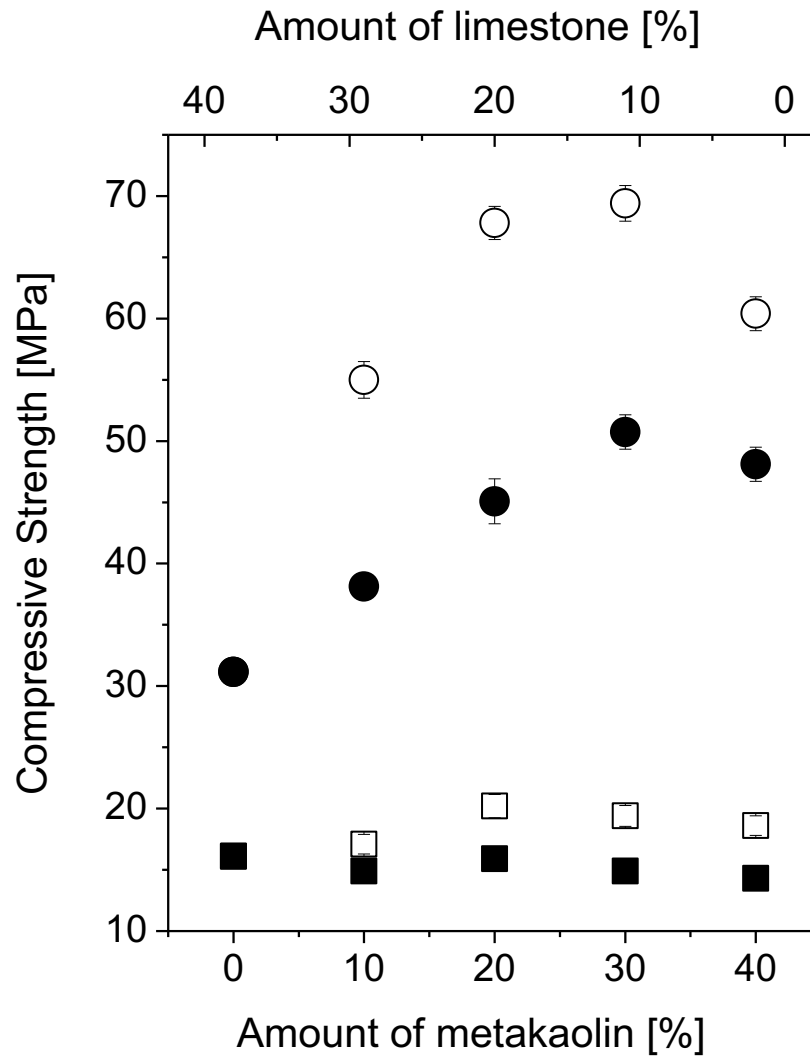


# Assessing the Synergistic Effect Between Limestone and Metakaolin and Novel Methodology to Assess the Reactivity of Calcined Clays

**D. Nied, M. Zajac, M. Ben Haha, C. Stabler**

1<sup>st</sup> International Conference - Calcined Clays for Sustainable Concrete  
June 23rd – 25th 2015

# Composite Cements based on Limestone and Metakaolin



**How to assess the reactivity of calcined clays**

# Clay Raw Materials - Overview

## ■ Mineralogical characteristics

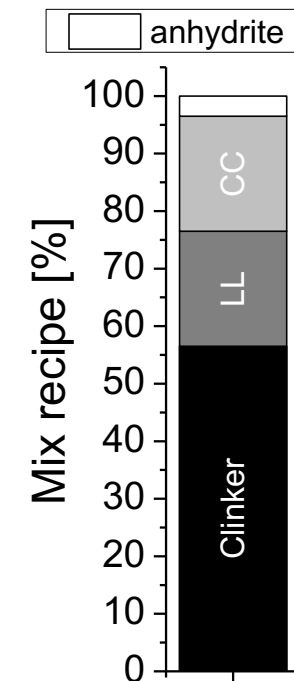
- Kaolinitic clays 50 – 95%
- Illitic clays 40 – 50 %
- Palygorskite 40 %
- Calcite 0 – 20 %
- Quartz 0 – 40 %
- Natural Pozzolans

## ■ Chemical characteristics

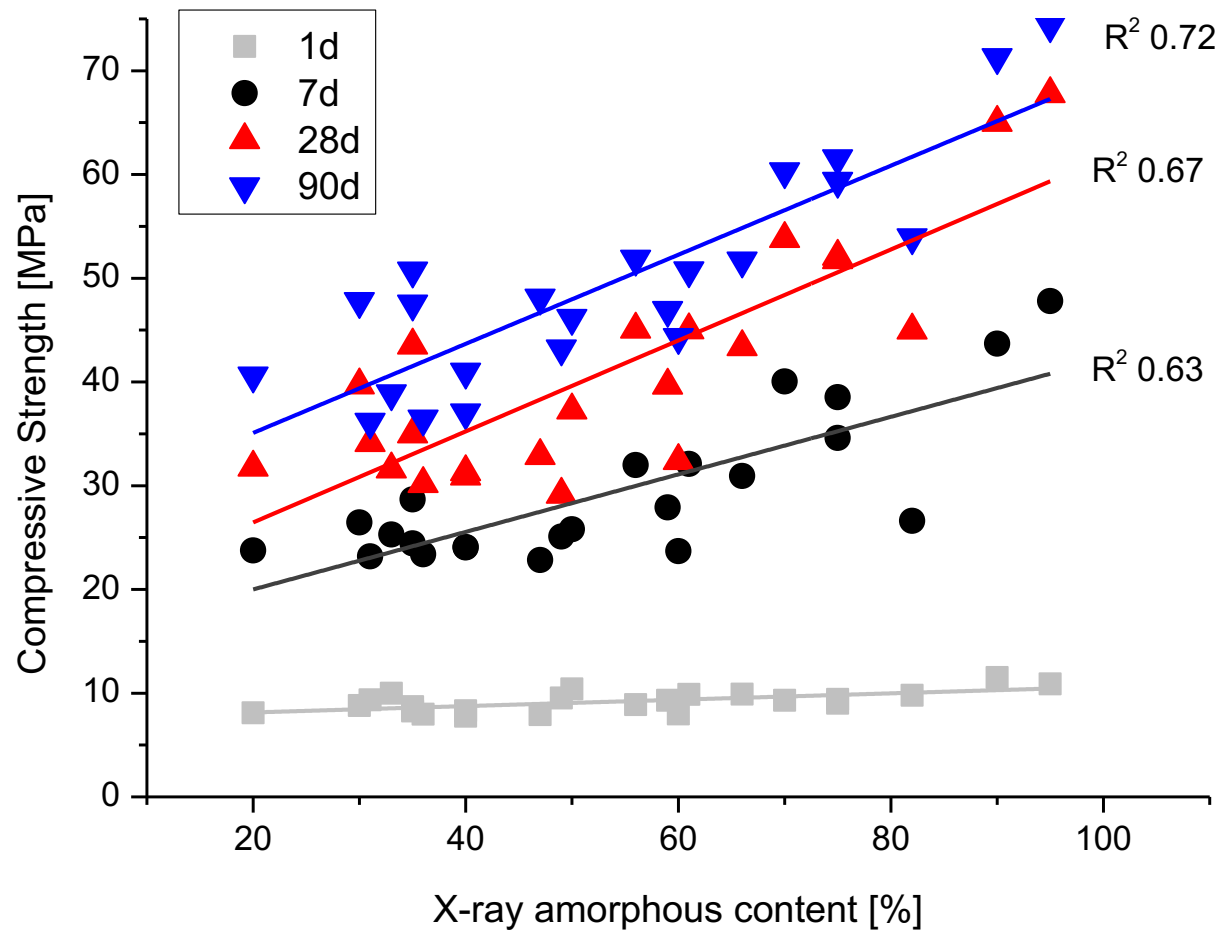
- $\text{Al}_2\text{O}_3$  11 – 45 %
- $\text{CaO}$  0 – 16 %
- $\text{Fe}_2\text{O}_3$  4 – 8 %

## ■ Investigated range of calcination temperatures

525 – 950°C



# X-ray amorphous content indication for pozzolanic activity?



Not suitable in predicting compressive strength development

## Pozzolan Test R<sup>3</sup>

- Very promising test result with new pozzolan test developed at EPFL



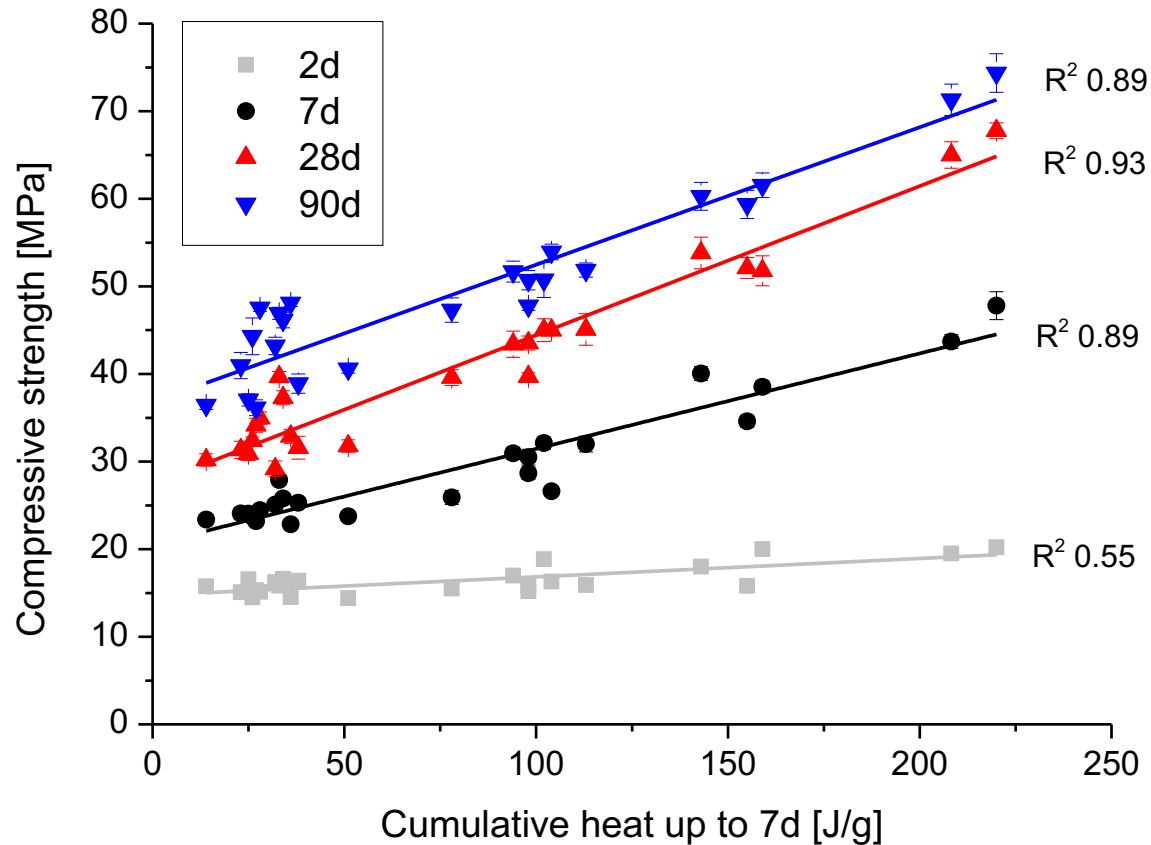
! Focuses solely on pozzolan reaction !

- Simulation of calcined clay (CC) hydration in cement:

Ca(OH) <sub>2</sub>	CC	K <sub>2</sub> SO <sub>4</sub>	Limestone	
60.0%	20.0%	7.0%	13.0%	w/b 1.2

- Mix is investigated in calorimeter at 20°C and cumulative heat after 7d is compared to compressive strength measurements

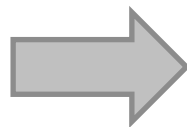
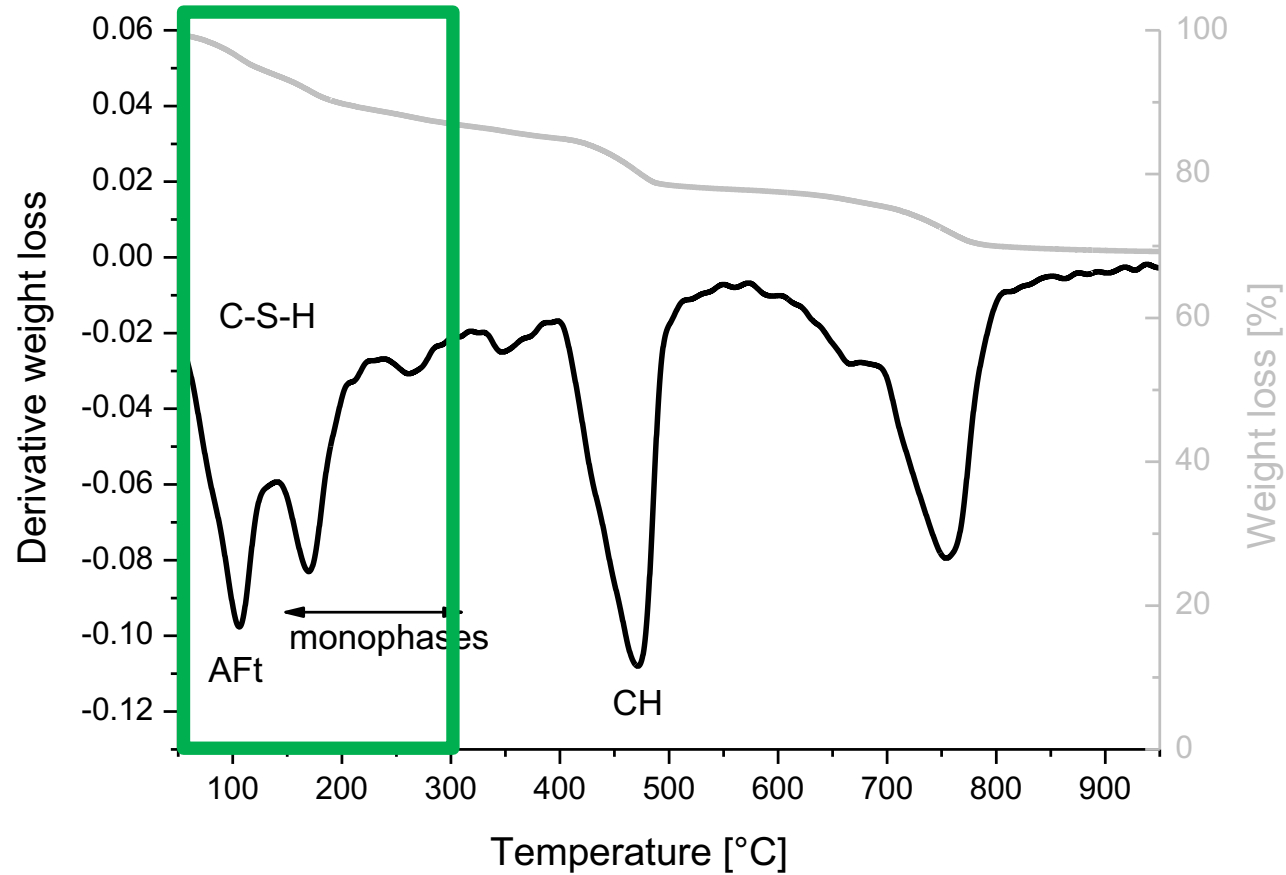
# Pozzolanic Test R<sup>3</sup> - Calorimetry



Global heat release of synthetic mixes is good indicator for pozzolanic activity of calcined clays

**BUT test requires investment in equipment and training**

# Modified R<sup>3</sup> Test – Basic Concept



Pozzolanic reactivity of CC will influence bound water content < 300°C

## ■ Modified R<sup>3</sup> Test - Methodology

- Simulation of calcined clay (CC) hydration in cement:

Ca(OH) <sub>2</sub>	CC	K <sub>2</sub> SO <sub>4</sub>	Limestone	w/b 1.2
60.0%	20.0%	7.0%	13.0%	

- Paste is sealed in plastic containers and cured at 40°C for 1 and 7d
- Disc is cut and dried over night in a drying chamber at 40°C
- Dried disc is heated for 2 h at 300°C to determine the weight loss between 40 and 300°C
- Weight loss is expressed in % of dry weight (300°C)

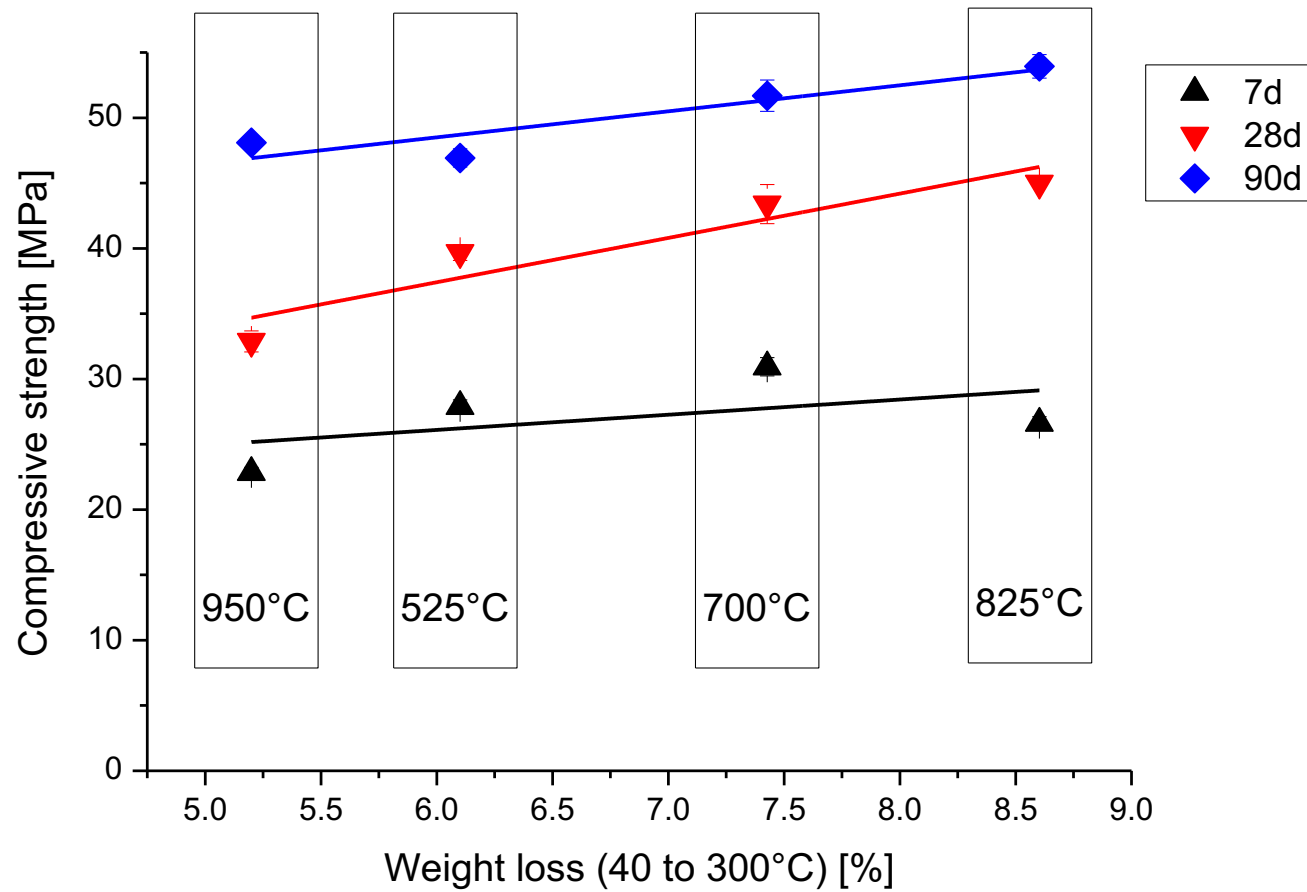


**Method is tested with different materials  
calcined at various temperatures**

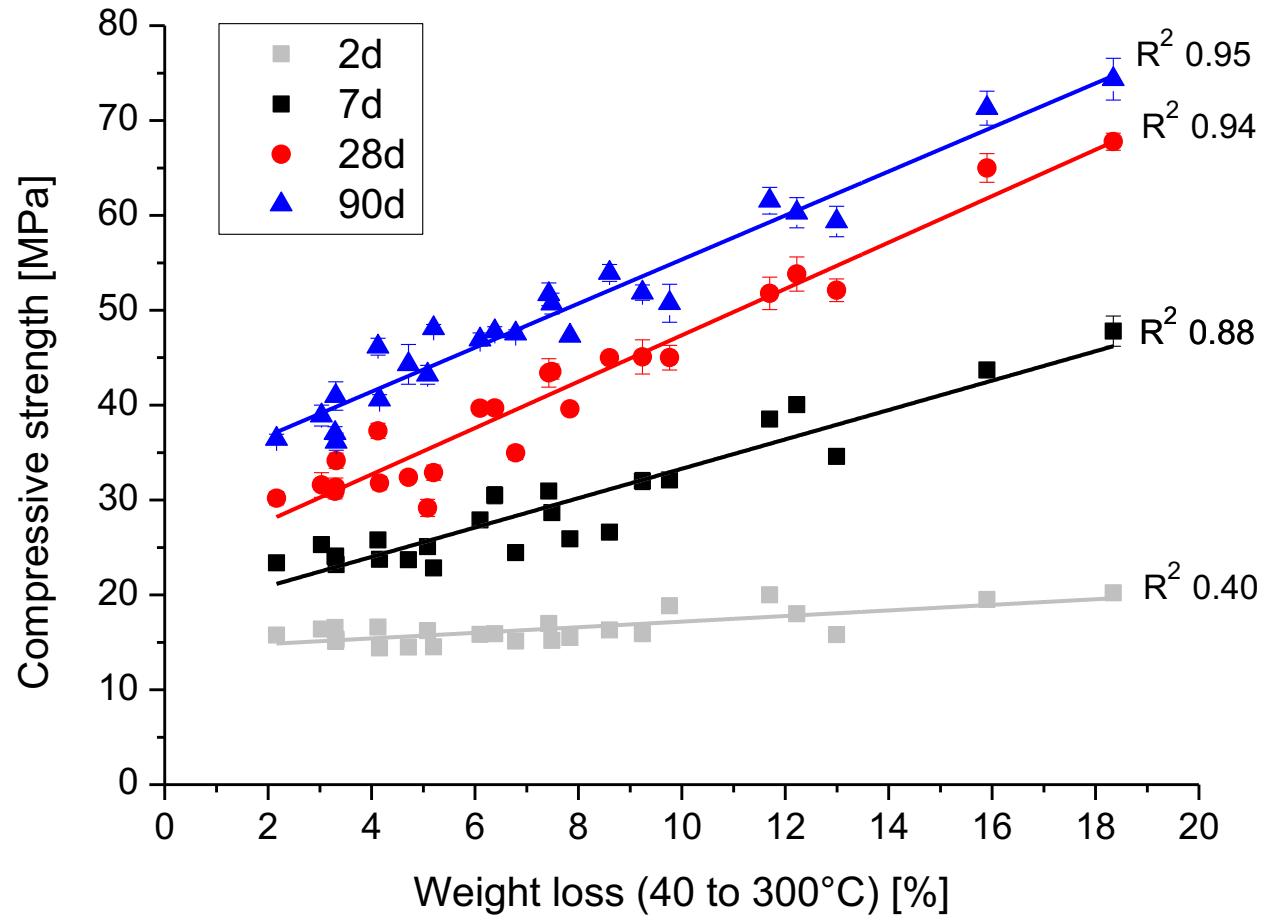


# Modified R<sup>3</sup> Test – Effect of Calcination Temperature

- Calcined at 525, 700, 825 and 950°C



# Modified R<sup>3</sup> Test – Weight Loss Method



Good correlation across different kinds of materials  
and calcination temperatures



**Thank you for your attention!**