BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF CHEMISTRY

Effect of Precursor and Activator Type on Effectiveness of Lignosulfonate Plasticizer in Alkali-Activated Materials

David Markusík, Vlastimil Bílek

Content of presentation

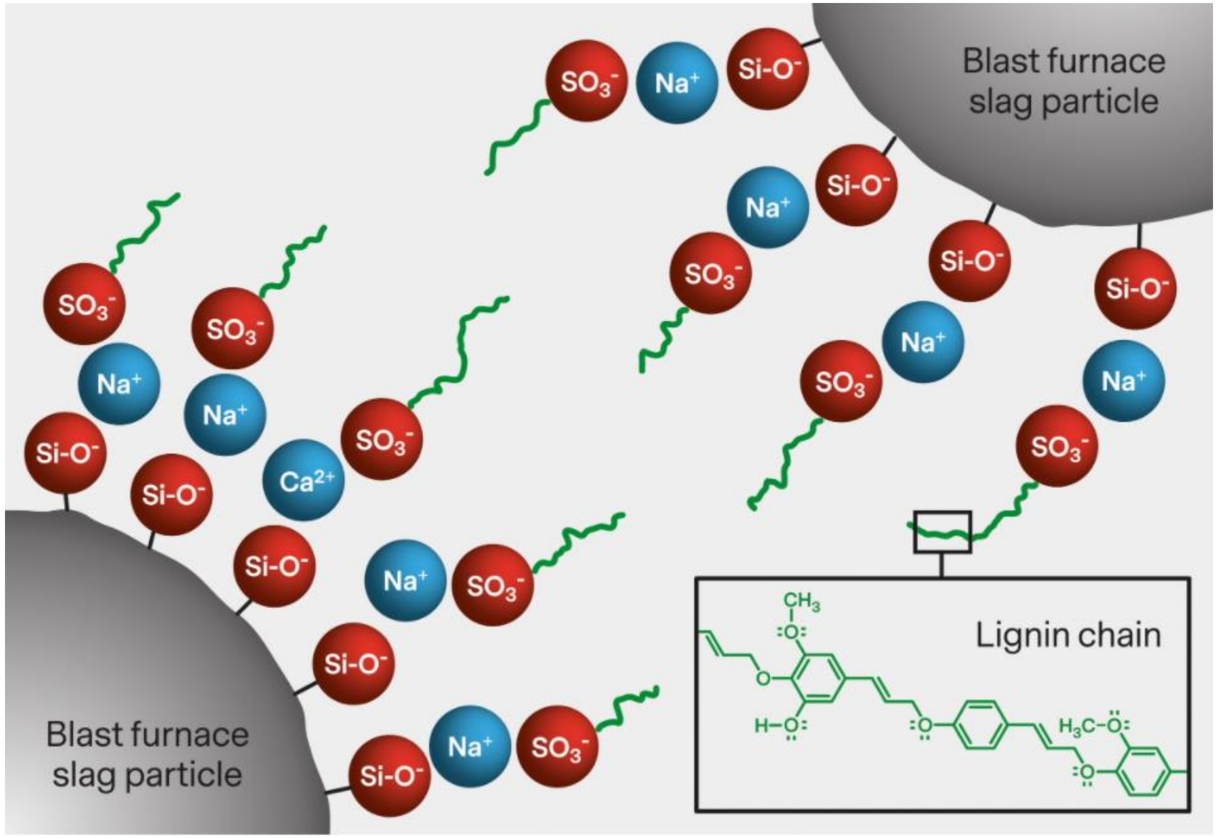
- Motivation and goals
- Plasticization mechanism and current reaserch
- Sample composition and work scheme
- Results and their correlations
- Conclusions and future plans

Motivation and goals

- Reology of AAM – very complex topic, but key to the application of AAM and cementious materials in general
- Major problems of AAM – large amount of mixing water, associated poor workability and significant shrinkage
- Project GA20-26896S, connection with current reasearch and publication (https://doi.org/10.1016/j.cemconres.2022.106822)
- The goal was to increase knowladge about affect of LS plasticizer to rheology of AAMs and compare results with published results

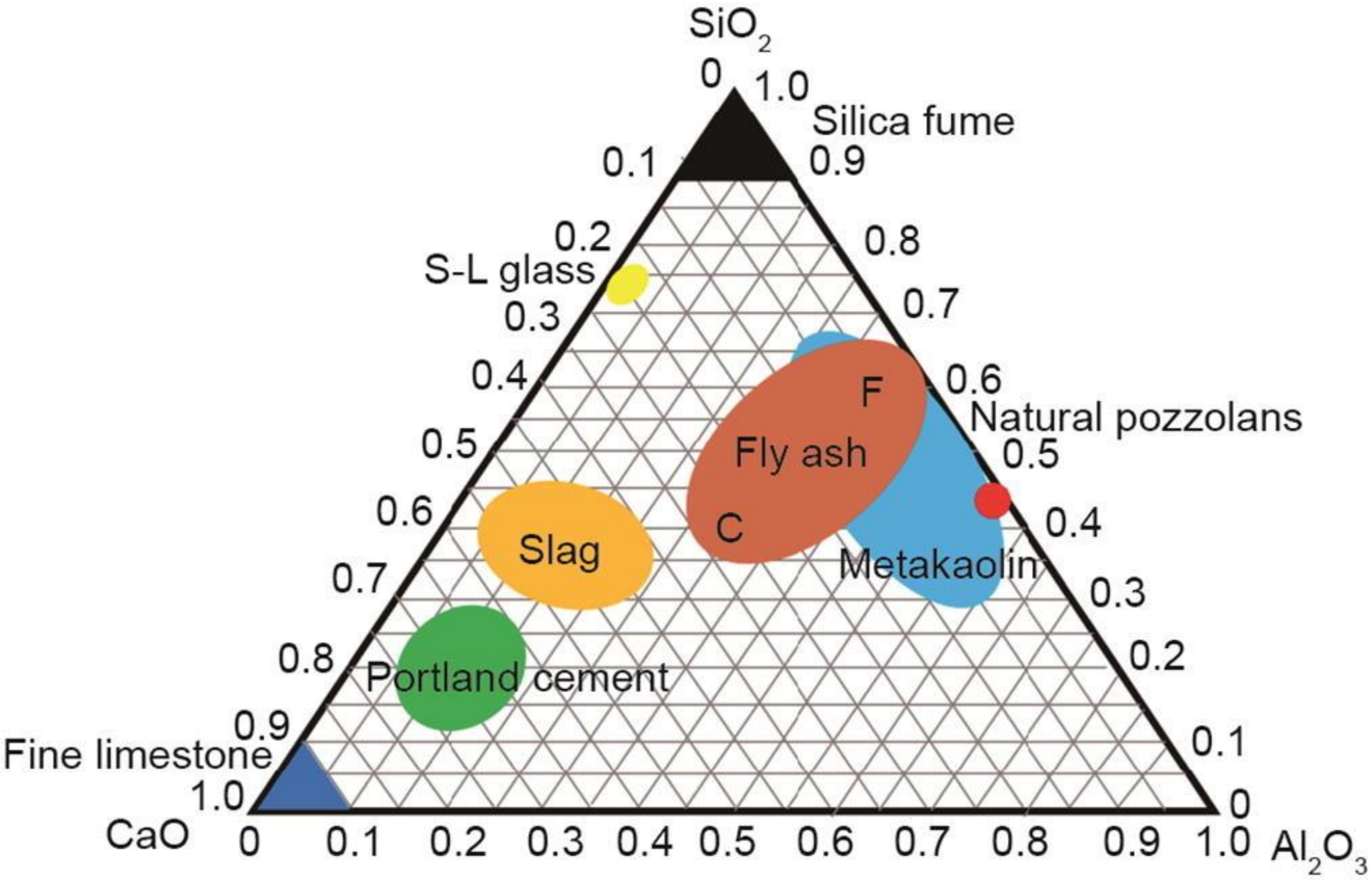
Mechanism of plasticization and current reaserch

- Plasticization is caused by electrostatic repulsion by the charge on the LS molecule as well as steric hindrance
- In the case of LS, primary steric hindrace was evaluated in literature
- Minimal effect with Fly ash in literature which contradicts our reaserch
- Minimal influence in the case of MK
- Probably influenced primarily by calcium content

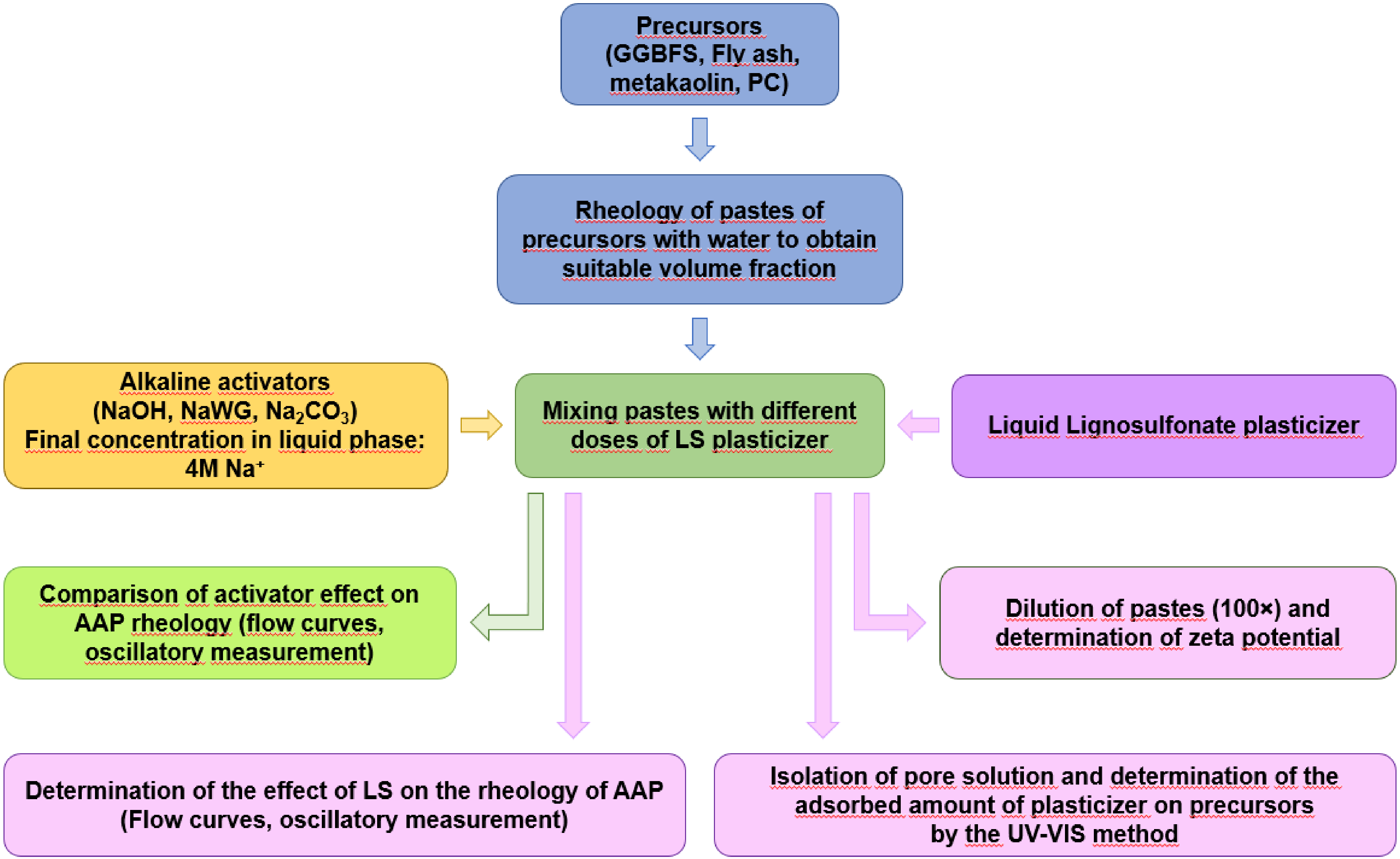


doi:10.1080/21650373.2019.1625827

Chemical composition of precursors



doi: 10.1016/j.eng.2019.08.019

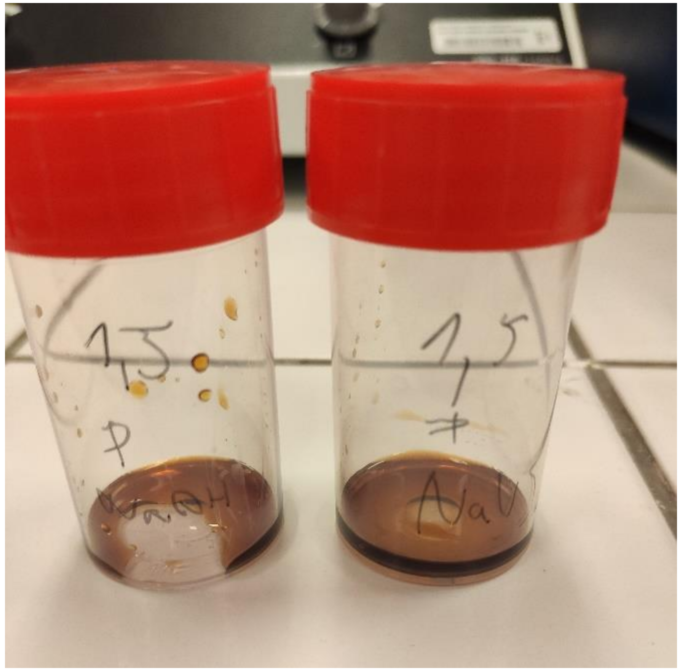

Precursors
(GGBFS, Fly ash, metakaolin, PC)
Rheology of pastes of precursors with water to obtain suitable volume fraction
Alkaline activators
(NaOH, NaWG, Na_2CO_3)
Final concentration in liquid phase:
4M Na^+
Mixing pastes with different doses of LS plasticizer
Liquid Lignosulfonate plasticizer
Comparison of activator effect on AAP rheology (flow curves, oscillatory measurement)
Dilution of pastes (100×) and determination of zeta potential
Determination of the effect of LS on the rheology of AAP
(Flow curves, oscillatory measurement)
Isolation of pore solution and determination of the adsorbed amount of plasticizer on precursors by the UV-VIS method

Key experiments

- Reology of precursors with water and alkaline activators
- Effect of plasticizer to rheology of AAM pastes
- Determination of the adsorbed amount of plasticizer to precursors
- Zeta potentials of diluted AAM pastes

DHR-2 rheometer

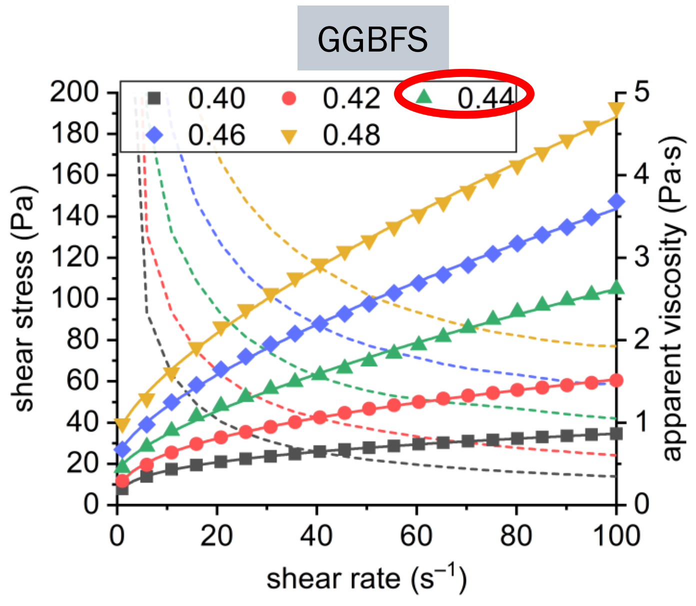
Vane geometry



Pore solutions after centrifugation and filtration

Results and evaluation

- Completely different rheological properties of pastes from different precursors
- Rheological measurements to test the appropriate volume fraction for each precursor for further experiments
- Model Herschel-Bulkley for evaluation of rotational measurements
- Volume fractions selected
  - GGBS: 0.44
  - Fly ash: 0.50
  - Metakaolin: 0.35
  - PC: 0.48.



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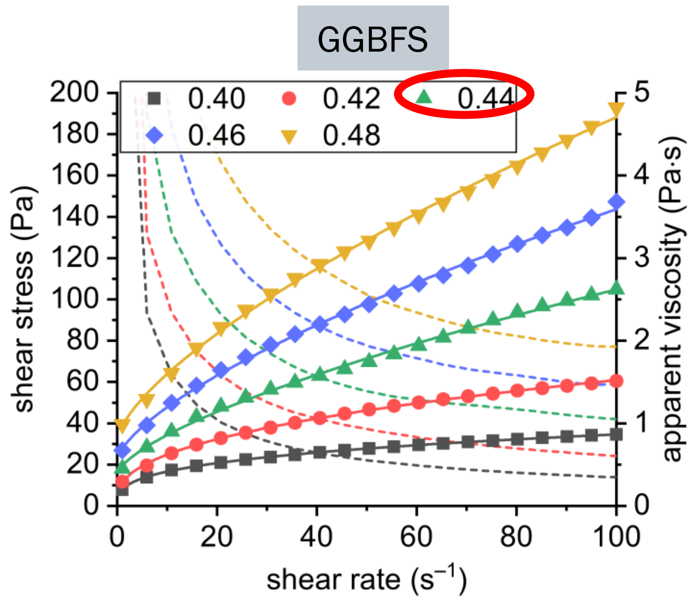

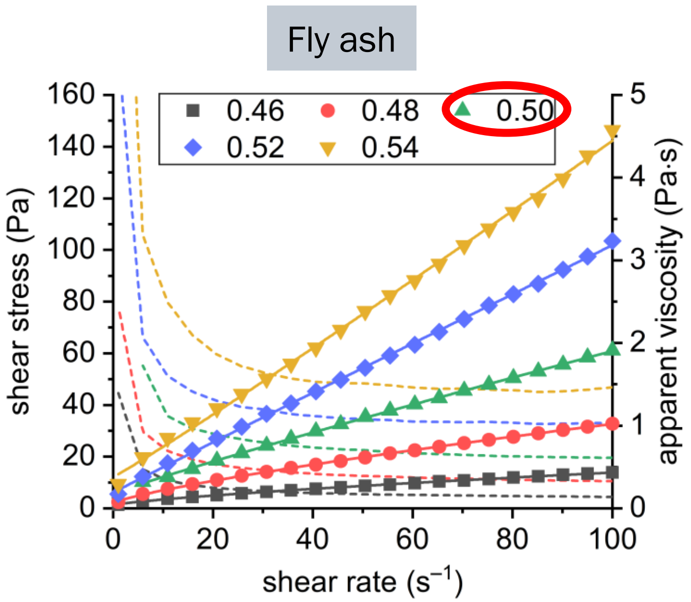

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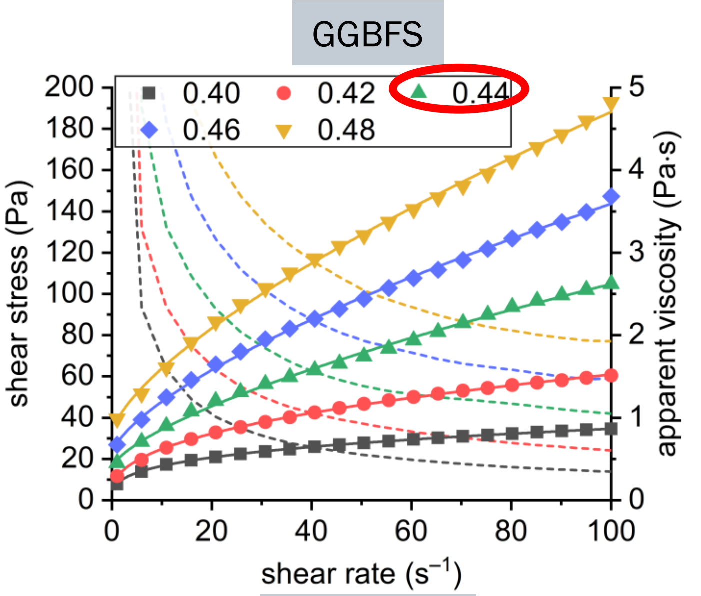

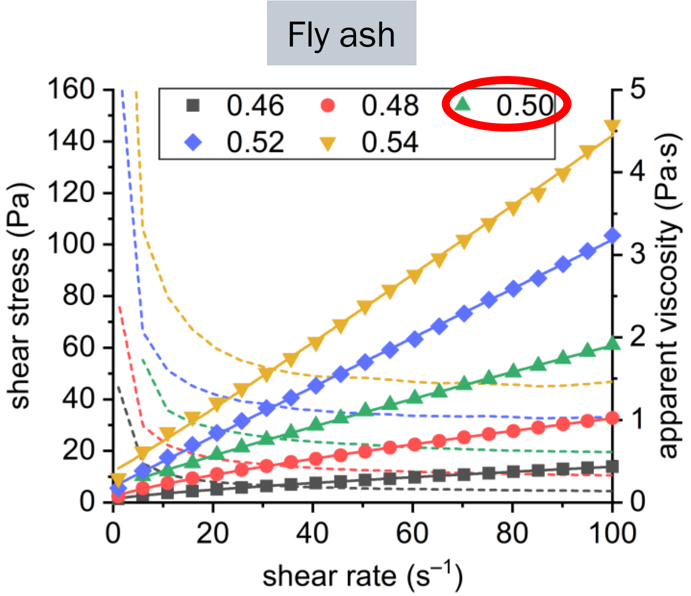

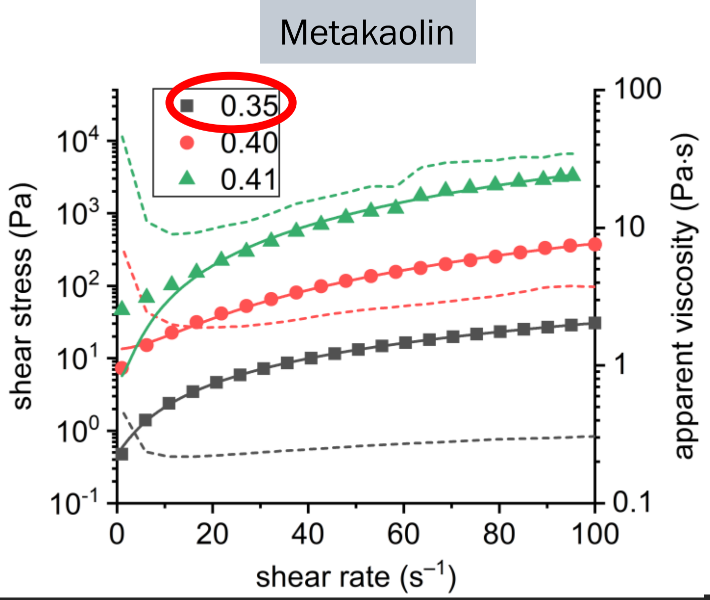

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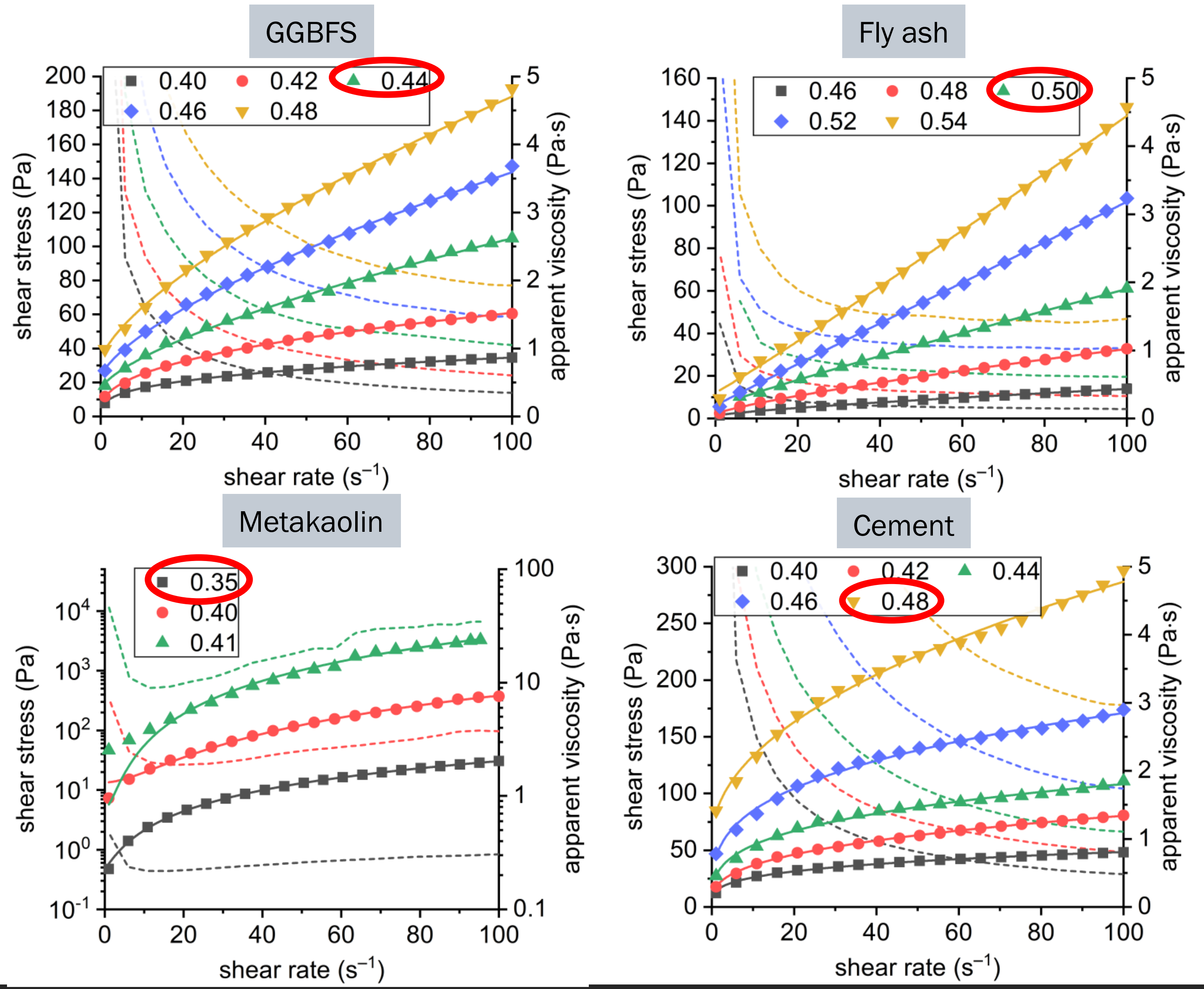
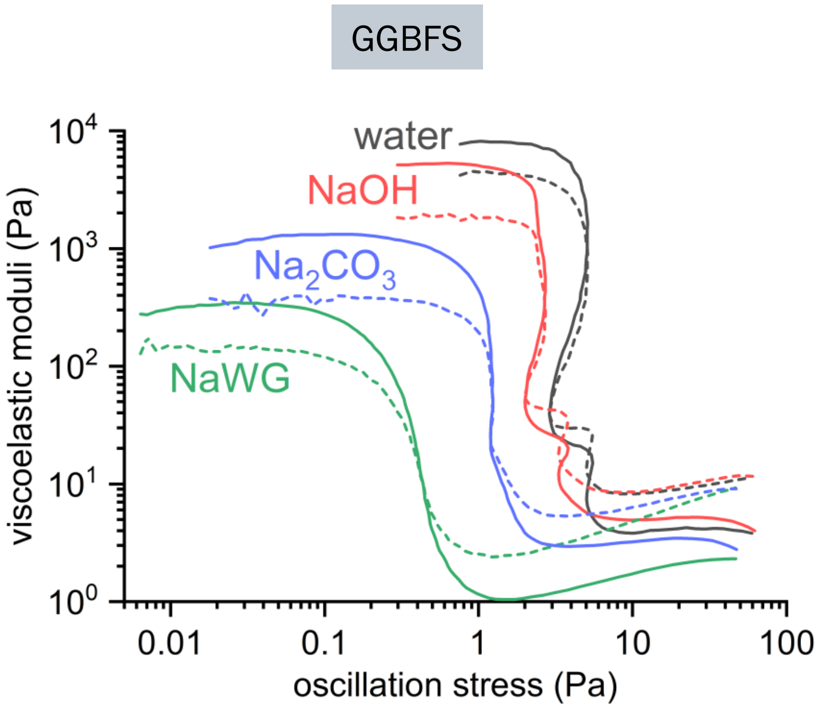


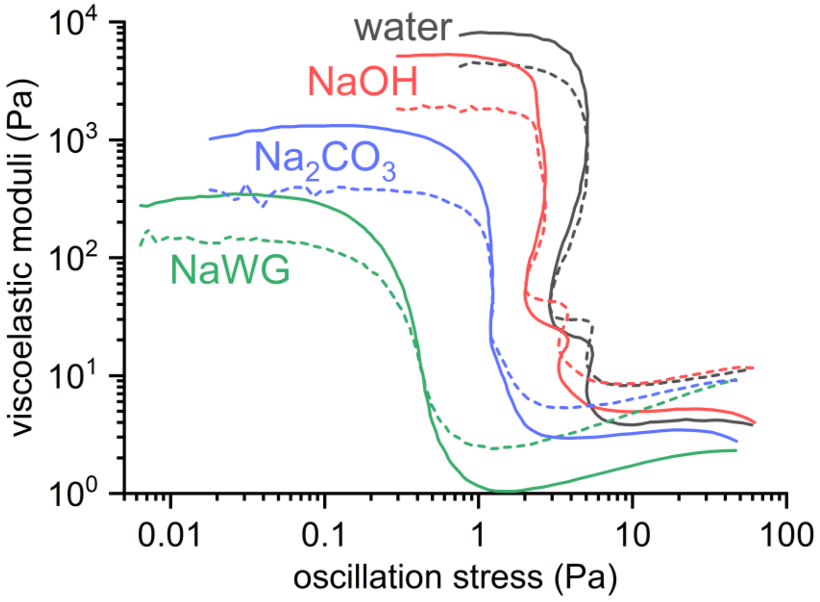
Effect of activator to rheology of AMM pastes



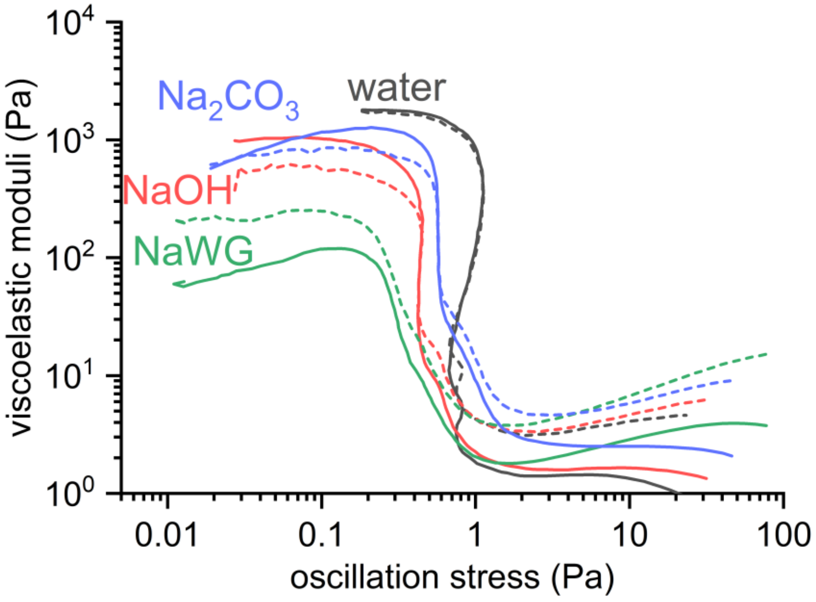
G′: solid line
G″: dashed line

Effect of activator to rheology of AMM pastes

GGBFS



Fly Ash



G′: solid line
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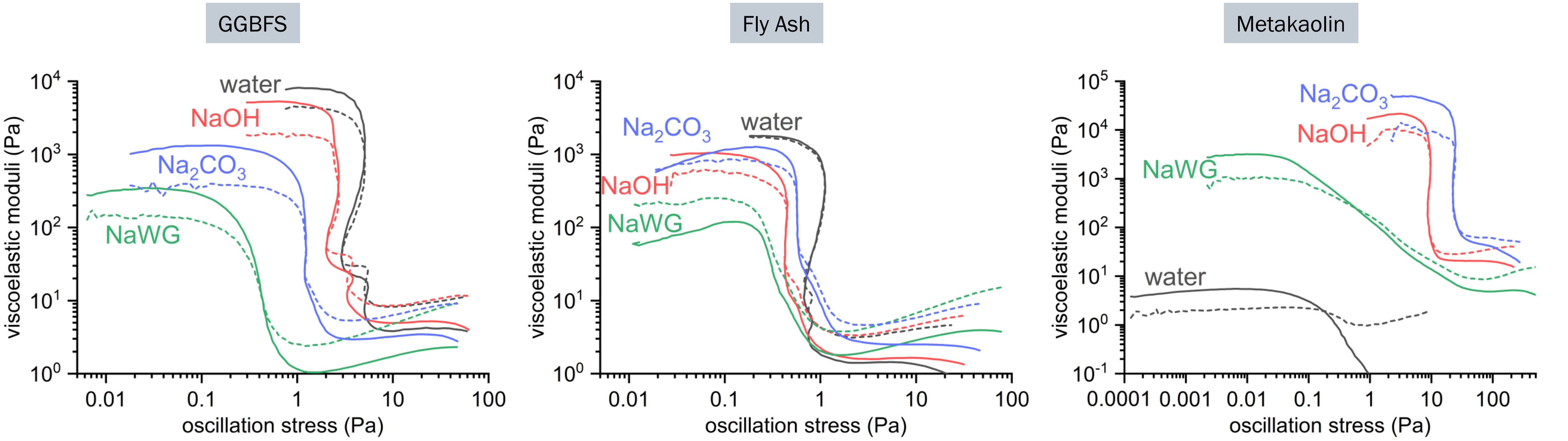
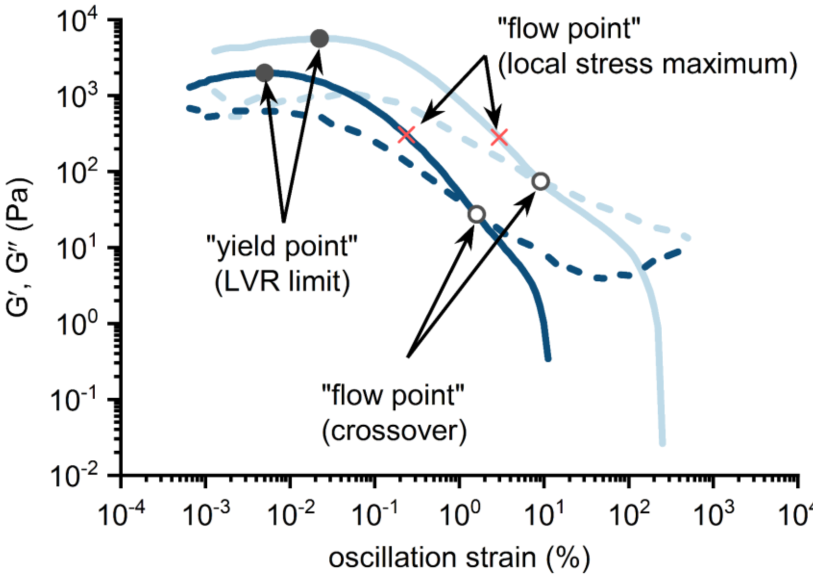
Effect of activator to rheology of AMM pastes

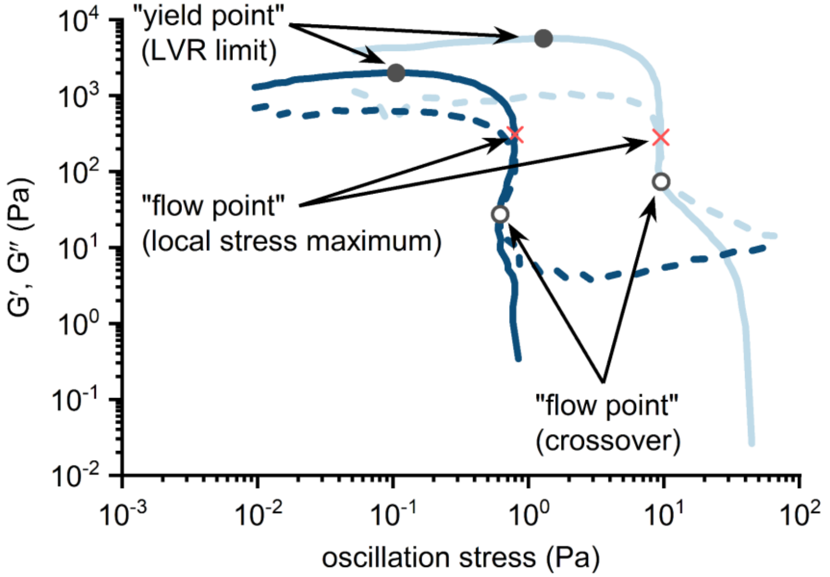


G′: solid line
G″: dashed line

Yield point, flow point (oscillatory rheology)

- Yield point: LVR limit (maximum value)
- Flow point: crossover of storage and loss moduli
- The evaluation was based on previous experience and publications

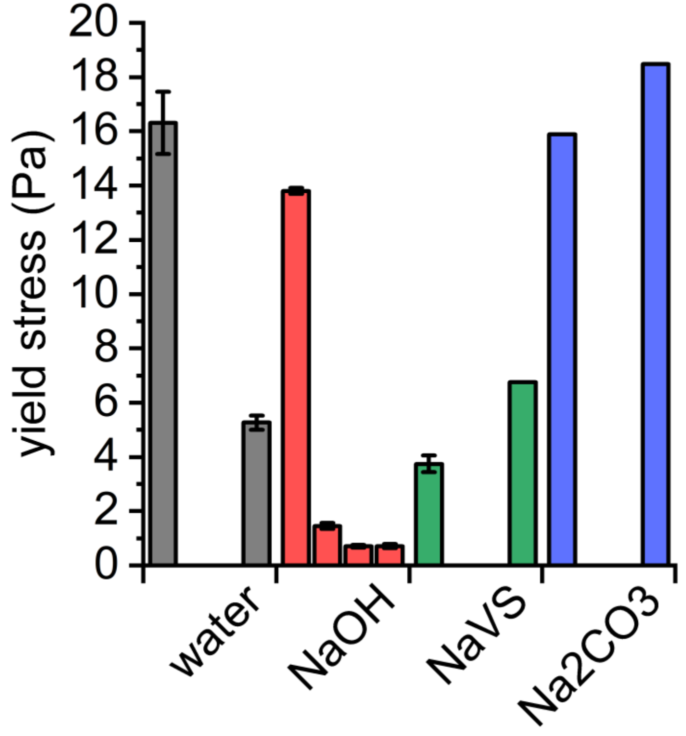




https://doi.org/10.1016/j.cemconres.2022.106822

Effect of LS to rheology of GGBFS pastes

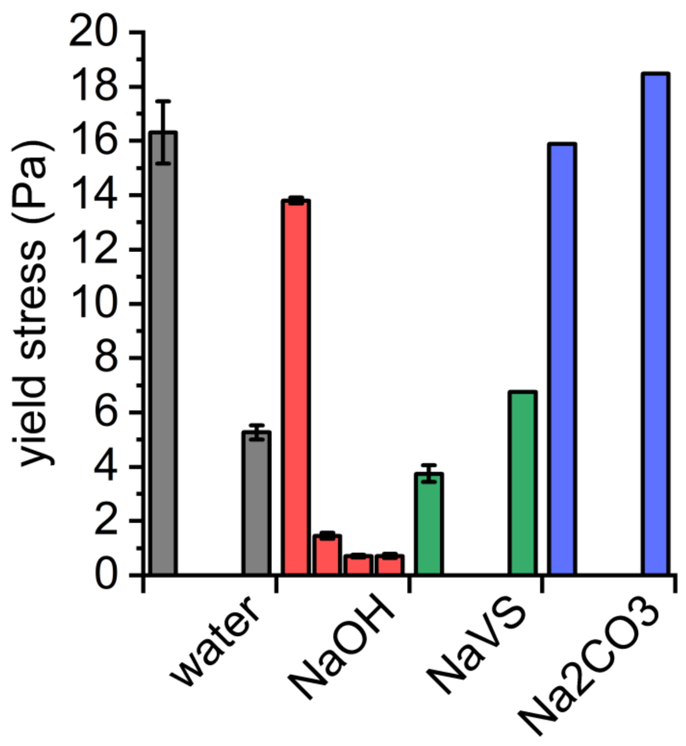
Yield stress from rotational measurements



0; 0,5; 1; 1,5 %
dose of LS

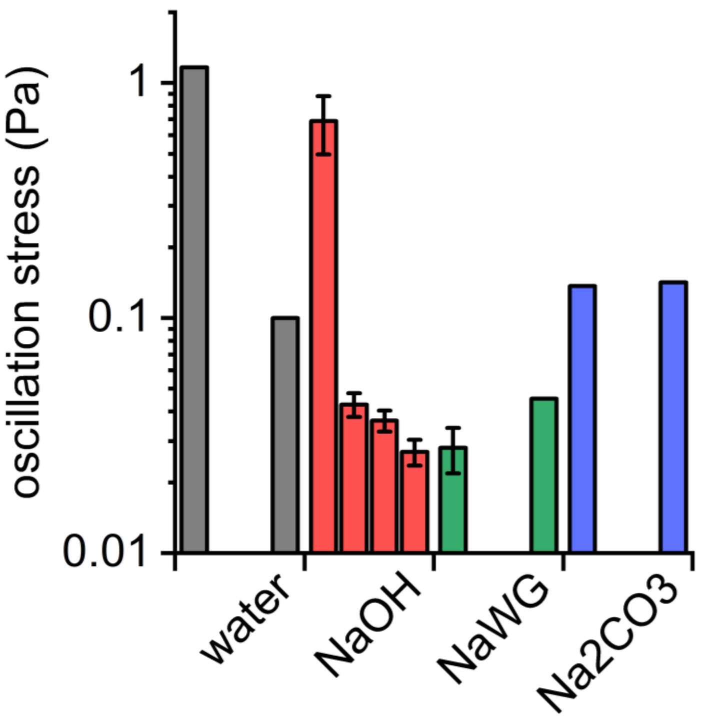
Effect of LS to rheology of GGBFS pastes

Yield stress from rotational measurements



Oscillation measurements

Yield point



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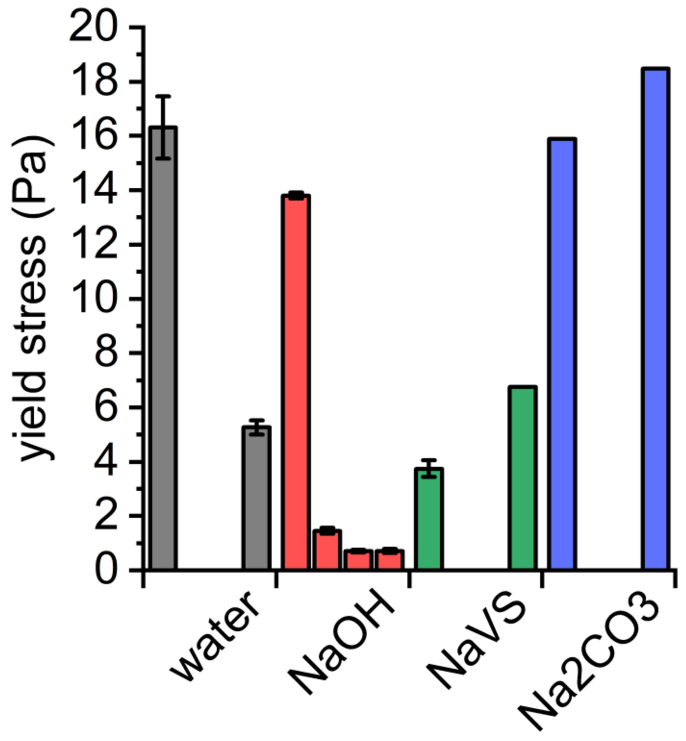
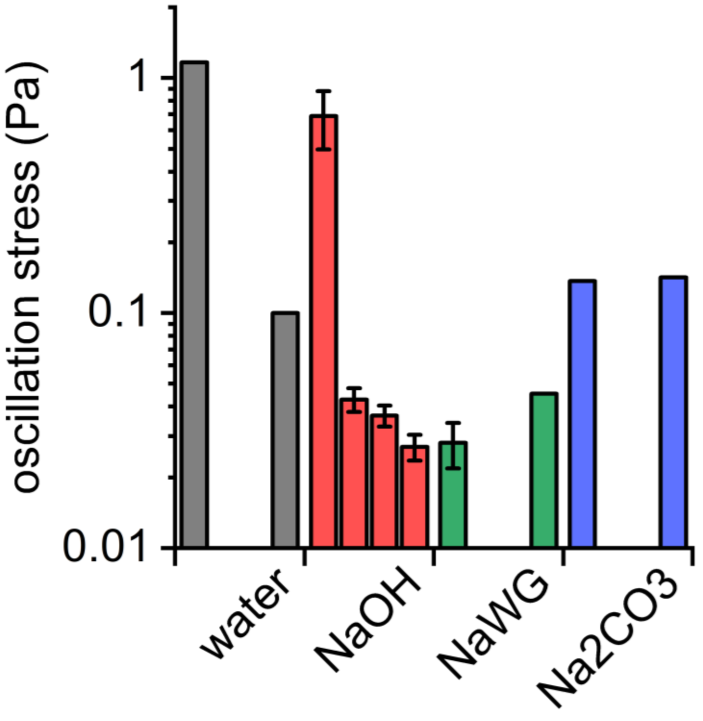
Effect of LS to rheology of GGBFS pastes

Yield stress from rotational measurements

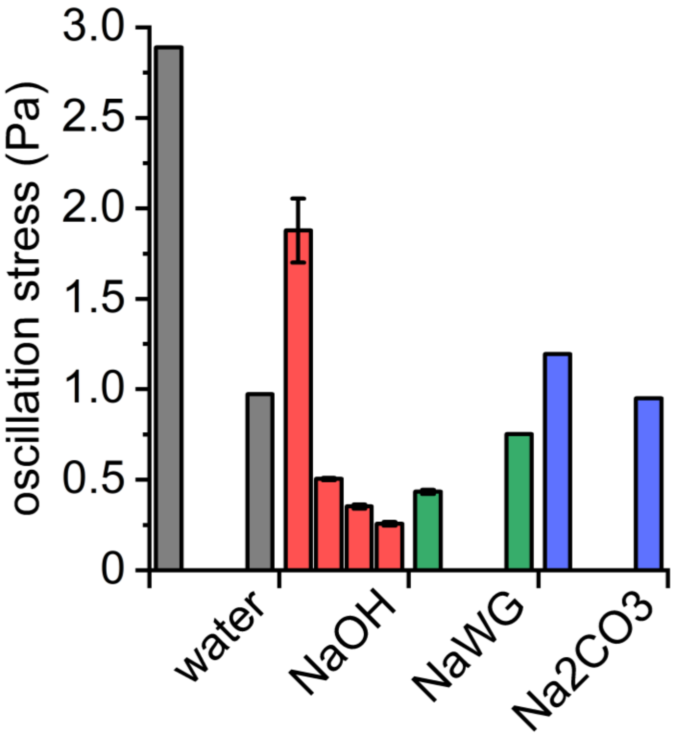


Oscillation measurements

Yield point



Flow point



0; 0,5; 1; 1,5 %
dose of LS

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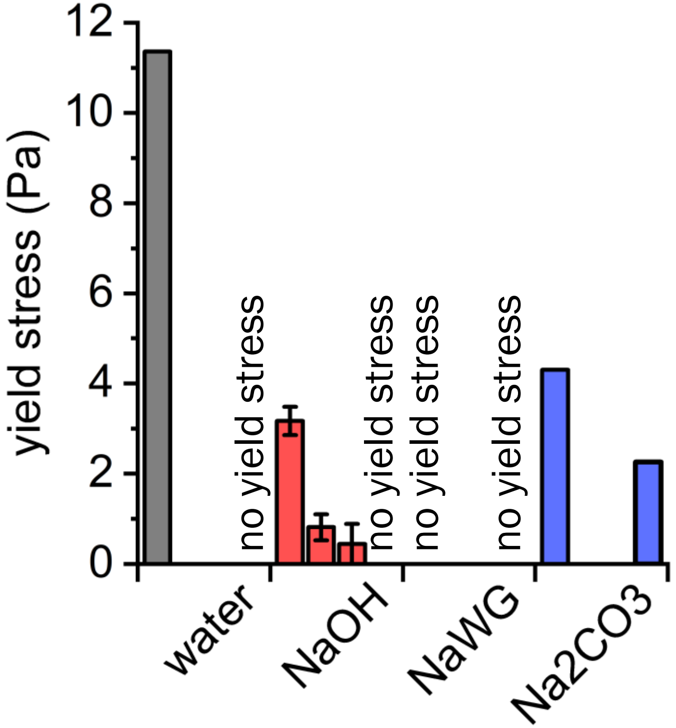
Effect of LS to rheology of Fly ash pastes

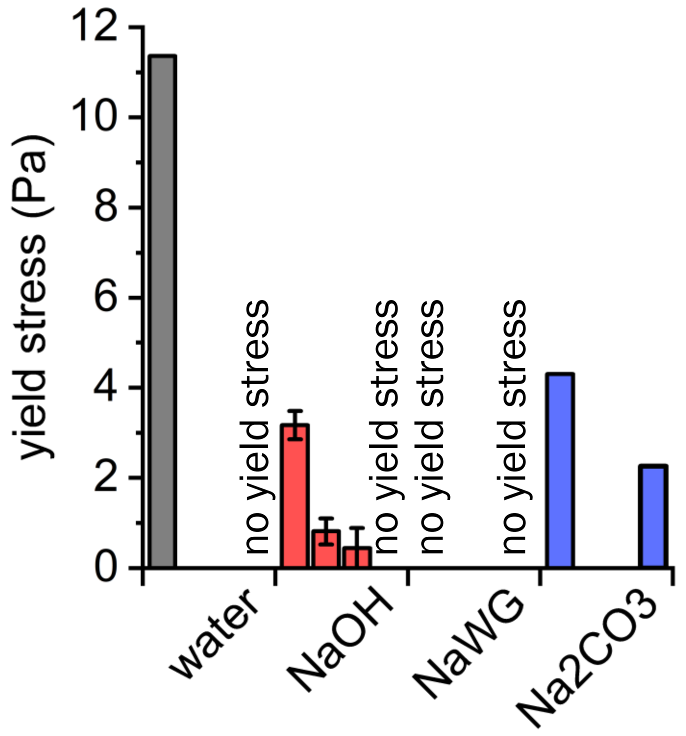
Yield stress from rotational measurements



0; 0,5; 1; 1,5 %
dose of LS

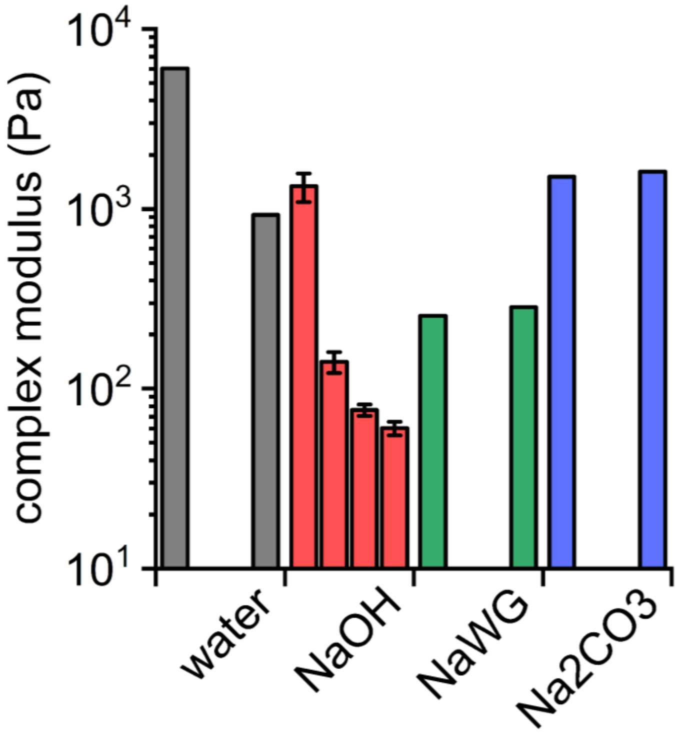
Effect of LS to rheology of Fly ash pastes

Yield stress from rotational measurements



Oscillation measurements

Yield point



0; 0,5; 1; 1,5 %
dose of LS

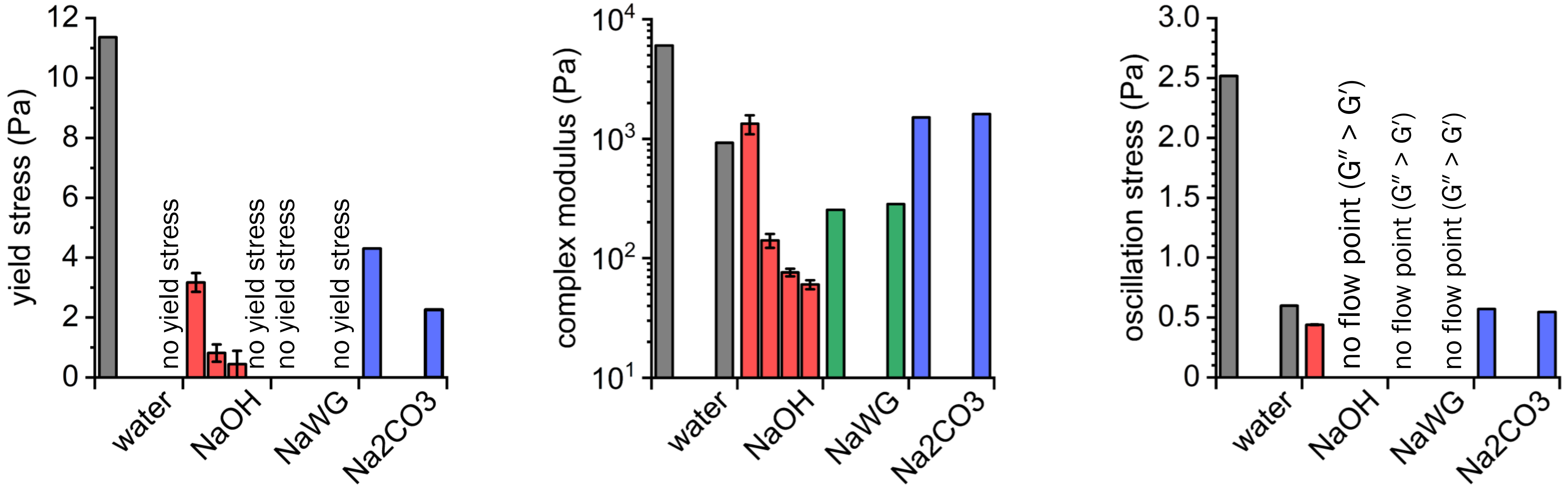
Effect of LS to rheology of Fly ash pastes

Yield stress from rotational measurements

Oscillation measurements

Yield point

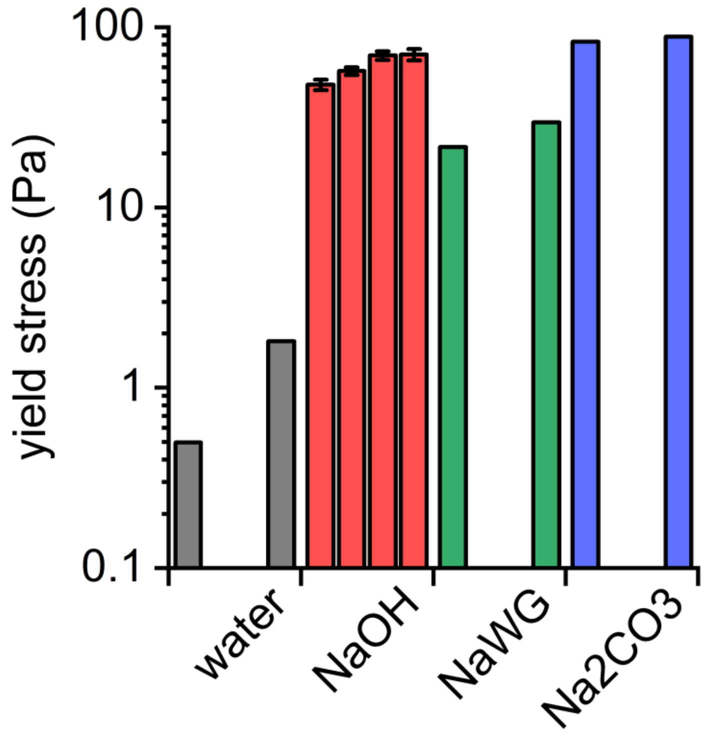
Flow point



0; 0,5; 1; 1,5 %
dose of LS

Effect of LS to rheology of Metakaolin pastes

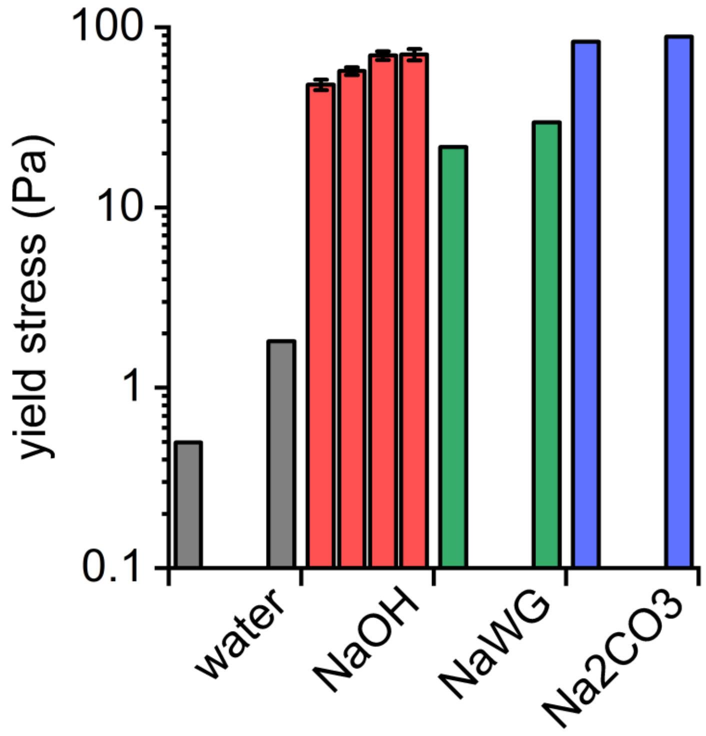
Yield stress from rotational measurements



0; 0,5; 1; 1,5 %
dose of LS

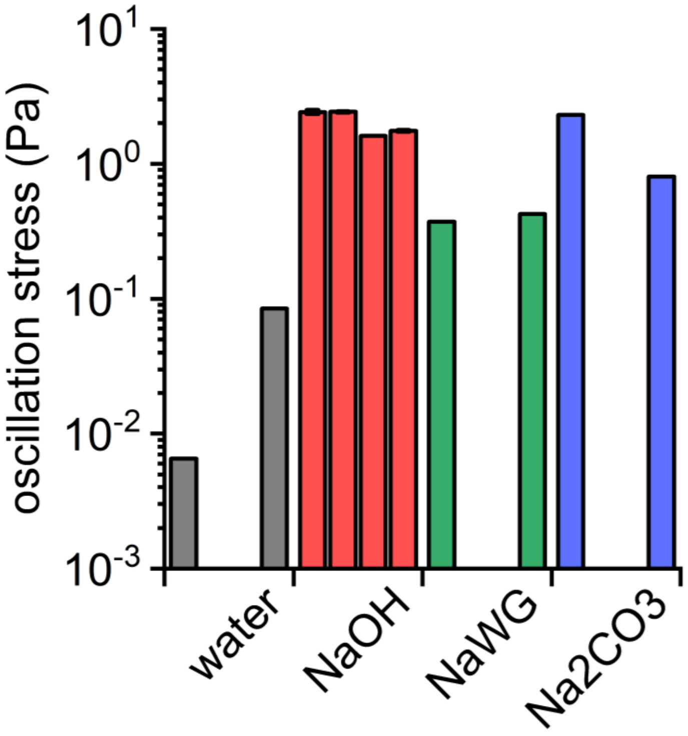
Effect of LS to rheology of Metakaolin pastes

Yield stress from rotational measurements



Oscillation measurements

Yield point



0; 0,5; 1; 1,5 %
dose of LS

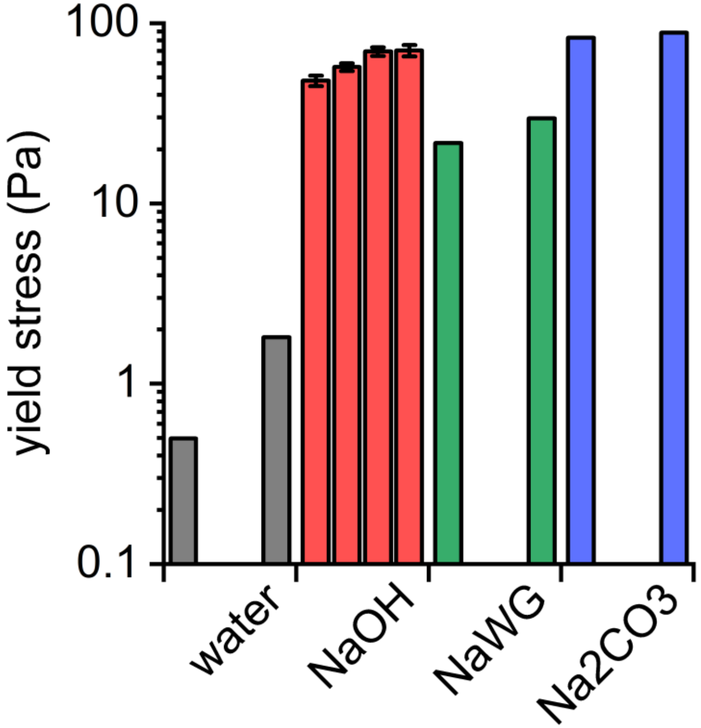
Effect of LS to rheology of Metakaolin pastes

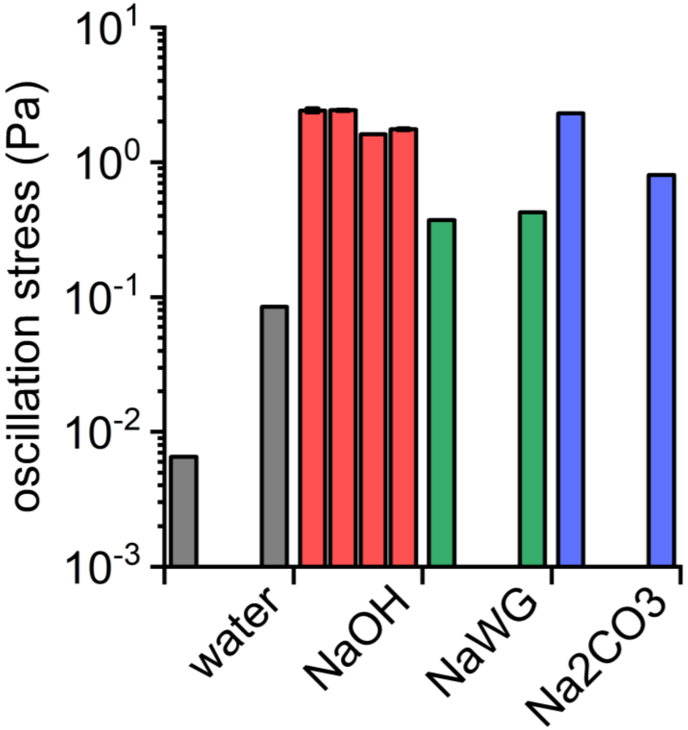
Yield stress from rotational measurements

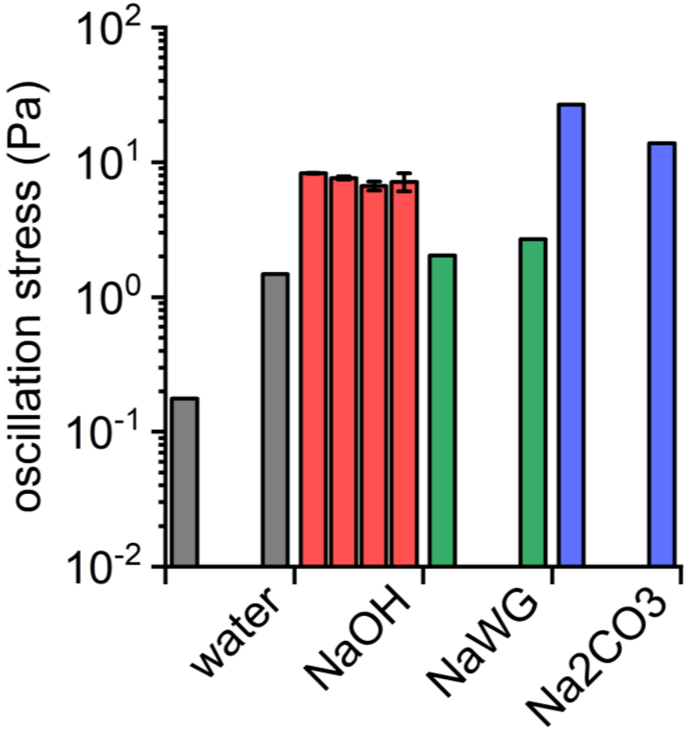
Oscillation measurements

Yield point

Flow point

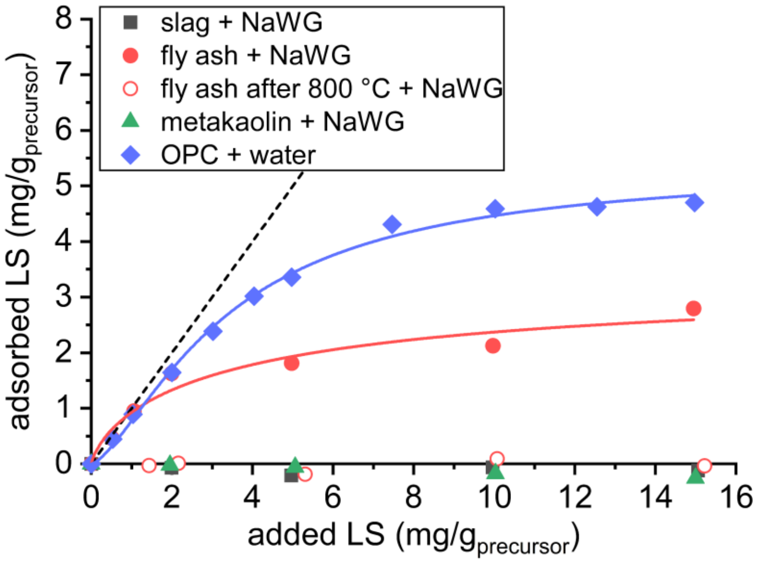


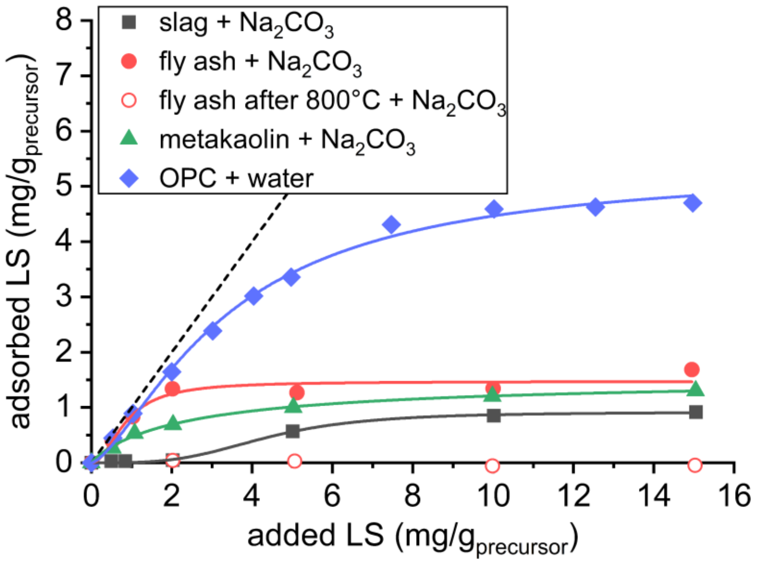




0; 0,5; 1; 1,5 %
dose of LS

Adsorption of LS on precursors





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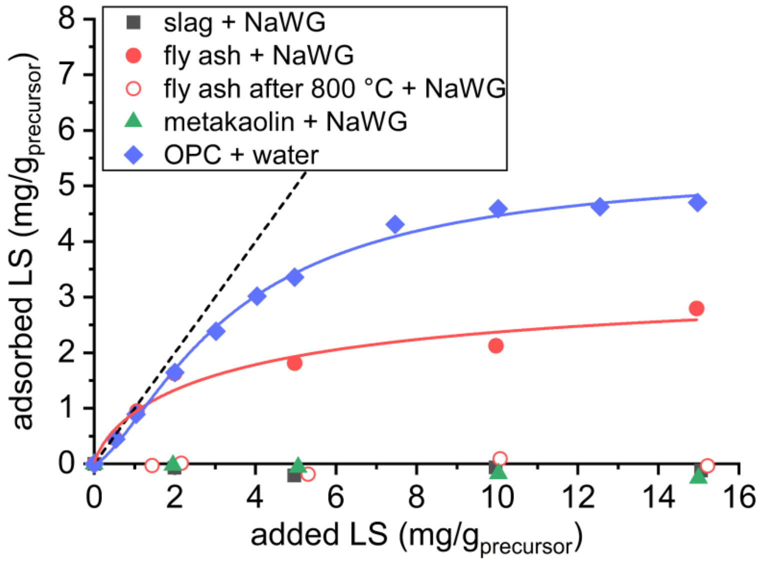
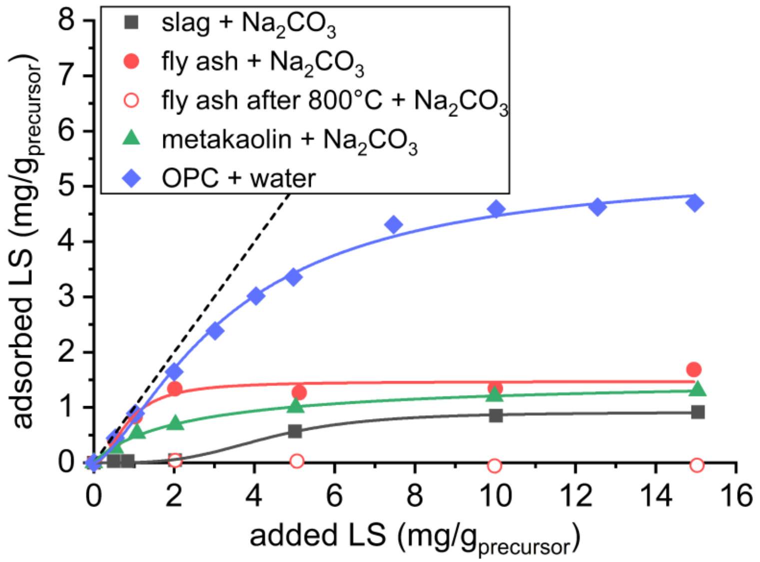
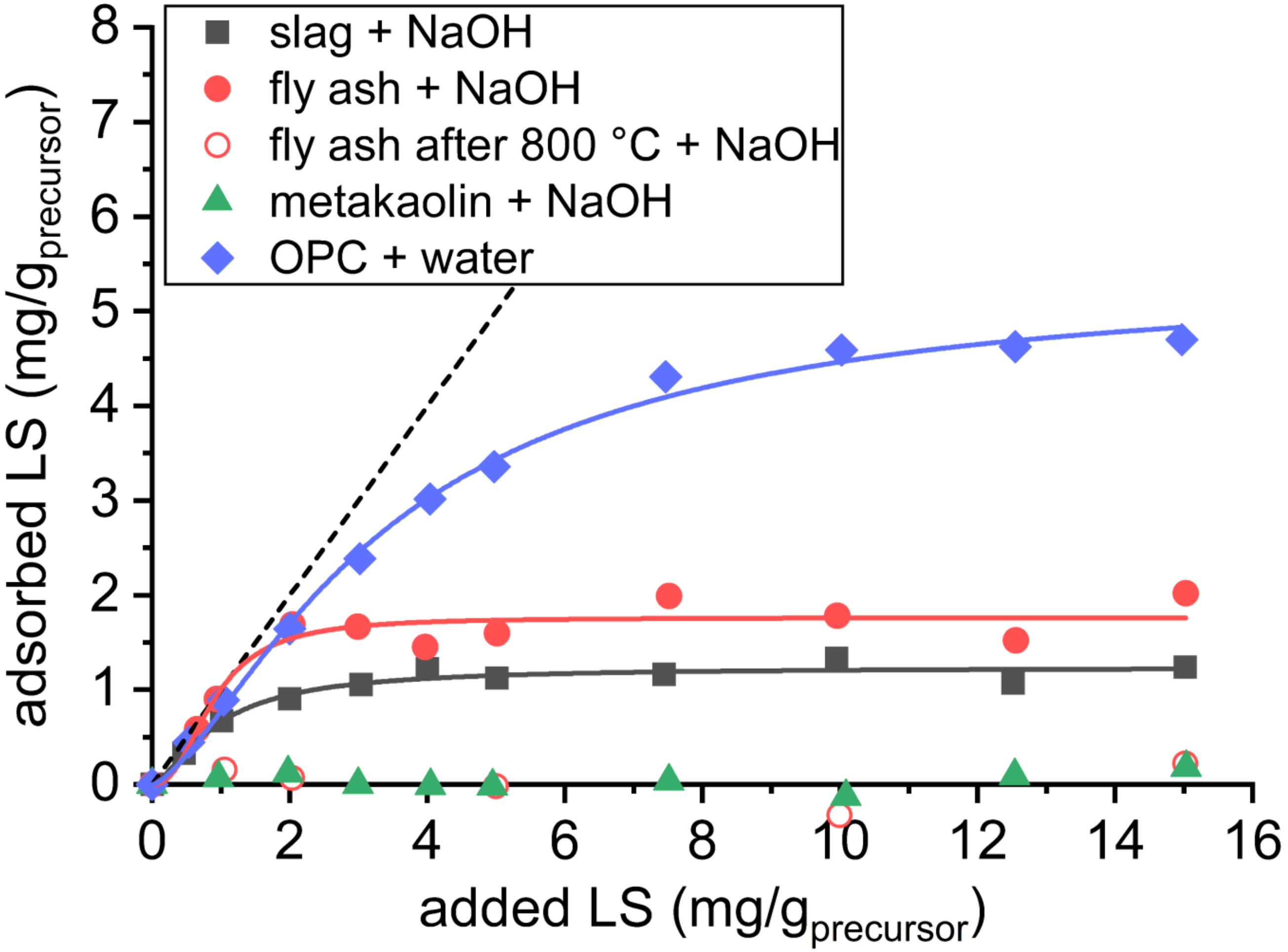




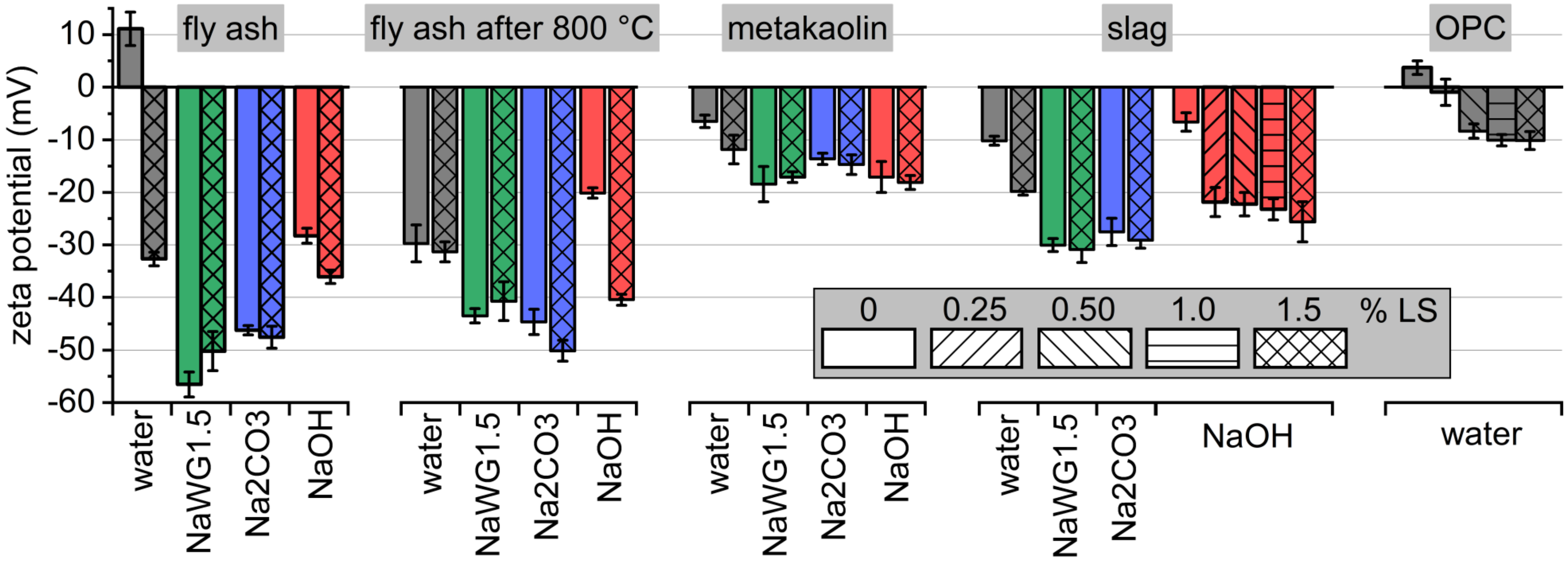


Issue of unburnt carbon in Fly ash

- Adsorption of LS on Fly ash due to unburnt carbon content
- Zero adsorption of LS on reburned Fly ash
- LS effective for both fly ashes with water and NaOH
- Possible explanation: weaker interactions between fly ash and plasticizer for detection, but strong enough for plasticizing effect

Determination of zeta potential

- Measured on 100× diluted pastes due to instrument limit
- The pastes were diluted 5 minutes after the start of mixing
- Considerable destabilization with adition of LS for suspension with fly ash or slag activated by NaOH
- Same trends for fly ash and reburned fly ash, indicating the same plasticizing effect



Conclusion

1) Workability of LS plasticizer for GGBFS and Fly ash upon activation 4M NaOH solution
2) Opening of other topics of influence of other organic admixtures on rheology of AAMs
3) An extension to the issue of common binders based on PC due to testing the functionality of the plasticizer with water as well

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Thanks for attention and Brno University of Technology for the opportunity to present at this amazing conference.