POTENTIALS OF POLYSACCHARIDES TO CONTROL THE RHEOLOGY OF CONCRETE
Wolfram Schmidt
Congratulations – 30 years of Conference Series “Rheology of Building Materials”

Thank you for 30 years of
– Interesting talks
– Exciting discussions
– Hosting the “rheology family”

https://www.150.bam.de
Polysaccharides
Role of polysaccharides in rheology

Past presentations on polysaccharides on this conference by the presenter:
- Influences of modification (2011)
- Casting robustness (2015)
- Sustainability (2017)
Polysaccharides
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- Sustainability (2017)
- Future casting technologies will require new admixture groups that can tailor the rheology at every process step.

https://tu-dresden.de/bu/bauingenieurwesen/ifb/forschung/spp2005
Polysaccharides
Role of polysaccharides in rheology

Superplasticizers can disperse particles and thus reduce the yield stress.

This alone cannot sufficiently create the rheological specifications required for more industrialised processing.

Polysaccharides can become an important group of novel agents in concrete technology.
Polysaccharides

What are polysaccharides?

- Polysaccharides are macromolecules consisting of monosaccharides (sugar)
- The most important ones occurring in nature are cellulose and starch, which consist of glucose only.

Starch

Cellulose
Polysaccharides

What are polysaccharides?

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- The most important ones occurring in nature are cellulose and starch, which consist of glucose only.

- Often polysaccharides are branched.

Starch

Amylose (linear, small)

Amylopectin (branched, huge)
Polysaccharides
What are polysaccharides?

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- The most important ones occurring in nature are cellulose and starch, which consist of glucose only.

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- More complex polysaccharides used in construction are e.g. diutan gum and guar gum.
Starch
Starch
Effect in liquid phase

\[ w = 100\% \text{ by volume} \]

- Yield stress
- Plastic viscosity

Starch
Diutan gum
Starch
Peculiarity of starch

No particles

In presence of particles

In presence of PCE
Starch

Yield stress and particle interactions

– With increasing particle volume fraction, the effect of starch becomes stronger.

– At very low w/p it is stronger than diutan gum.
Starch
Influencing factors

- Application (liquid/solid)
- Ratio of amylose and amylopectin
- Size and/or Mw of amylopectin
- Mode of modification
- Degree of substitution
- Presence of other polymers, e.g. PCE
- Adsorption
- Time / cement hydration
**Starch**

Role of polysaccharides in rheology

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**Potentials of polysaccharides to control the rheology of concrete**

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10.03.2021 Rheology of Building Materials | Online Colloquium | 30 Years | virtual Regensburg

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Starch
Role of polysaccharides in rheology

Cassava starch
→ Negative zeta potential with Ca\(^ {2+} \)
→ \( R_{\text{hyd}} \sim 100 \text{ nm} \)
Starch
Role of polysaccharides in rheology

https://youtu.be/4H0R75Zyv0?list=PLKqa3Uo_GQNsmogyrcCYusuYtbJWOcT3
Potentials:

• inexhaustible global availability
• great variability
• low cost

https://youtu.be/4H-0R7Zyv0?list=PLKqa3Uo_GQNs0mogyrCCYusuYtbJWOcT3
Acacia gum
Acacia gum
Typical uses and properties

- Easily water soluble gum
- Grows in the tropical and subtropical regions of Africa, India, and the Americas
- Typical use in food industry and cosmetics
- ¾ of the global consumption is produced in Sudan
Acacia gum
Effect in cementitious materials

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Polymer content [% by mass of powder]
Torque [Nmm]

Stabilising effect
Plasticizing effect

- PCE (pre-cast)
- PCE (ready mixed)
- Acacia gum (Sudan)
- Acacia gum (South Africa)
- Lignosulfonate
Acacia gum
Performance specifications

Workability depends on:

- Dosage of gum
- Mixing intensity
- Mixing duration
- Particle volume fraction
  - No plasticizing effect at very low w/c
  - Plasticizing effect at moderate w/c
Acacia gum

Performance specifications

- Negative zeta potential
- Water-solubility

Potentials:
- not yet commercialised in many regions in the world
- occurs in regions with restricted access to admixtures
- no complex processing required
Triumfetta pendrata A. Rich
Triumfetta pendrata A. Rich

What is it?

Par Tatoute — Travail personnel, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19808793

0.08% Nkui
Triumfetta pendrata A. Rich

Thixotropy

Similar flowability after 15 x lifting and dropping

Significant flow reduction only under gravity load

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Triumfetta pendrata A. Rich

Thixotropy

Shear rate [1/s]

Shear stress [Pa]

Time [min]
Triumfetta pendrata A. Rich
Thixotropy

\[ \text{Triumfetta pendrata A. Rich} \]
\[ \rightarrow \text{Negative zeta potential} \]
\[ \rightarrow \text{With Ca}^{2+} \text{agglomerates up to 5 µm} \]

**Potentials:**
- Rapid structural build-up without need to accelerate the cement hydration
Summary and outlook
Summary and outlook

Biopolymers vs. synthetic polymers

Polysaccharides have enormous potentials as rheology modifiers

- Starch
- Acacia gum
- Bark gum of Triumfetta

The approach is different from synthetic polymers, which can be tailored to the application:
1. First understanding of basic mode of operations
2. Identify ideal use
Summary and outlook

New sources need to be identified

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<th>Ref</th>
<th>Animal based</th>
<th>Bio-waste based</th>
<th>Plant based</th>
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<td>Stat. yield stress</td>
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<td>dyn. yield stress</td>
<td>1.6</td>
<td>1.4</td>
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</tbody>
</table>

Relative flow gain/loss [-]
Summary and outlook
Sustainability potentials

GLOBE Global Consensus on Sustainability in the Built Environment
Circularity – environment - socio-economic equity

http://globe.rilem.net
Thank you for your attention.

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