



Building Leadership Excellence



# The Effects of Certain Polymers on Tensile Strength and Tension Relaxation of Wet Web

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**RETHINK PAPER:**  
**Lean and Green**

A scanning electron micrograph (SEM) showing a complex, fibrous, and textured surface, likely a material interface or biological structure. The image is in grayscale and has a grainy, high-magnification appearance. At the top, there is a faint header with technical details: "Interface advancement x 500" and "50.0um".

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# Background (1/3): Wet web strength studies

- **Lyne & Gallay 1954:** The strength of wet web (up to a dryness level of 25%) originates from surface tension forces and friction between fibers. Above this level of dryness, inter-fiber bonding starts to play an essential role
- **Gierz & Roedland 1979:** There is bound water on fiber surfaces. When two fibers with high amount of bound water get close to each other, a high adhesion between these fibers is formed
- **Pelton 1993 & 2000 / Hubbe 2006 / Myllytie 2009:** Wet fiber surface can be considered as a gel-like layer of hydrated cellulose microfibrils and polymers. The mixing and orientation of the polymers in the bonding domain affect the strength of dry and wet web
- **Tajedo & van de Ven 2008 & 2009:** Entanglement friction between fibers plays a major role in wet web strength (at dryness 30-55%), whereas surface tension forces have more or less no effect at a given dryness level

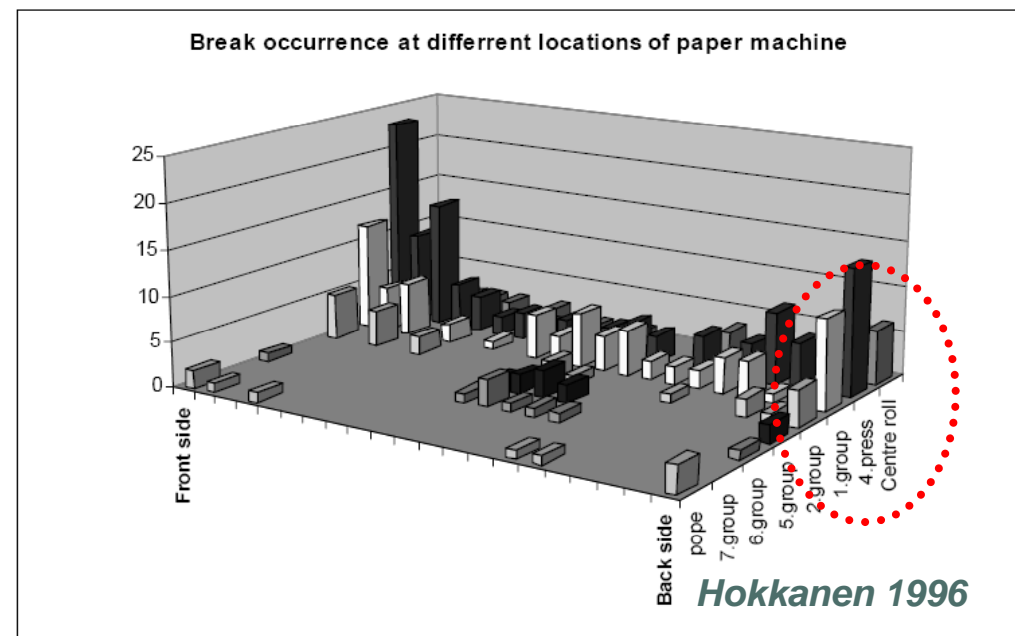
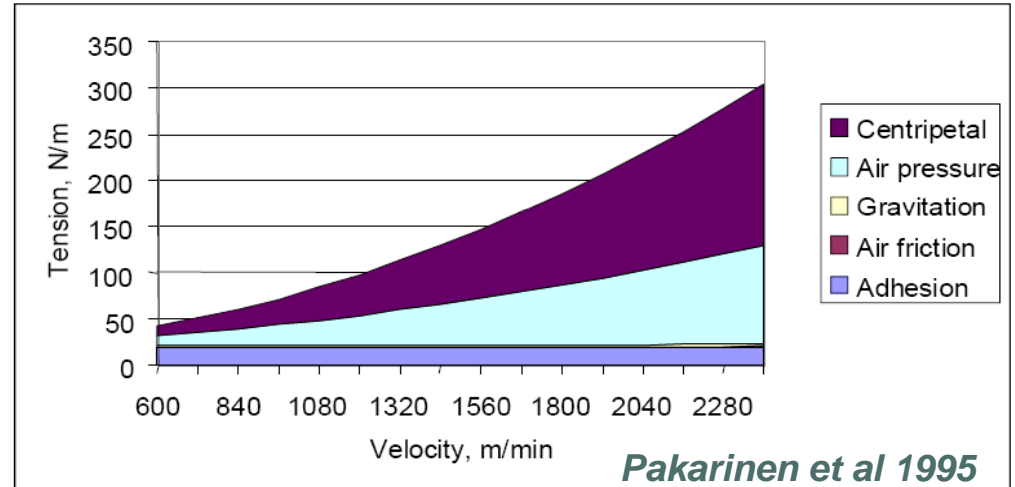


# Background (2/3): Wet web properties and paper machine runnability

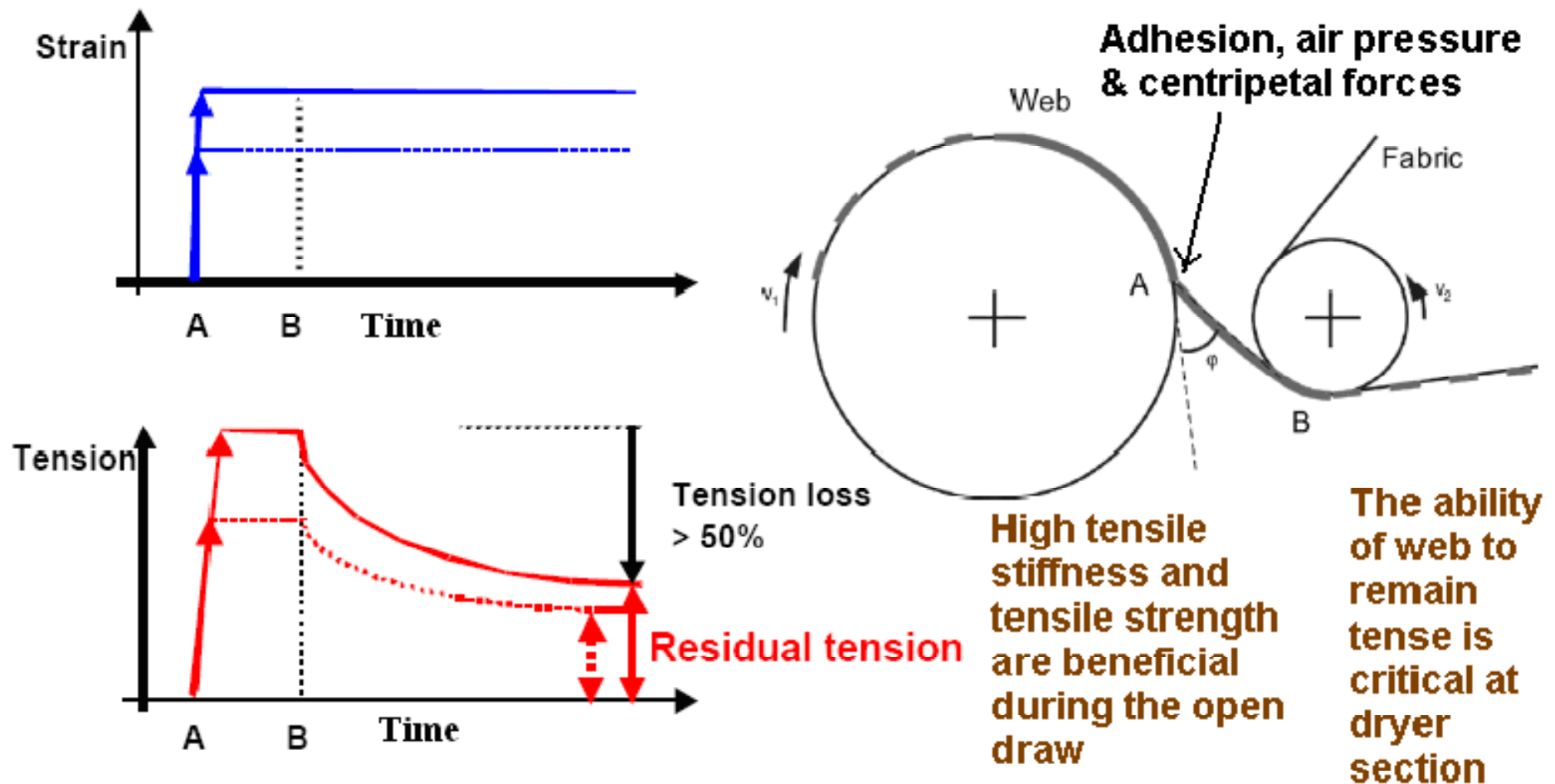
- Paper machines have reached their practical maximum width (~11 m). ➡ To increase production, higher speed and less downtime is required

- Increase of production speed is often limited by mechanical properties of wet web

- The fact remains that paper mills do not typically add chemicals to improve mechanical properties of wet web



# Background (3/3): What should we measure from wet web?



Modified from Kurki et al 2004 & Kurki et al 2000



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# Objective of this study...

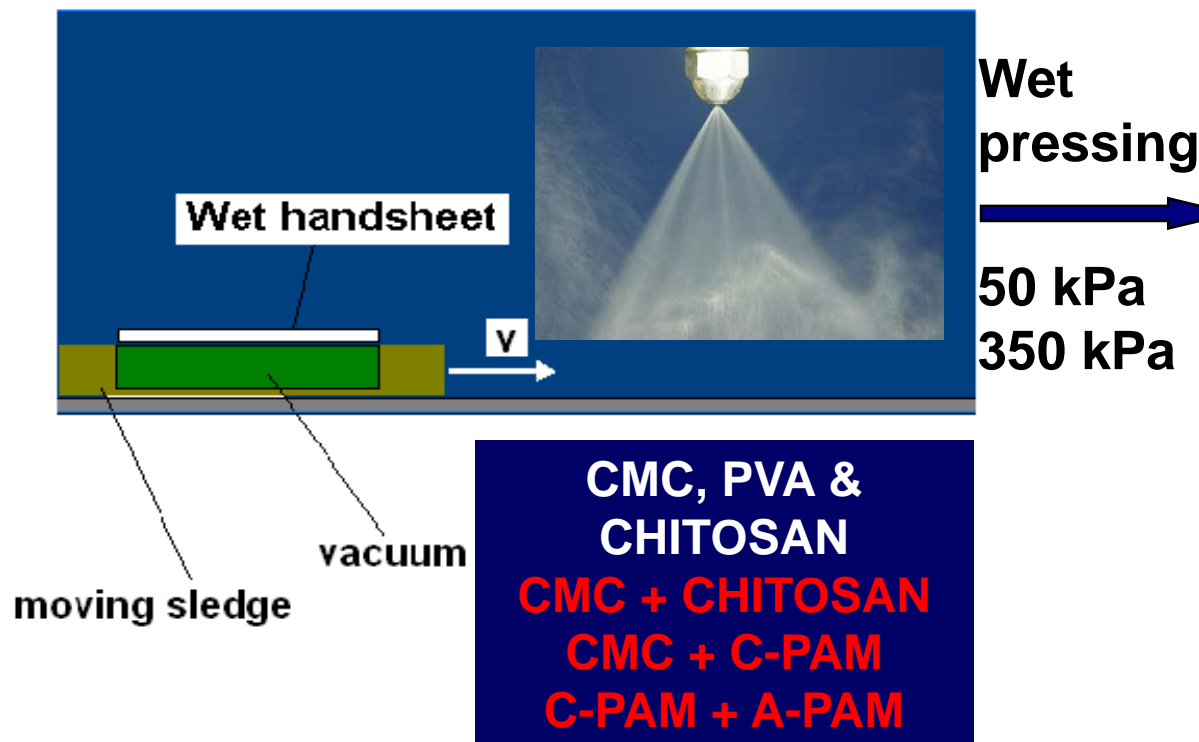
**...was to clarify the effects of some commercially available polymers or combinations of polymers on tensile and relaxation characteristics of wet web**



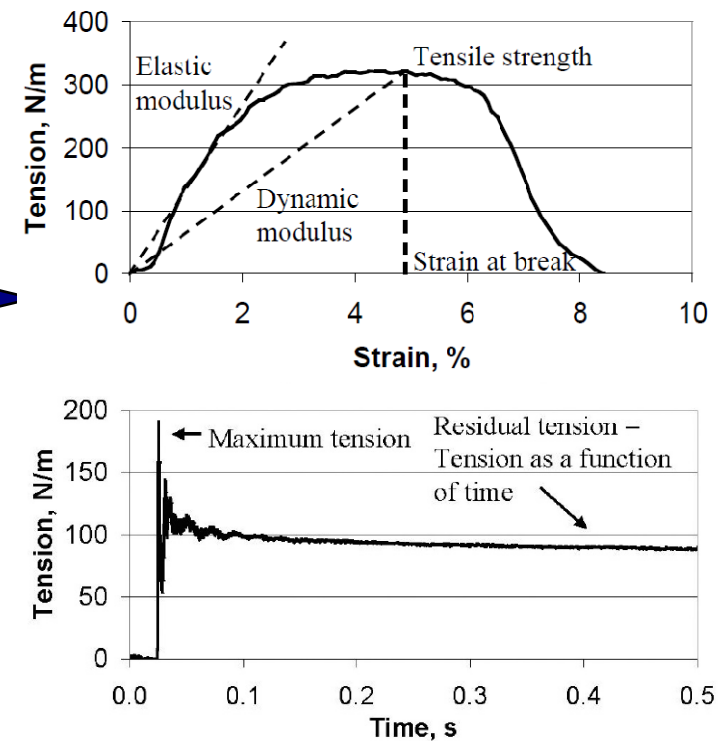
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# Methods (1/2): Spraying tests

## Preparation of samples

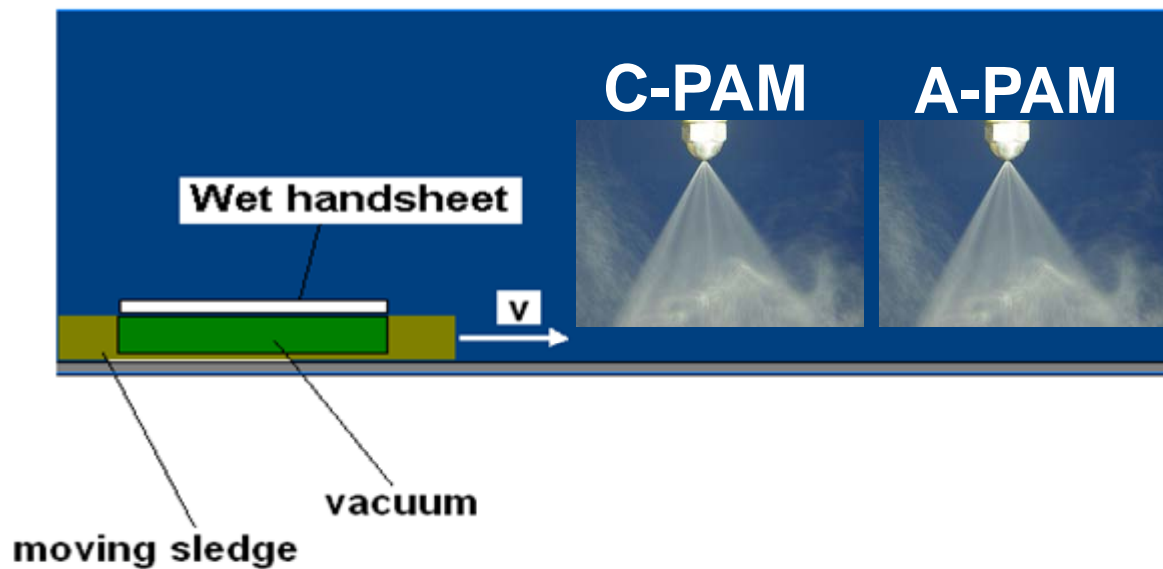


## Measurements

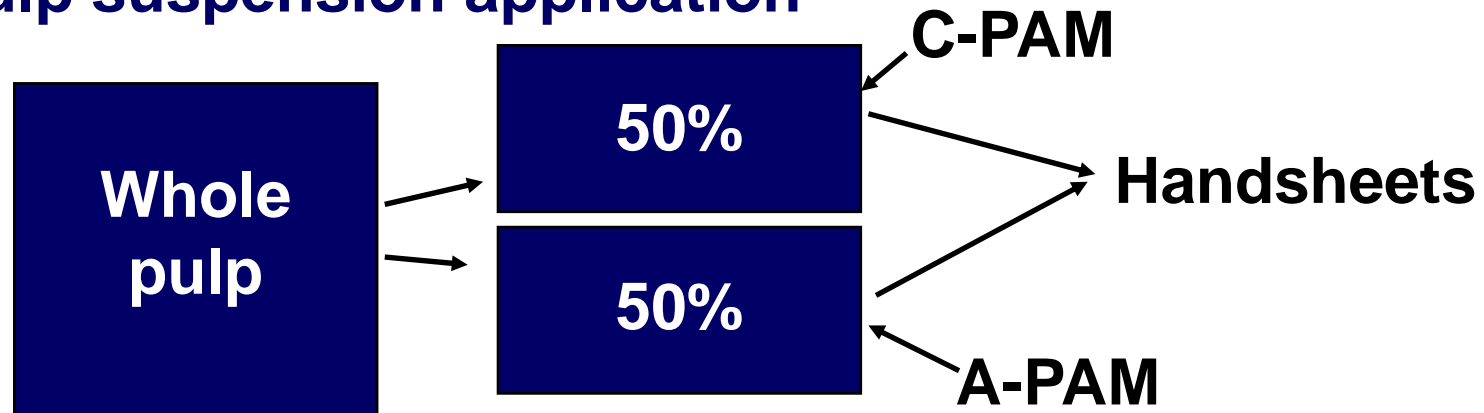


# Methods (2/2): Mode of addition tests

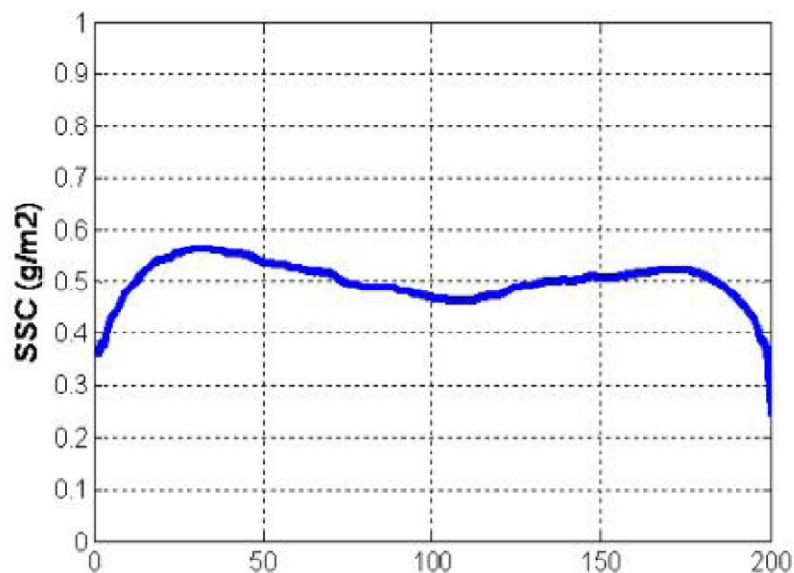
## Spray application



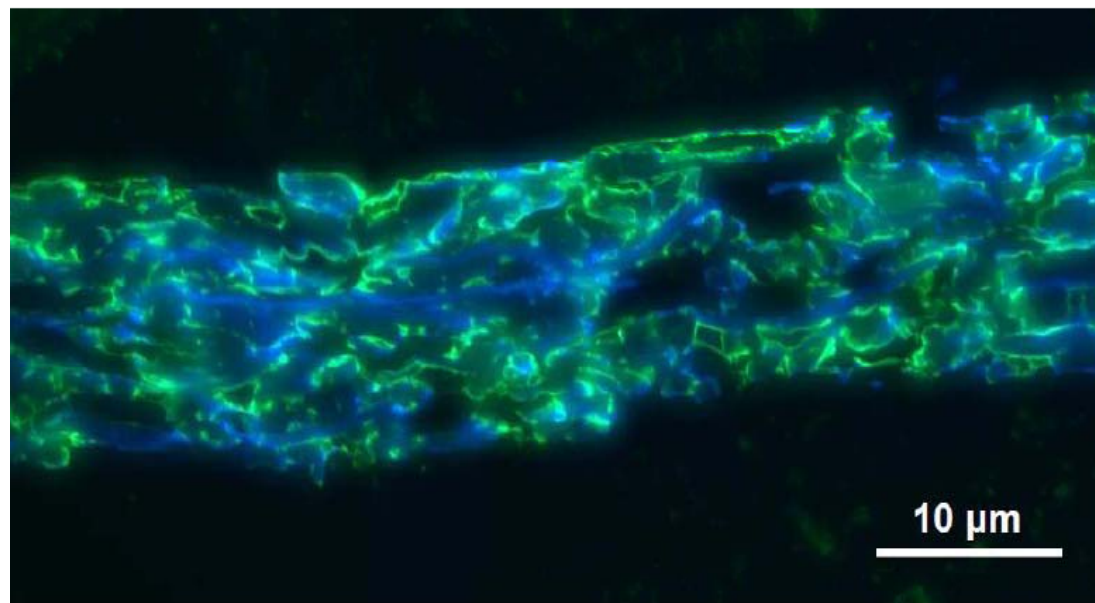
## Pulp suspension application



# Why to add polymers by spraying?



Relative depth from top surface



Immunolabelling (Paul Knox,  
Univ. of Leeds)

- ✓ Higher retention of polymers (with no cationic charge)
- ✓ No effect on formation
- ✓ To avoid adsorption of polymers mainly to fines fraction



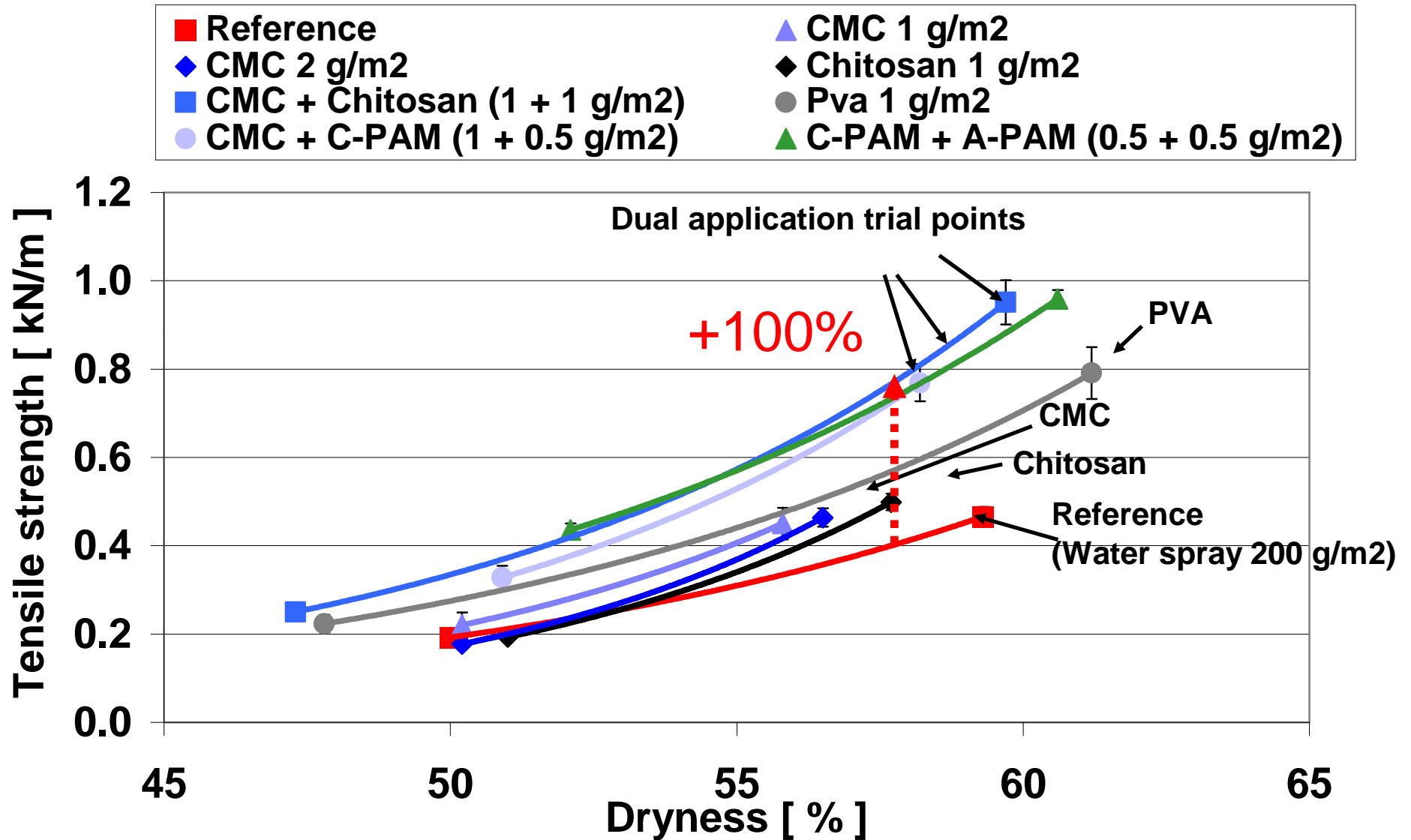
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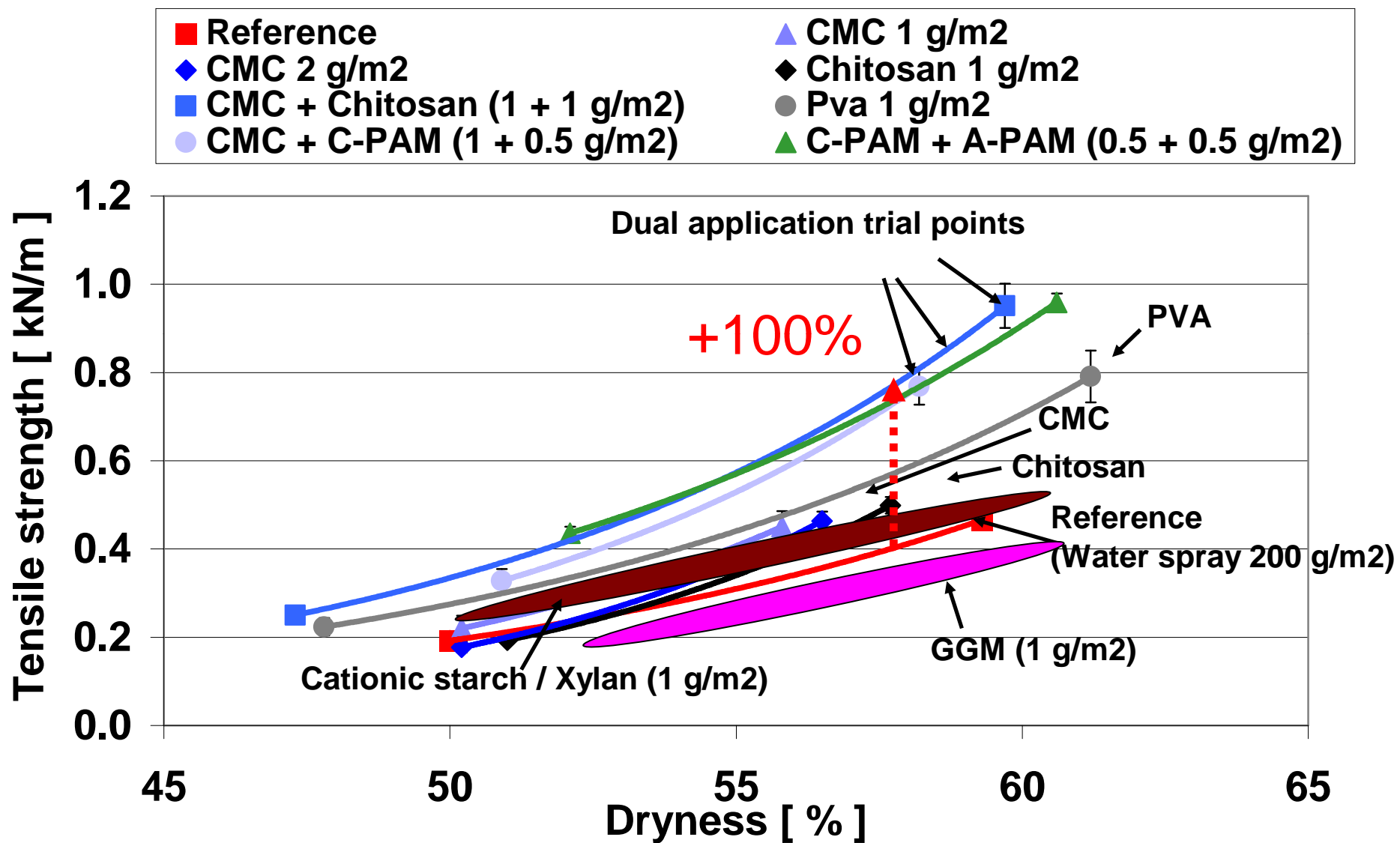
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# Results: Spraying tests

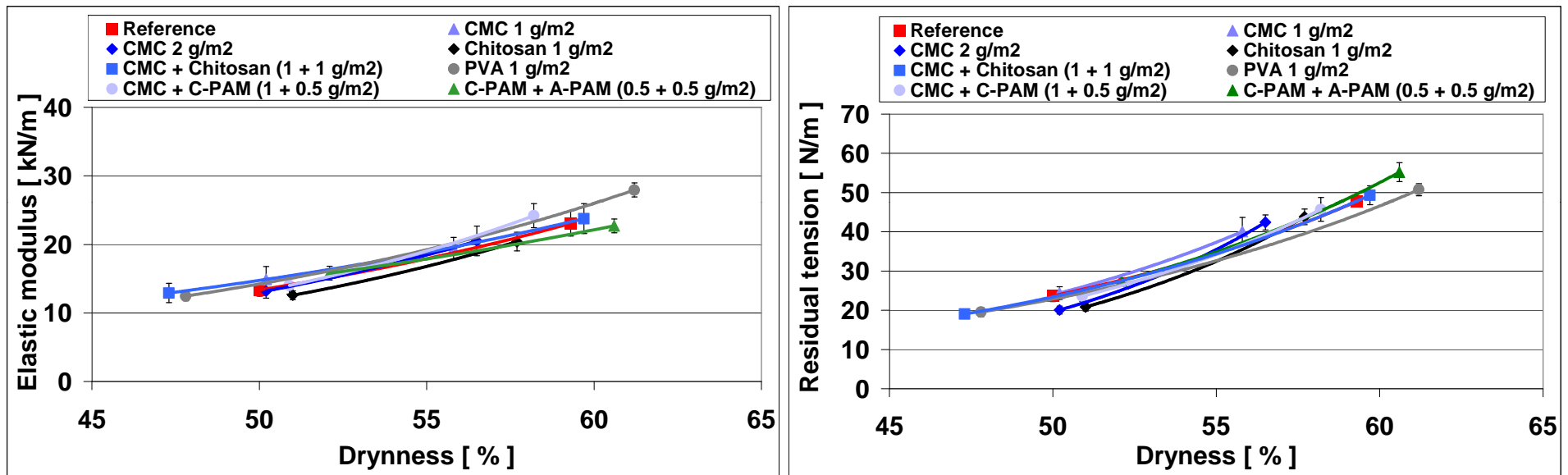


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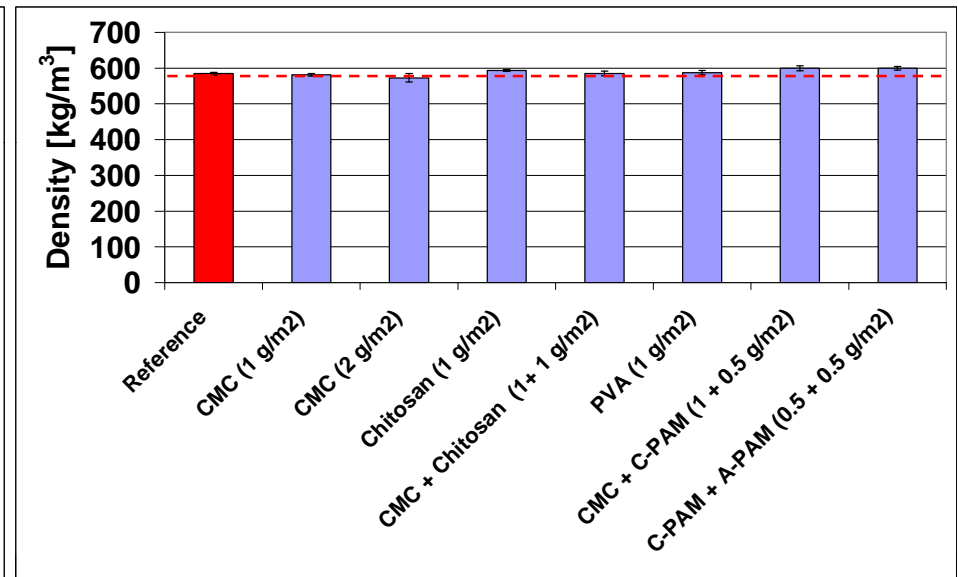
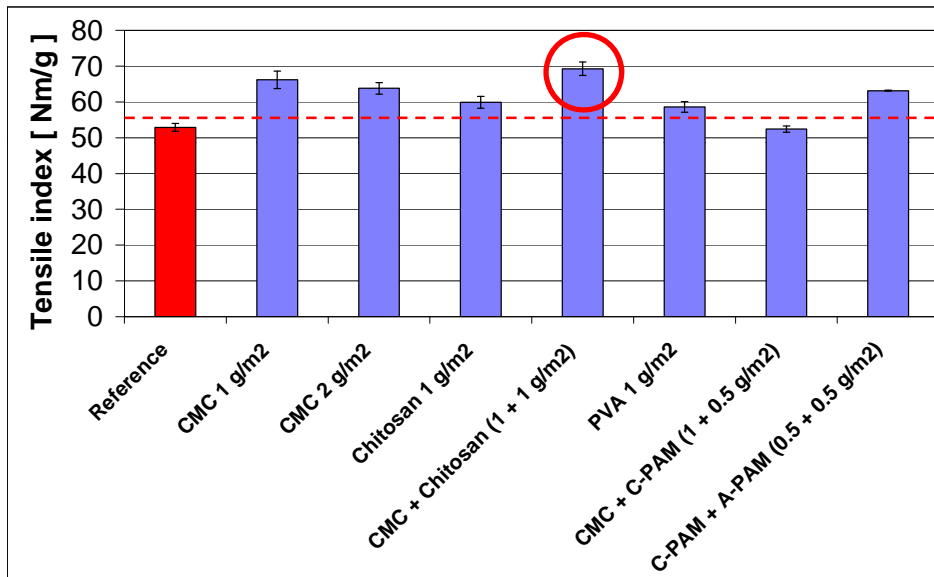
Adding different polymers had no clear effect on elastic modulus (tensile stiffness) and residual tension (the tension remaining after 0.475 s of relaxation) of wet web



➡ It seems likely that different polymers increased strength of fiber-fiber contacts, but had only minor if any effect on the readiness of fiber segments to carry load

Adding different polymers by spraying increased dry paper tensile index, but had no effect on density.

➡ Bond strength increases



Biggest increase in dry paper tensile strength was obtained with sequential addition of CMC and chitosan



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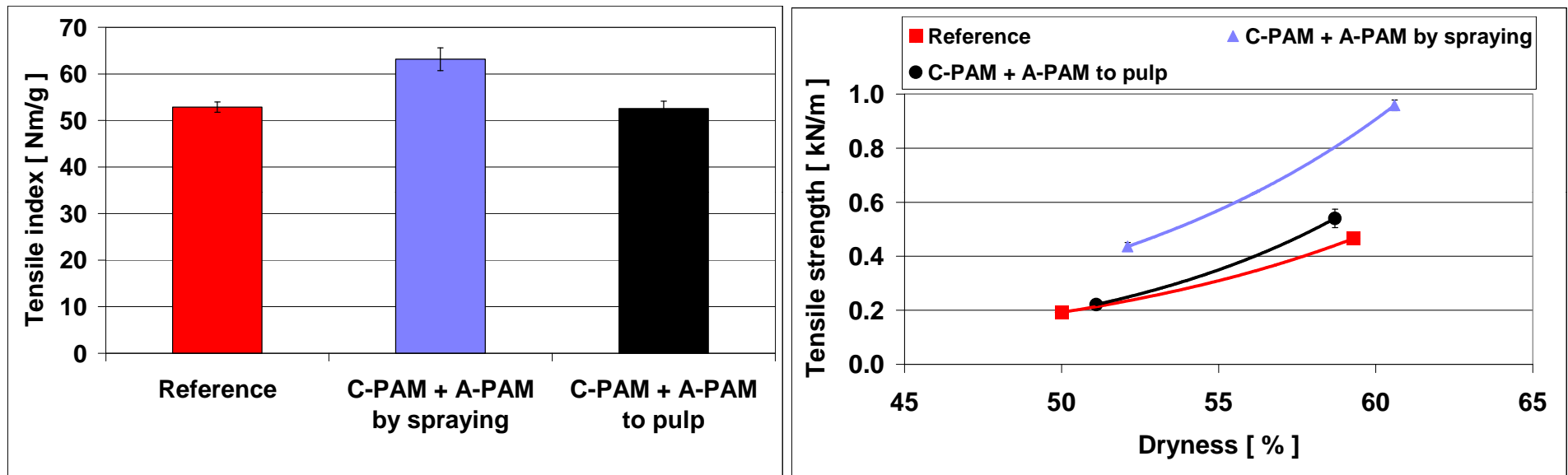
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# Results: Mode of addition tests



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**Sequential addition of oppositely charged polymers improved dry and wet web strength, while adding of the same polymers on separately to different part of pulp suspensions (50/50) only minor effects were seen**



**➡ Adding polymers to pulp suspension resulted as lower adsorption of polymers and impaired formation of the sheets (compared to spray application trial point)**



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# Summary / Conclusions

- Spraying of polymers seems to be an interesting possibility to improve dry and wet web strength
- It could enable higher retention of different polymers and thus reduce the cost of polymers on paper mill or it could make possible the usage of polymers having no cationic charge
- The effect of polymers on strength of dry and wet web was characteristic for each polymer
- Polymers improved the strength of the wet web significantly more (relatively) than dry paper
- Highest increase in wet web strength was obtained with sequential spray addition of oppositely charged polymers and with a hydrophilic polymer having high molar mass
- Spraying of anionic polymers to the outermost layer of paper might also reduce adhesion problems at (anionic) center roll
- It seems also likely that electrostatic interactions play an essential role in wet web strength



# Questions?



# Thank you for your attention!!!

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