Enhancement of Agricultural Residue Ash Reactivity in Concrete through the Use of Hydrothermal Pretreatment processes

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Agricultural Residue Ash (ARA)

- **Common available materials:**
  - Rice husk ash (RHA)
  - Sugarcane bagasse ash(SBA)
  - **Rice straw ash (RSA)**
  - **Wheat straw ash (WSA)**
  - **Corn stover ash (CSA)**
- **Pozzolanic Reaction:**

$$2C_3S + 6H \rightarrow C_3S_2H_3 + 3CH$$

$$2C_2S + 4H \rightarrow C_3S_2H_3 + CH$$

From ARA

$$3CH + 2S \rightarrow C_3S_2H_3$$

Pozzolanic reaction

Notations: C=CaO, S=SiO_2, H=H_2O

Research Objectives

- Determine if biofuel pretreatment pretreatment processes can be applied to agricultural residue ash production to control optimum burning temperature
- Understand the role of impurities on ash production

Experimental Plan

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Hot Water/ Steam Explosion

Parr 4843 high pressure reactor

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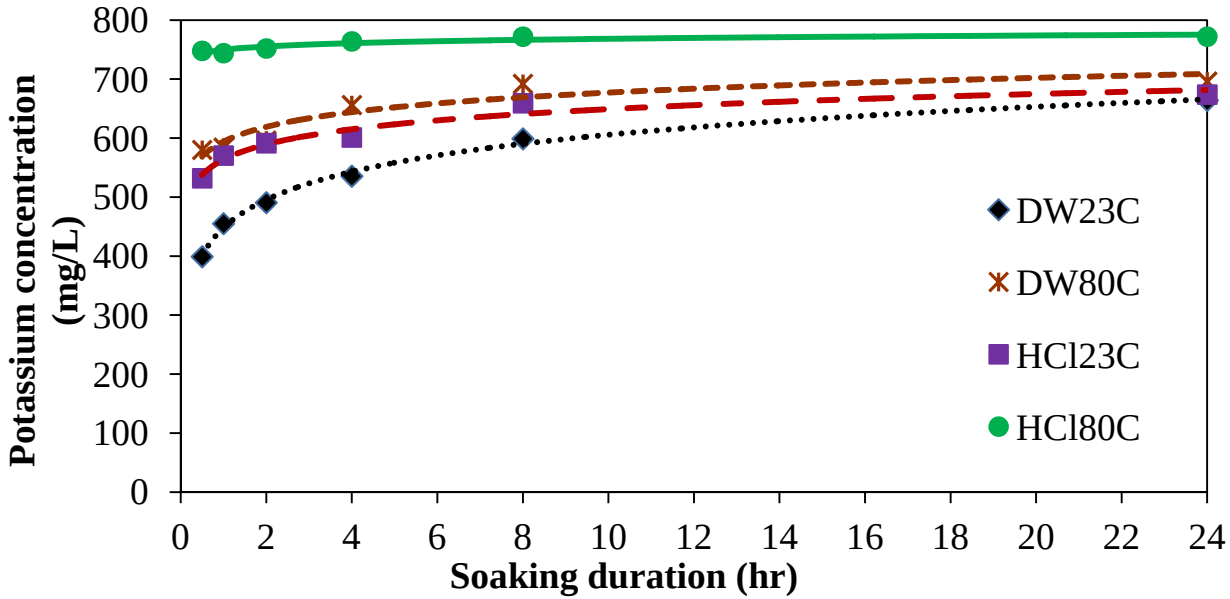
Methodology

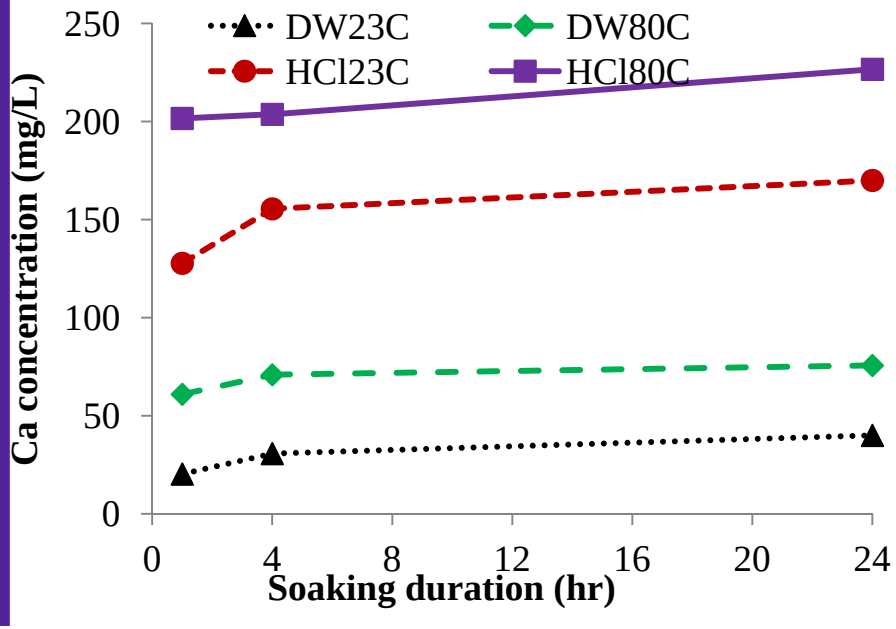
- **ARA Characterization:**
  - Loss on ignition (LOI)
  - Amorphous silica content measurement (Nair, Jagadish, and Fraaij 2006)
  - Surface area (BET Nitrogen Adsorption)
  - Particle size distribution (Laser diffraction)
  - X-ray diffraction
- **Tests for quantifying reactivity:**
  - Heat of hydration of cement paste containing ARA
  - Cement paste $Ca(OH)_2$ content
  - Mortar compressive strength

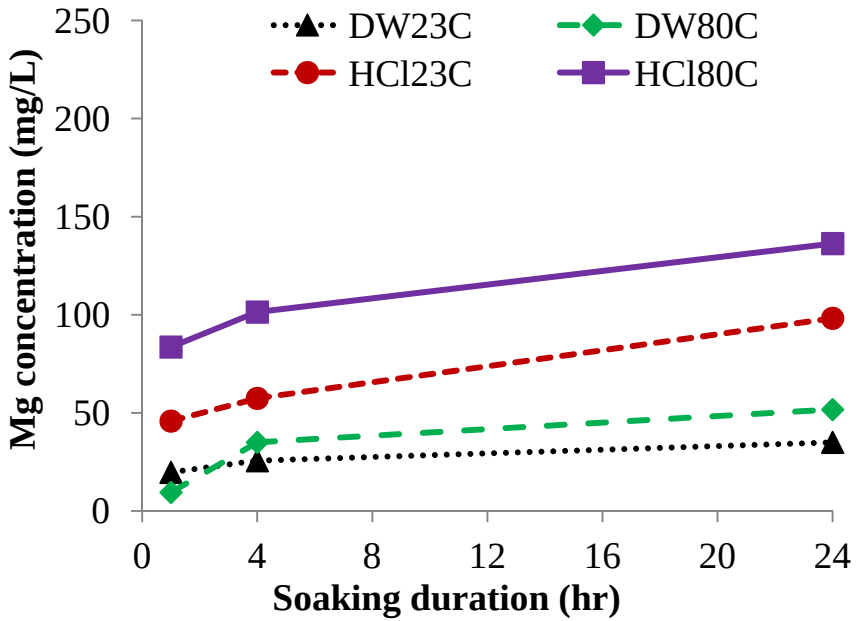
*20% cement replacement by ARA used in this study

**w/cm=0.5 for paste, w/cm=0.55 for mortar

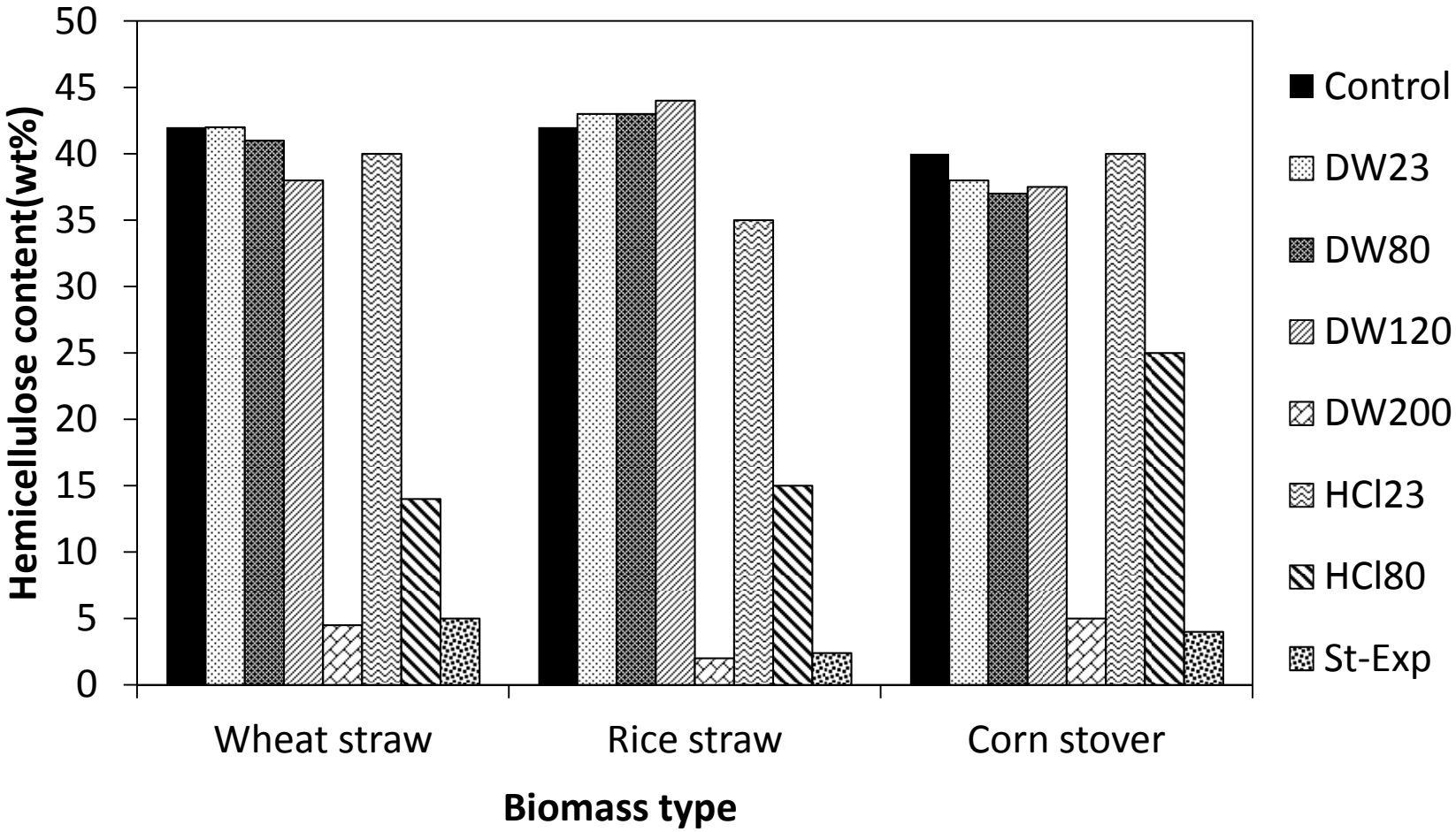
Leachate Composition: K







Straw Hemicellulose Content after Pretreatment



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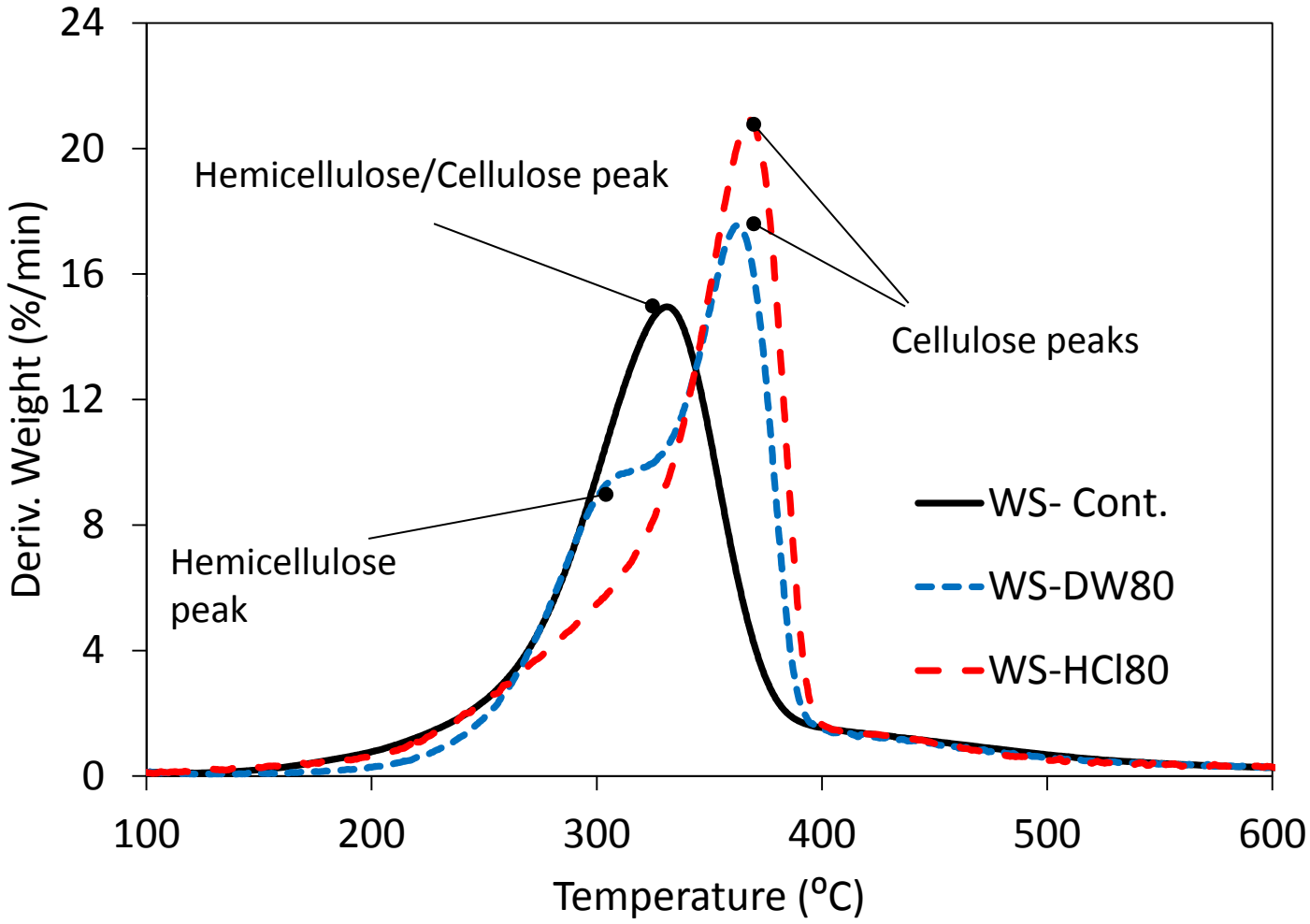
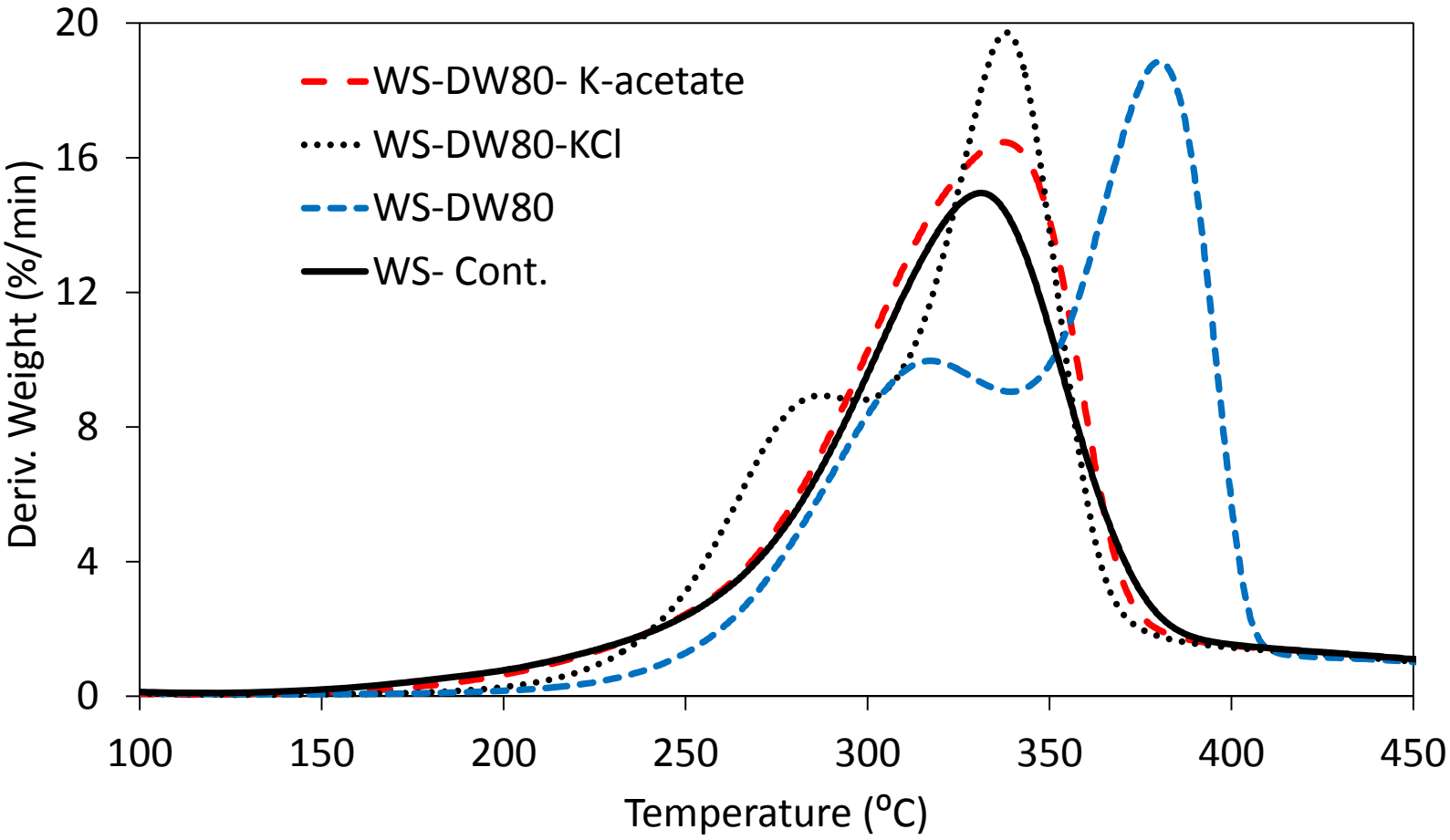
Thermal Degradation (pyrolysis)



Thermal Degradation (Pyrolysis)



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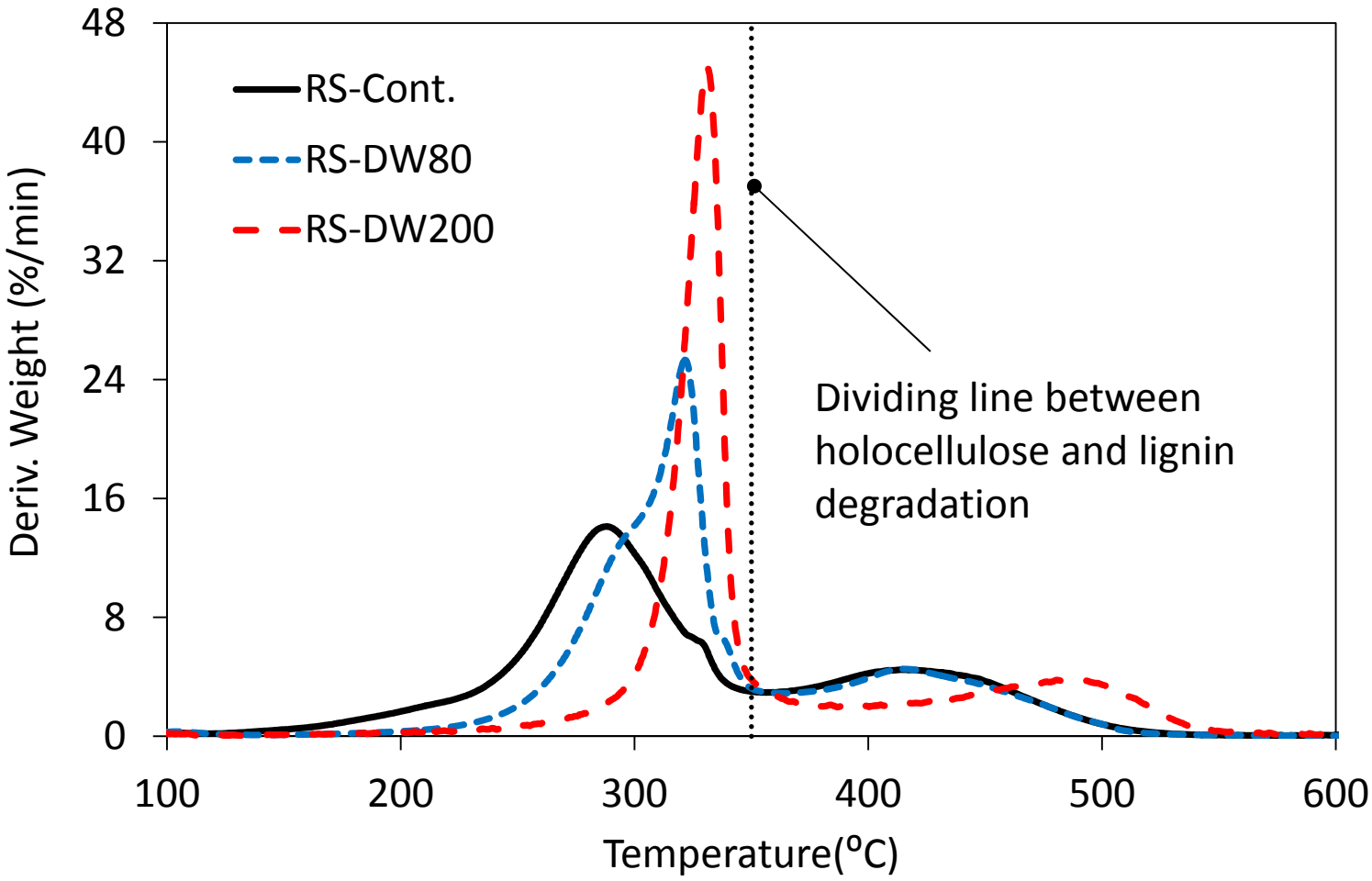
Thermal Degradation (Combustion)



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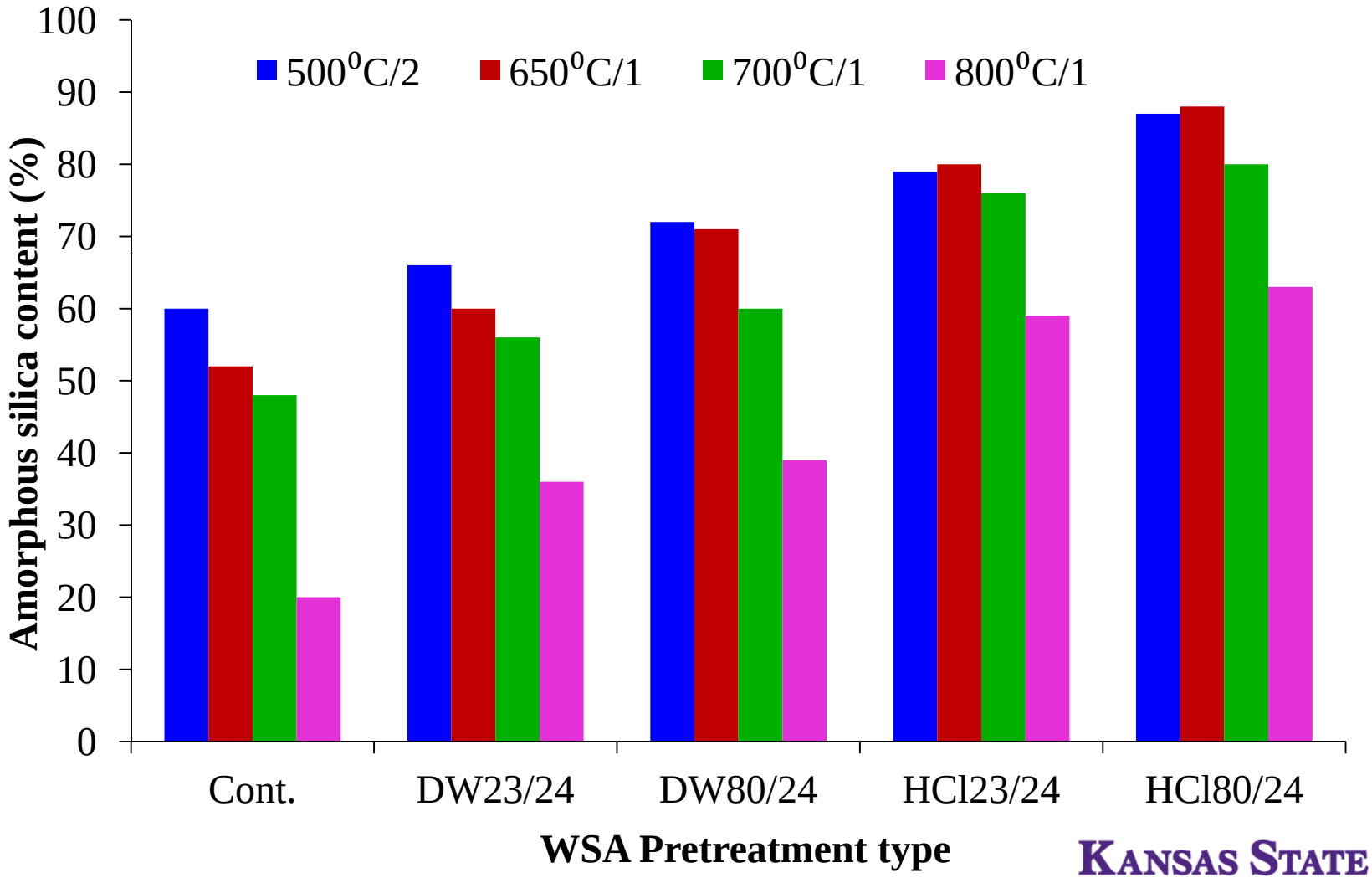
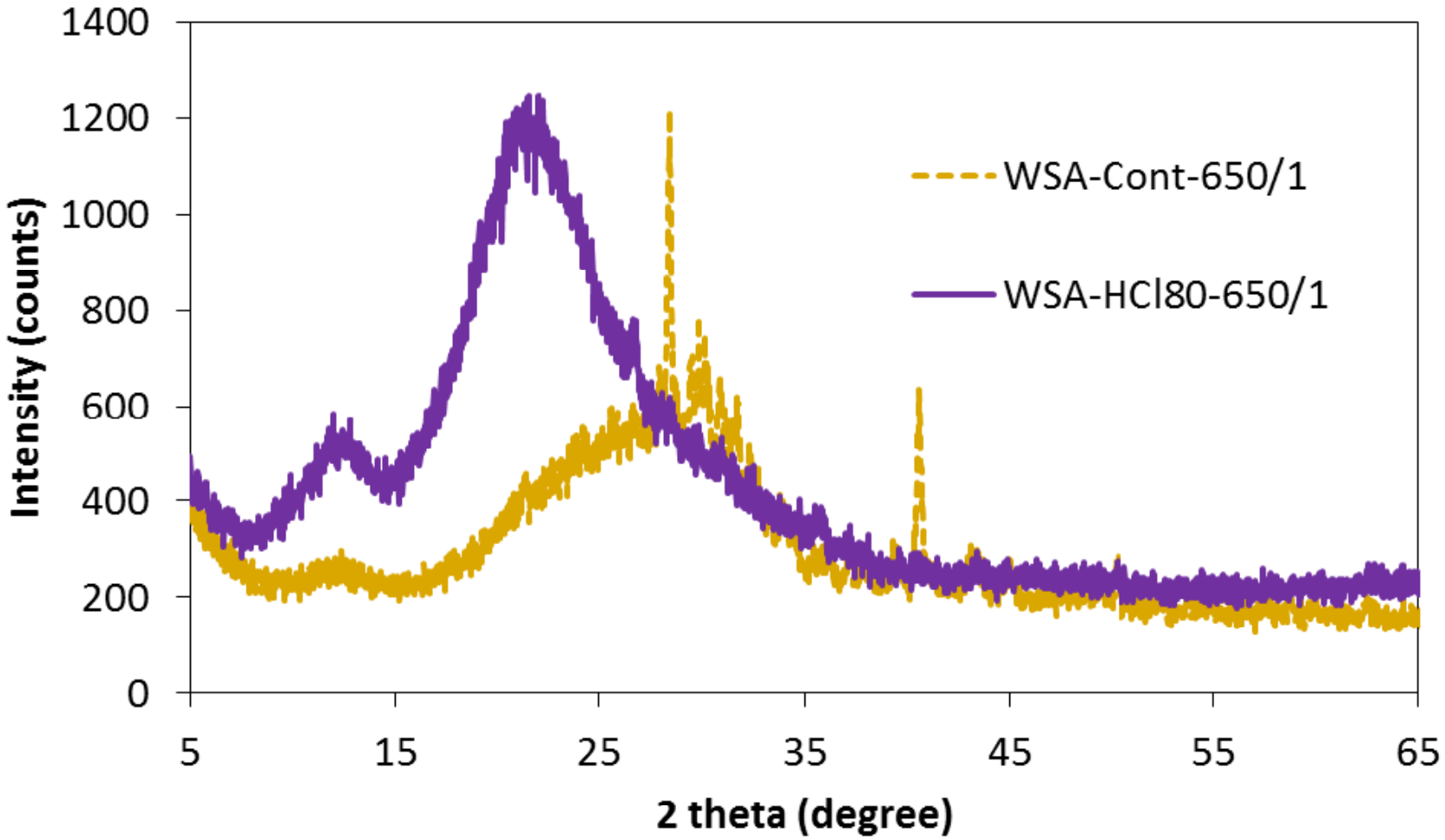
Amorphous Silica Content



X-Ray Diffraction



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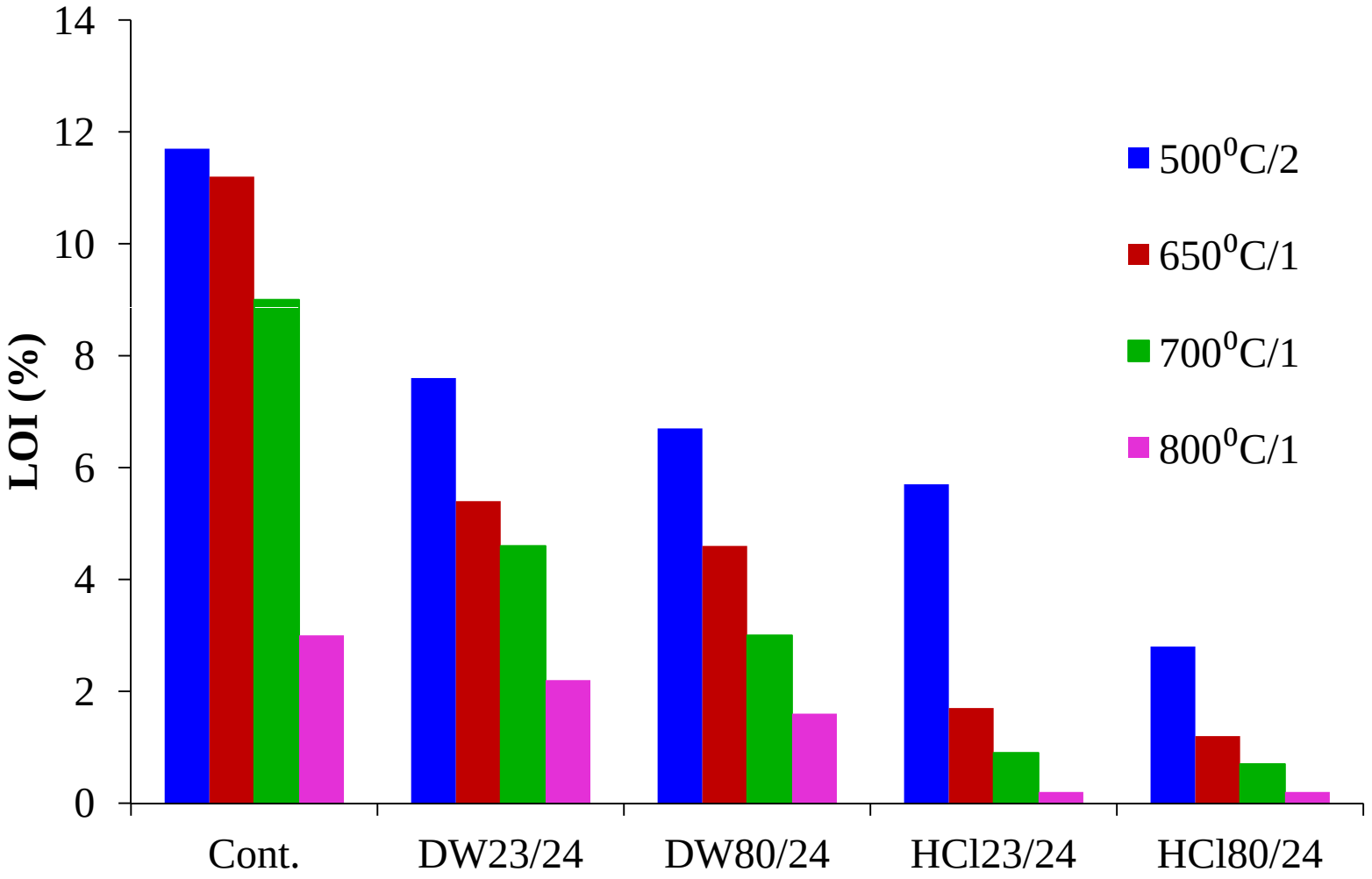
Loss on Ignition



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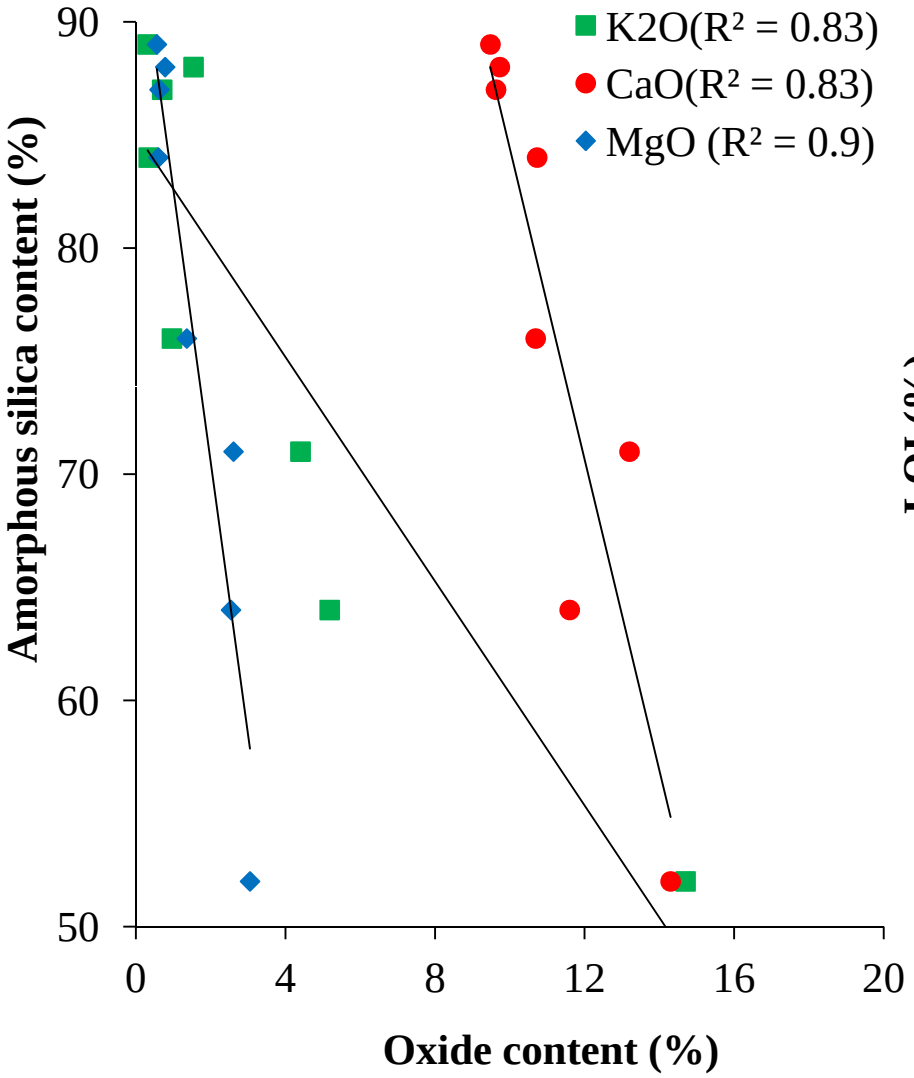
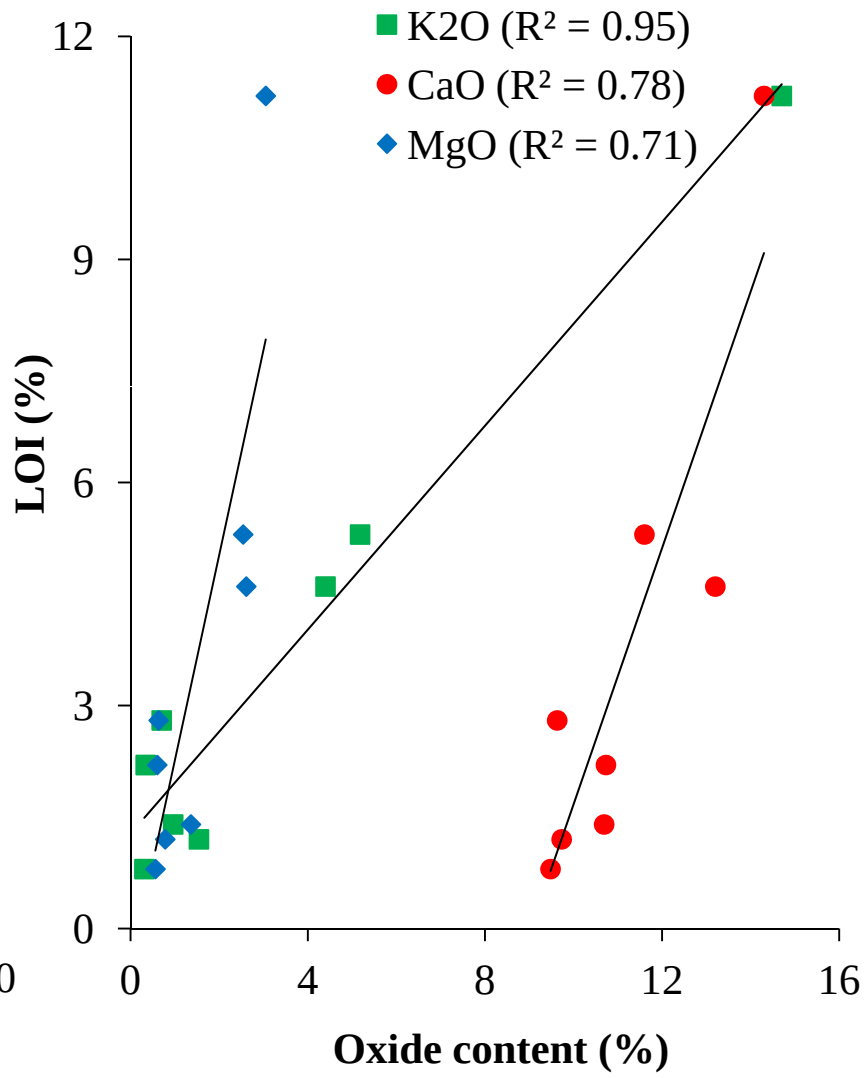
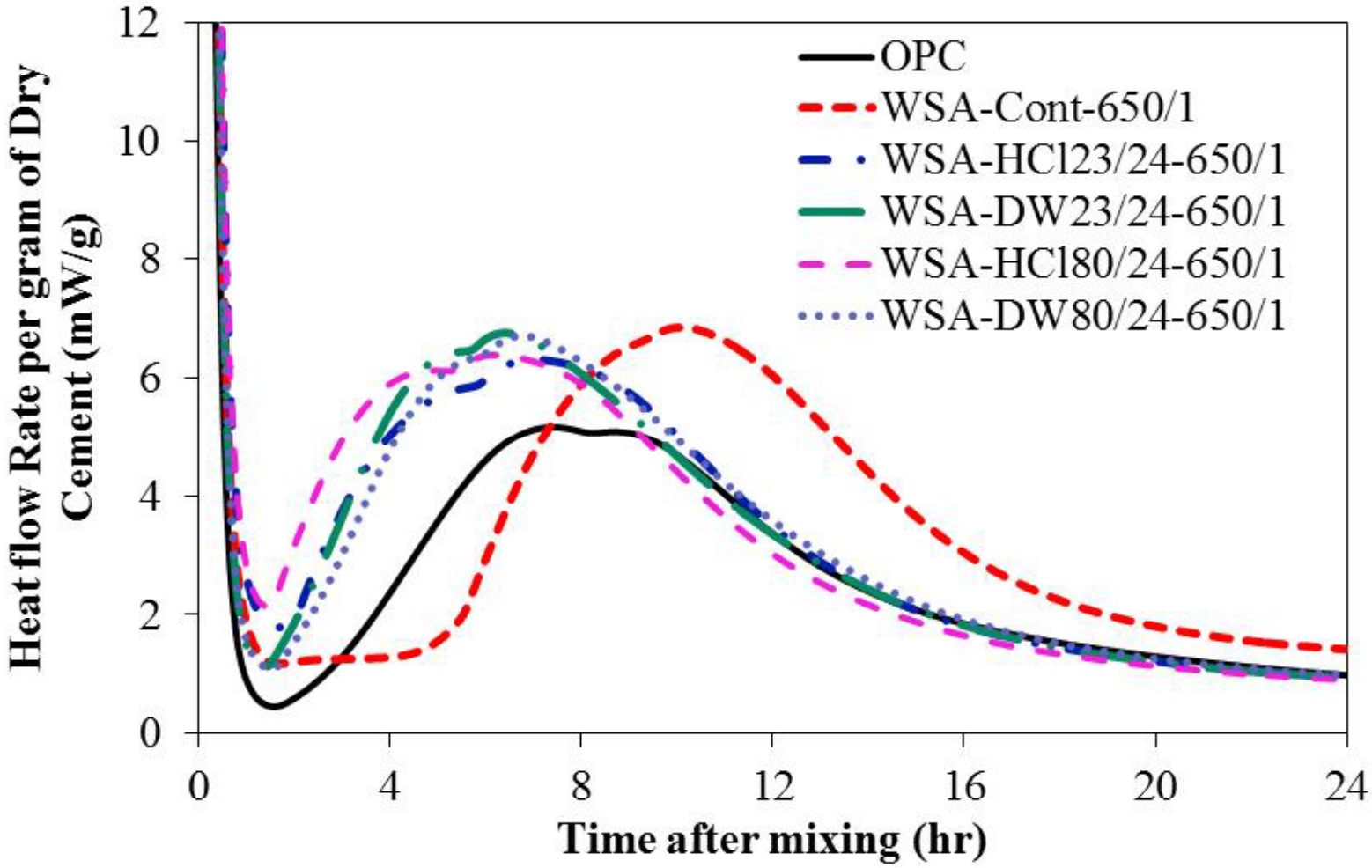
Metal Impurities





Heat of Hydration Rate



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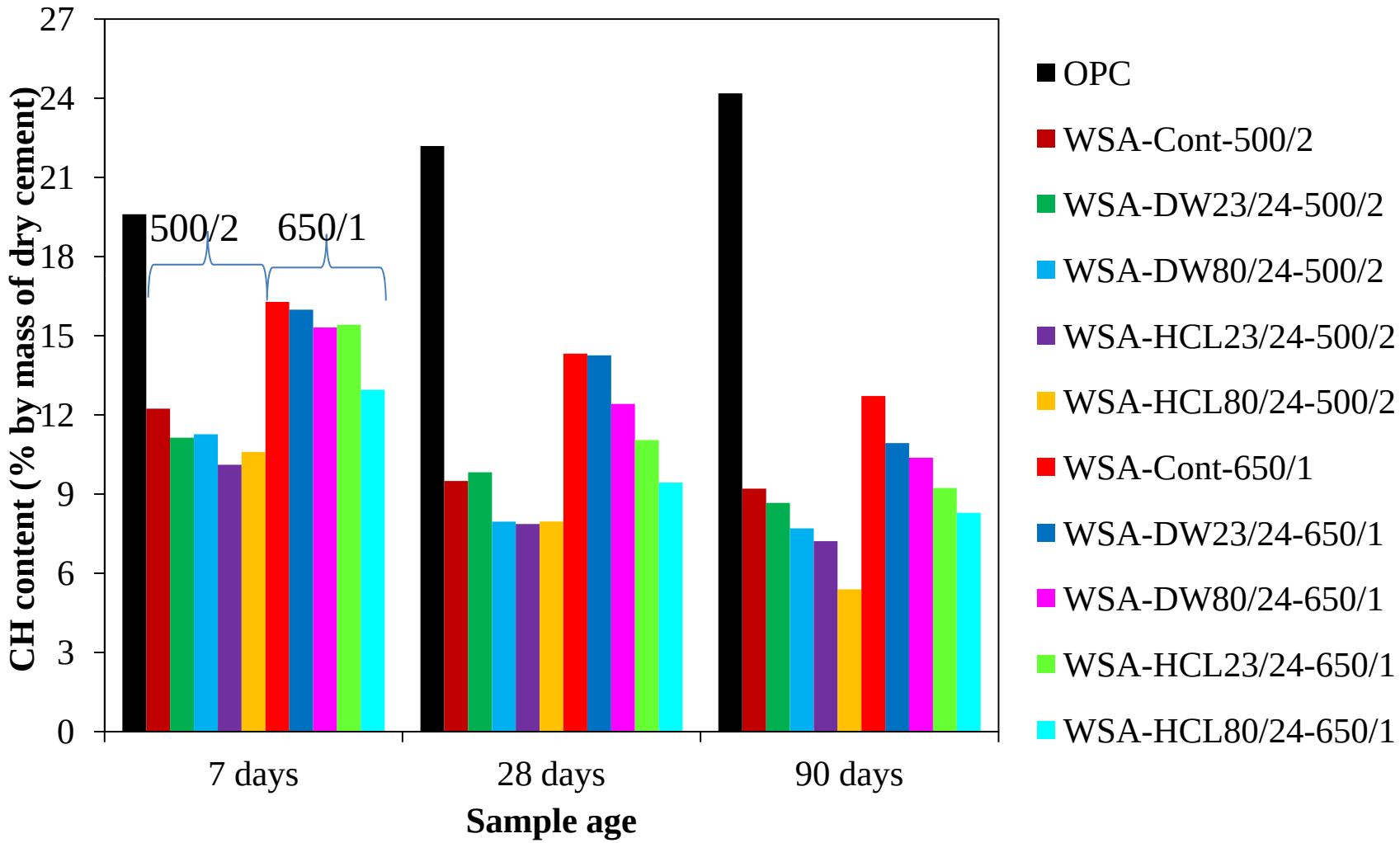
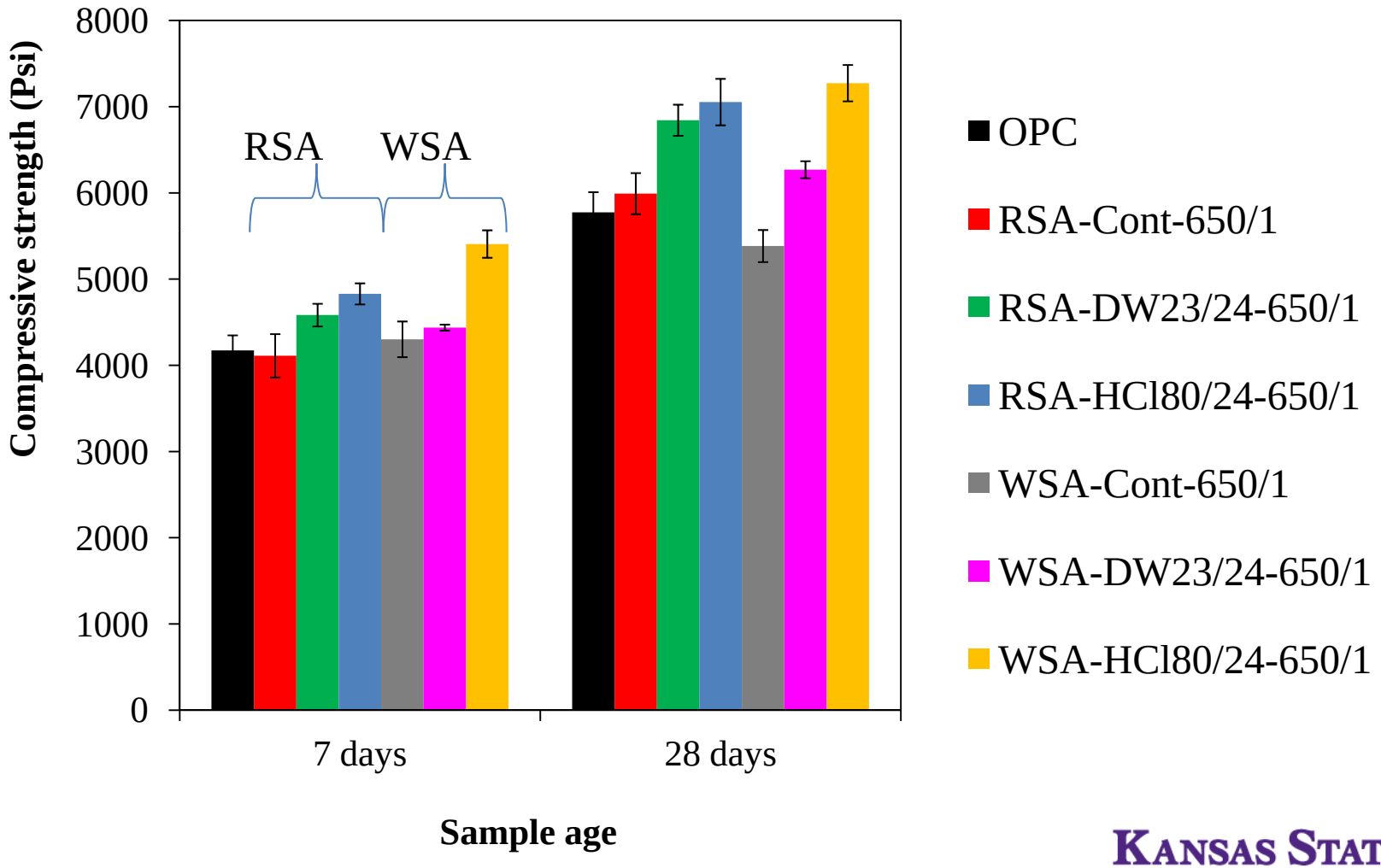
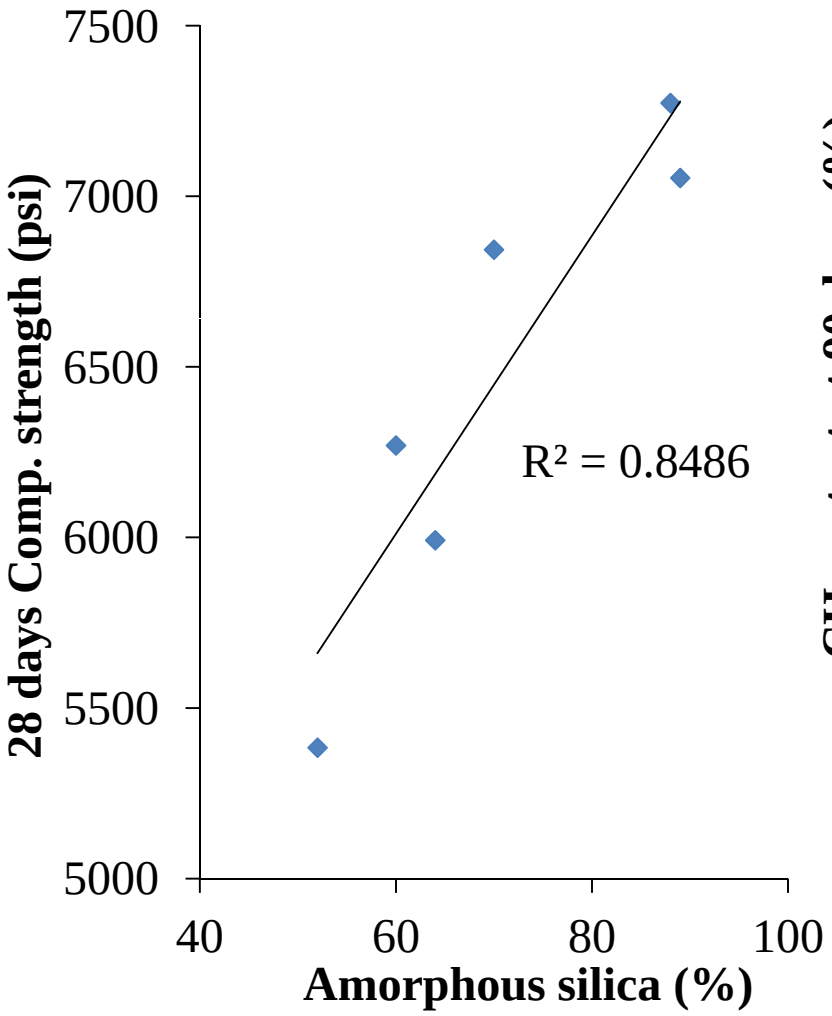
CH content

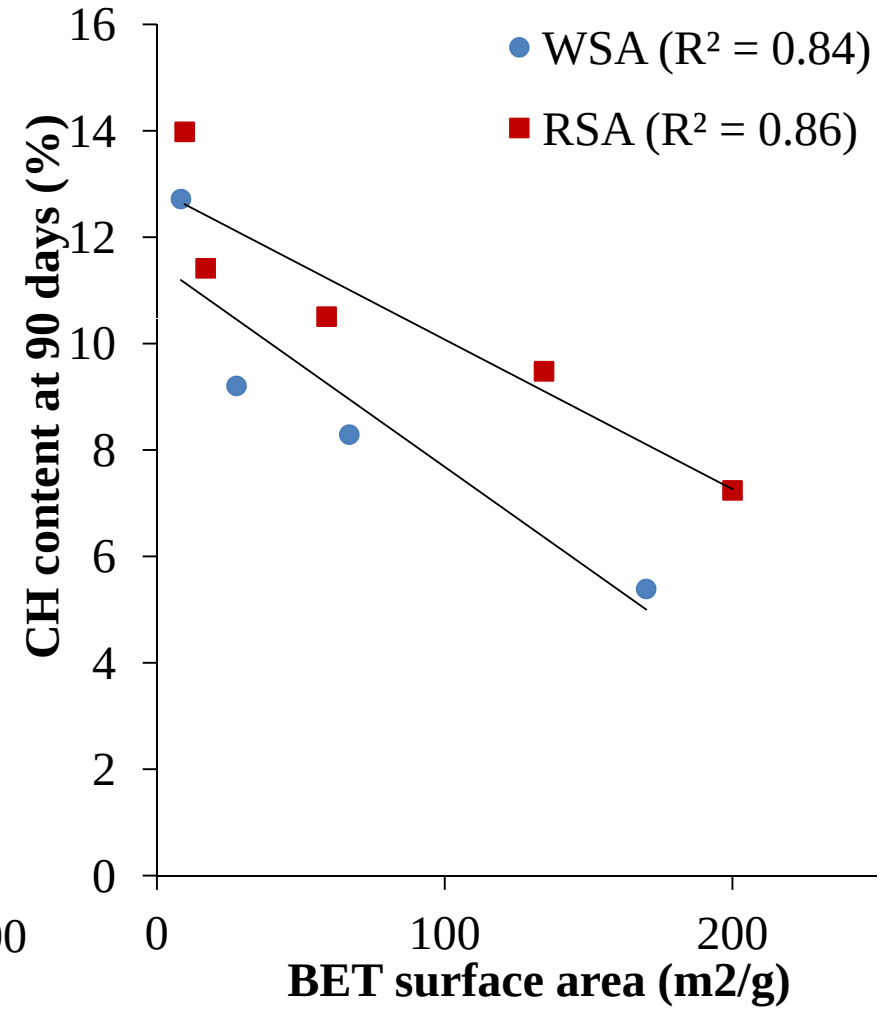

27
24
21
18
15
12
9
6
3
0
CH content (% by mass of dry cement)
500/2
650/1
7 days
28 days
90 days
Sample age
OPC
WSA-Cont-500/2
WSA-DW23/24-500/2
WSA-DW80/24-500/2
WSA-HCL23/24-500/2
WSA-HCL80/24-500/2
WSA-Cont-650/1
WSA-DW23/24-650/1
WSA-DW80/24-650/1
WSA-HCL23/24-650/1
WSA-HCL80/24-650/1

Compressive Strength



Factors Affecting Strength





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Conclusions

- Improved reactivity of pretreated ARA was attributed to:
  - Lower Ca, Mg, and K content
  - Lower LOI
  - Higher amorphous silica content
  - Higher surface area

Acknowledgements

- NSF for funding the research
- Dr. Donn Beighley
- Monarch cement company
- Antoine Borden for assistance with pretreatments and AA measurements
- National Renewable Energy Laboratory for supplying HLR

References

1. Nair, D.G., Jagadish, K.S., and Fraaij, A. “Reactive pozzolanas from rice husk ash: An alternative to cement for rural housing.” *Cement and Concrete Research*, 36(6) (2006), 1062-1071.