A New Class of Methylcelluloses for Ceramic Extrusion at Elevated Temperatures which provides higher Shape Retention

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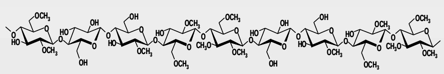
1 Introduction

Main plasticizing agents for the extrusion of ceramics:

- **Methylcellulose (MC)**
- Hydroxypropylmethyl cellulose (HPMC)
- Hydroxyethylmethyl cellulose (HEMC)

Main properties of Methylcellulose (MC):

- Viscosity
- Degree of Substitution (DS)
- Reversible Thermal Gelation
- Water retention
- Film formation
- Stickiness, lubrication, plasticization
- Rheology



2 Reversible Thermal Gelation

MC

MC forms strong gels at high temperature

HPMC
HEMC

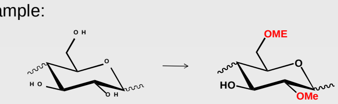
HPMC/HEMC forms a weak gel structure at high temperature

3 Degree of Substitution (DS) of MC

Average "Degree of Substitution" (DS):

- Indicates how many hydroxyl groups of an anhydroglucose unit are etherified on average
- DS-values: theoretically 0-3 , in reality 1.3-2.2

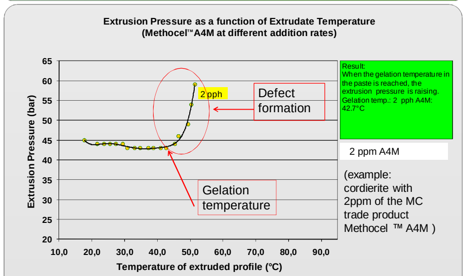
Example:



DS (Me) = 2

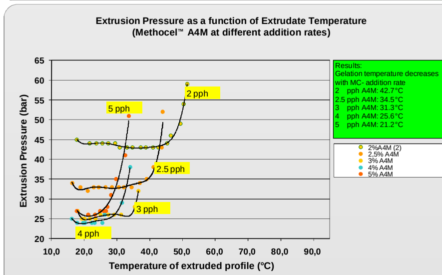
- DS (Me) of commercially available MC: 1.64- 1.92
- **DS (Me) of this newly developed MC: 1.4-1.5**

4 Problem Description I



Extrusion of a ceramic paste above the gelation temperature leads to defect formation

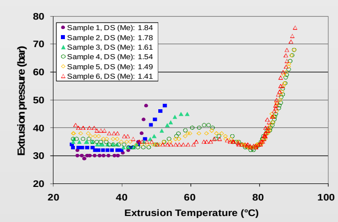
5 Problem Description II



Increasing MC-addition rates lead to lower gelation temperatures: e.g. at 5 pph: gelation at room temperature → better cooling required

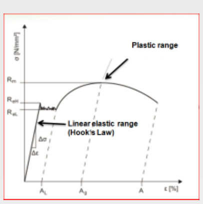
- Limited cooling capacity requires speed reduction
- More intensive cooling requires more energy (on industrial scale often electrical water cooling)

6 Solution: MC´s with a reduced DS (Me)



- The gelation temperature increases with decreasing DS (Me)
- A DS (Me) of 1.54 and lower leads to larger „temperature windows" for extrusion

7 Evaluation of the Wet Green Performance



Extruded pastes behave mainly plastic, however, in a certain range of deformation they behave linear-elastic. → Hooks law is valid. Typical stress-strain curve of a deforming solid allows evaluation of:

- Wet green (bending) modulus (Youngs modulus)
- Wet green (bending) strength
- Wet green elongation at break

8 Results of Wet Green Testing

DS (Me)	Modulus (MPas)	Elongation at Break	Comment
1.78	1.20	0.245	Trade product
1.49	1.44	0.291	Development
1.41	1.62	0.245	Development

- The lower the DS (Me), the higher the modulus
- The lower the DS (Me), the lower the wet green elongation at break
- No visible effect of the DS (Me) on the wet green strength

9 Final Conclusions

Current MC-trade products used as plasticizer in the extrusion of ceramics do have limitations:

A low gelation temperature that can lead to defect formation during extrusion

To overcome this difficulties the DS (Me) of the MC was reduced leading to

- a gelation temperature up to 40°C higher
- the option to extrude at significant higher temperatures
- the option to extrude at significant higher speeds
- a ceramic paste having a higher wet green modulus → higher shape retention of the profile
- a minor elongation at break

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