TAPPICON

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# Amphoteric Dry Strength Chemistry Approach to Deal with Low-Quality Fiber and Difficult Wet-end Chemistry Conditions in the Asian and North American Markets

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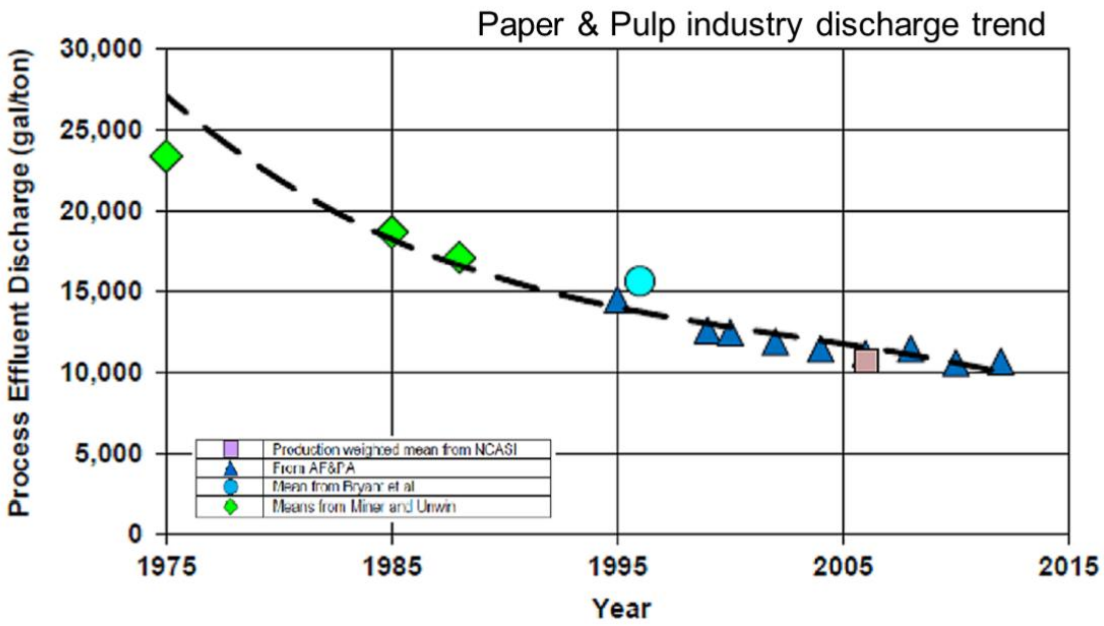
# Overview

1. Industry trends
2. Differences between Cationic and Amphoteric papermaking strength additives
3. Short description of AmPAM
4. Lab examples of performance
5. Mill cases
6. Synergy between GPAM and AmPAM application

# Papermaking condition




Water Quality

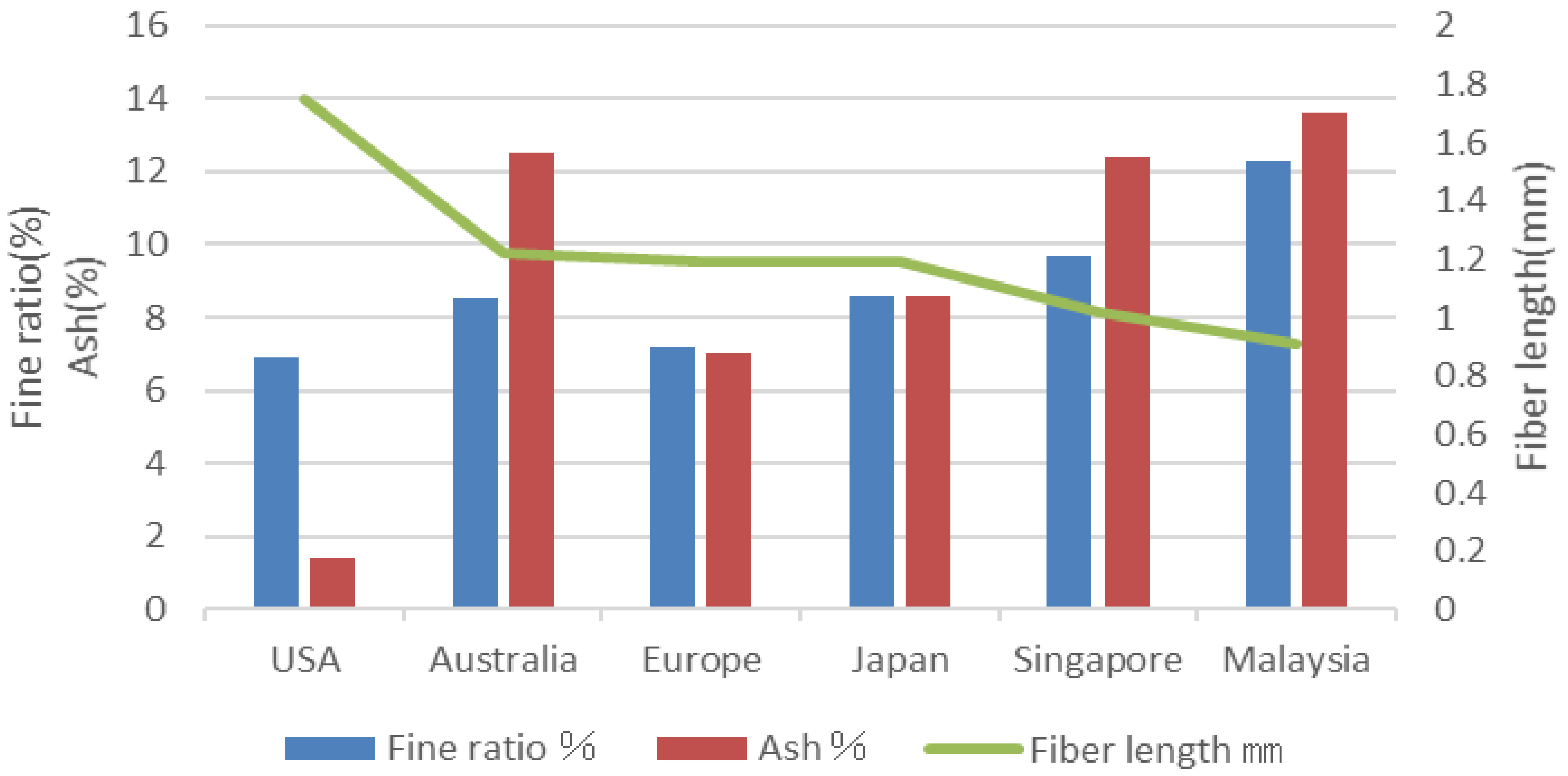
Fiber Quality

OCC

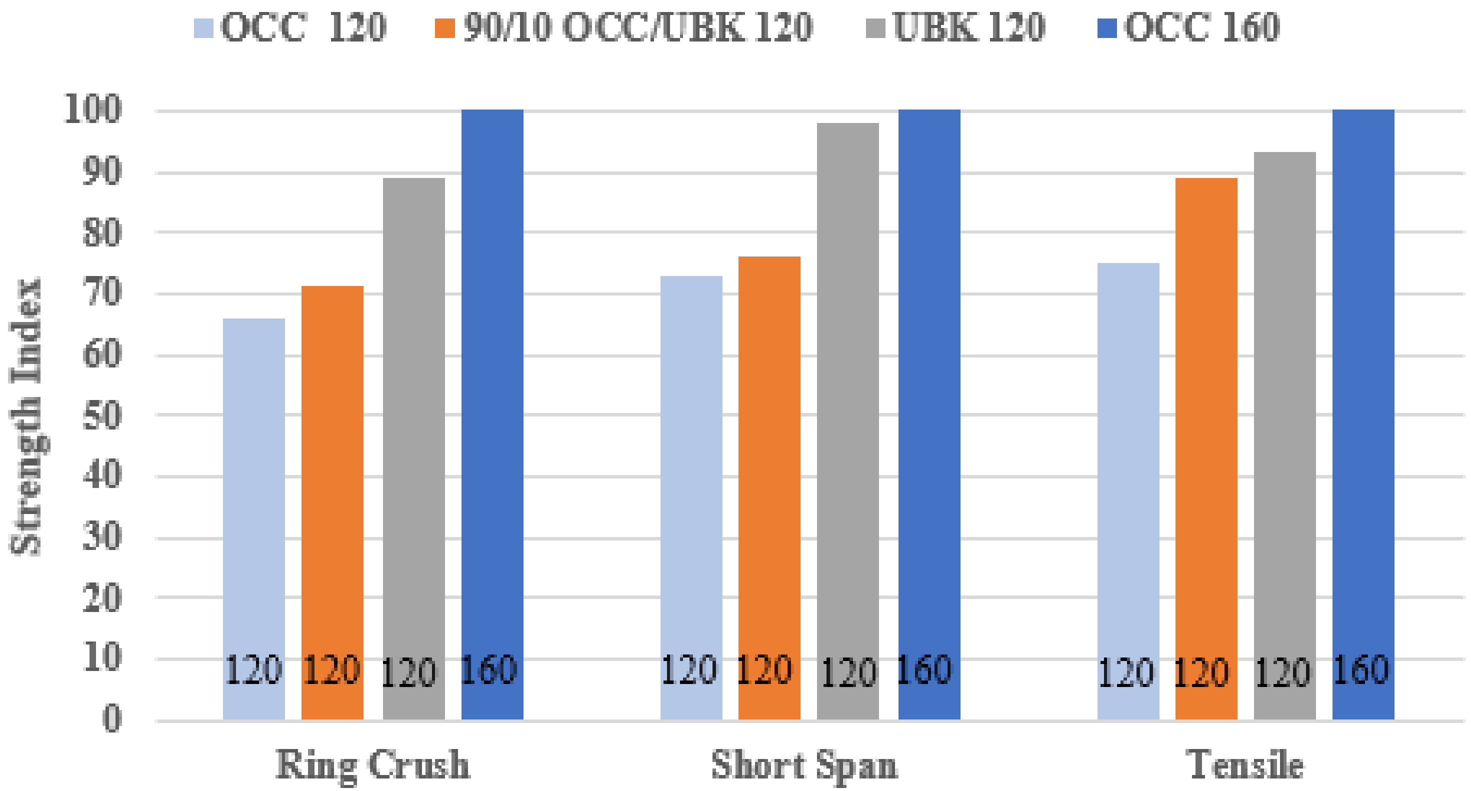
Mixed Waste

OCC

# OCC quality based on 2018 data.



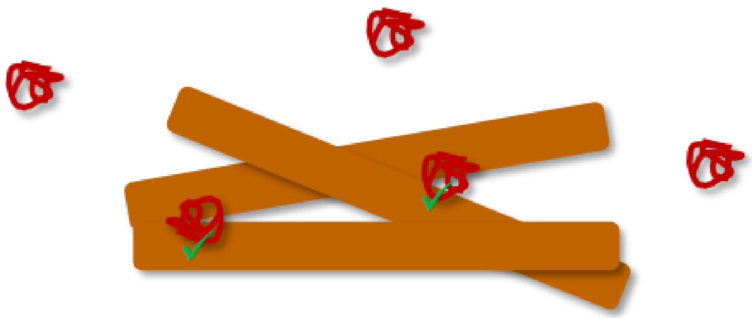
# Strength of paper with OCC



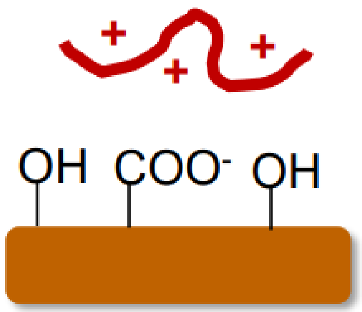

Strength properties for UBK, OCC and UBK/OCC (10/90) at 25lb (120 g/m$^2$). Dark blue bar represents OCC pulp at 33lb (160g/m$^2$). Data are relative to the strength of the 33lb OCC handsheet (100%).

# Cationic Additive Design and Its Limitation

## Design



Only additives on fiber can deliver performance

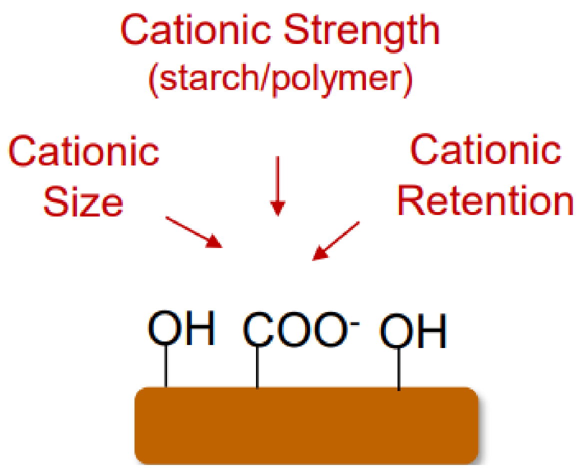



Cationic additive design

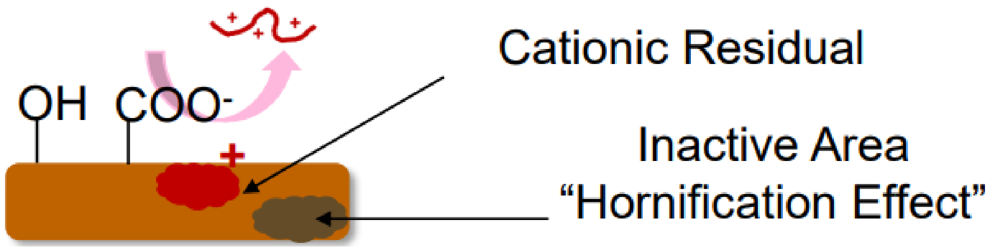
- Good Design
- Current Primary Strategy (US Market)

## Limitation

- Limited Loading Capacity

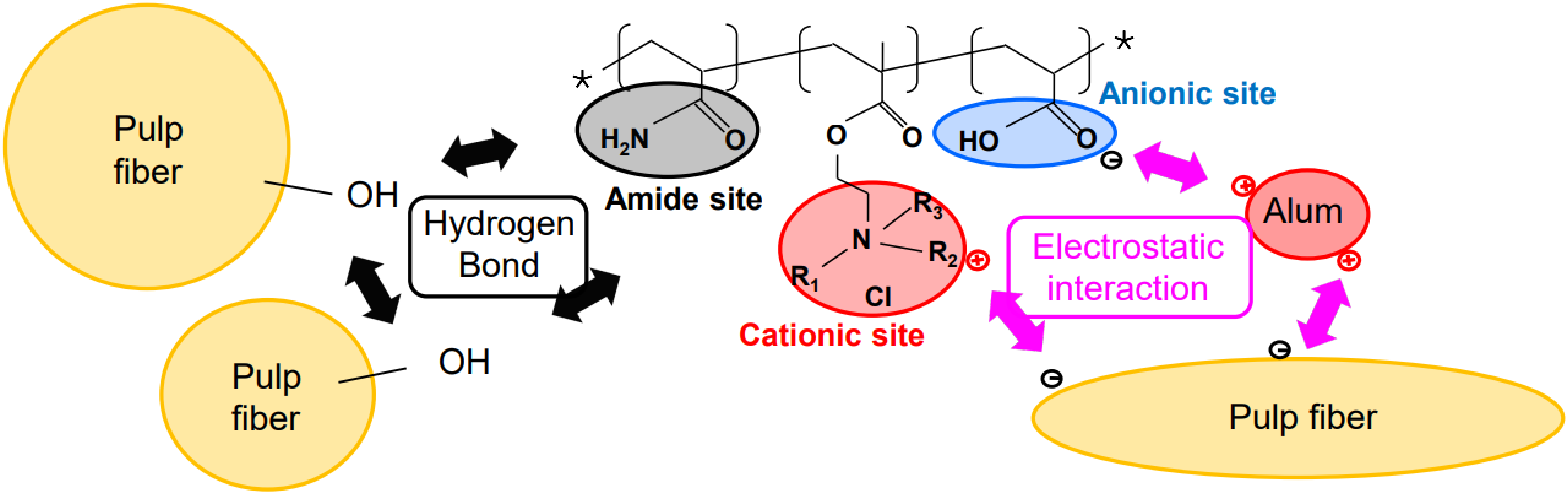



- Reduced Performance on Lower Quality Fiber



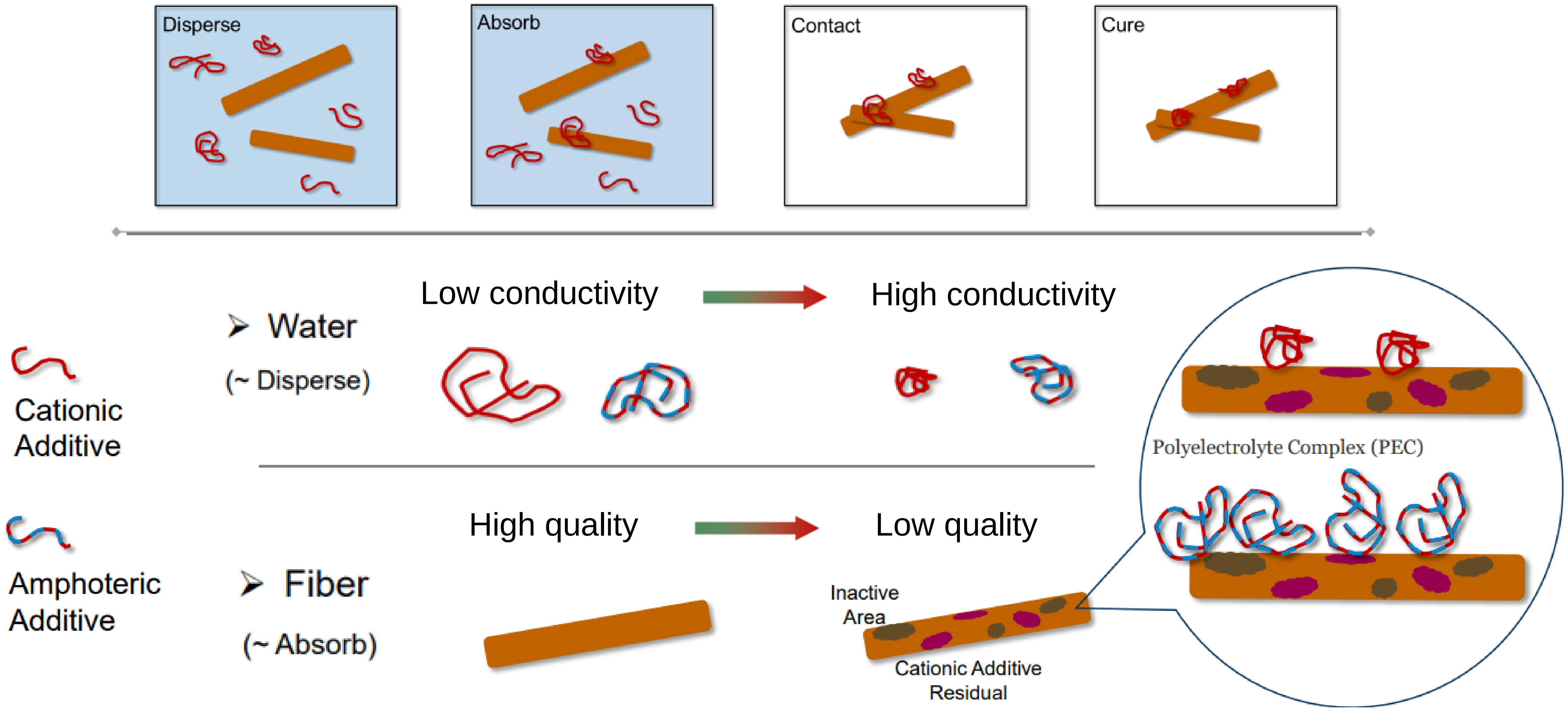
Due to raw material fiber quality and high level of mill closure, Japanese and other Asian markets rely almost entirely on Amphoteric dry strength agents.

# Amphoteric Polyacrylamide Dry Strength Agent (AmPAM)

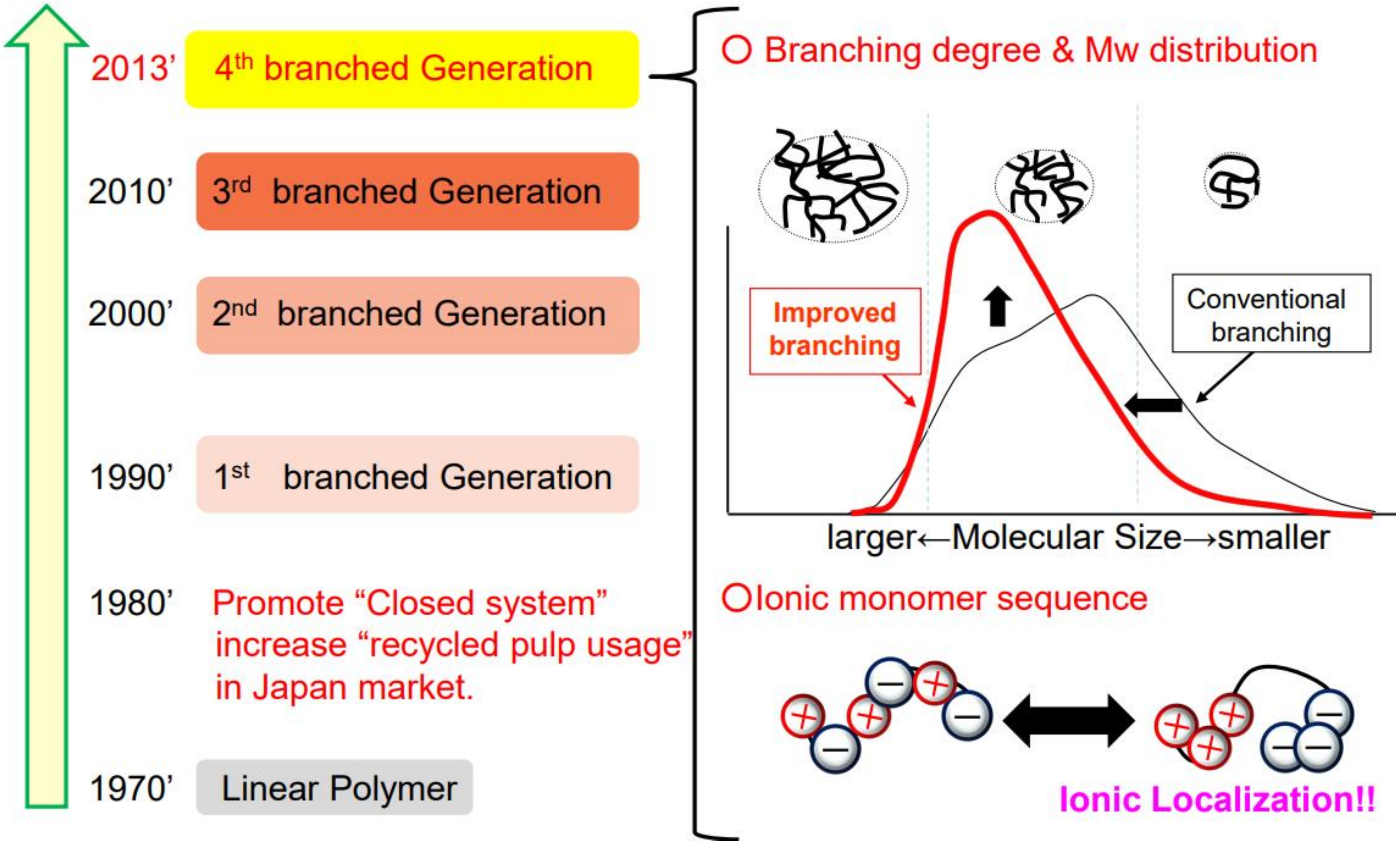



- More available interaction modes with the fiber for adsorption.
- Less net cationic charge – more loading on the fiber possible.
- No longer short life.

# Impact of Low Water/Fiber Quality on Chem Efficiency (cationic vs. amphoteric)

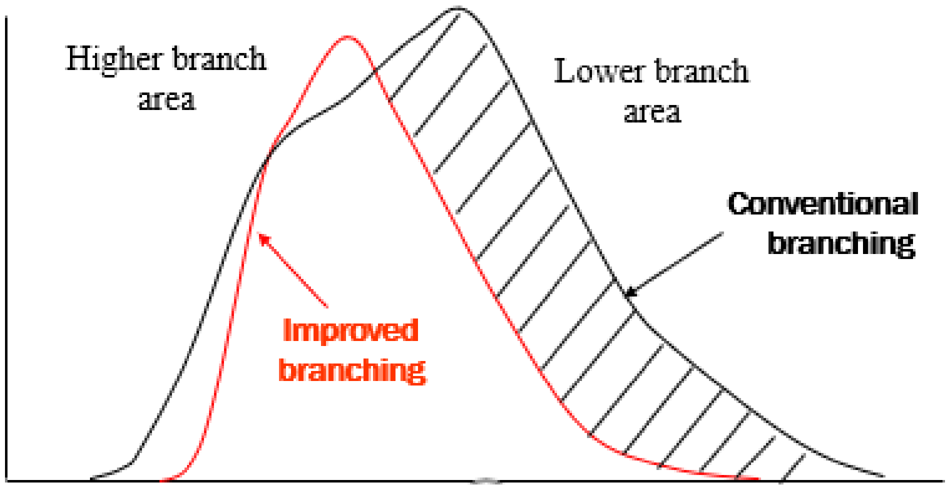


# Development of Amphoteric PAM



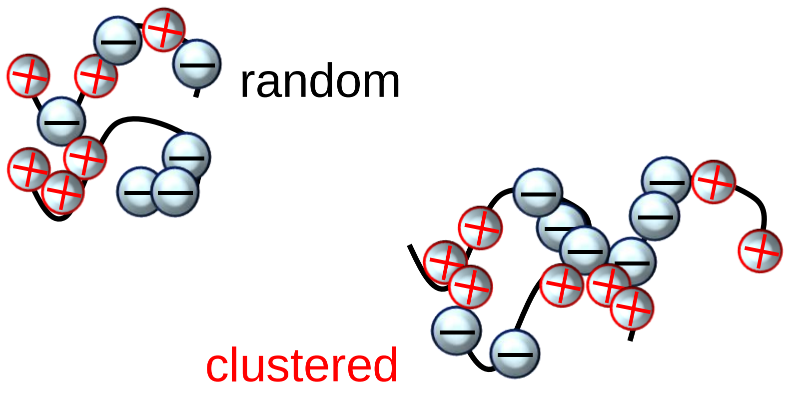
# Our Technology and Product

1) Improved branching:
Both Smaller molecular (not adsorb enough to the pulp) and ultra-large molecular (may bad formation) is cut.




Ultra large ← large ← Molecular size → small

2) Charge distribution:
We make ions localized in the polymer, and which polymers easily become large volume poly-ion complex and precipitate to some extent.

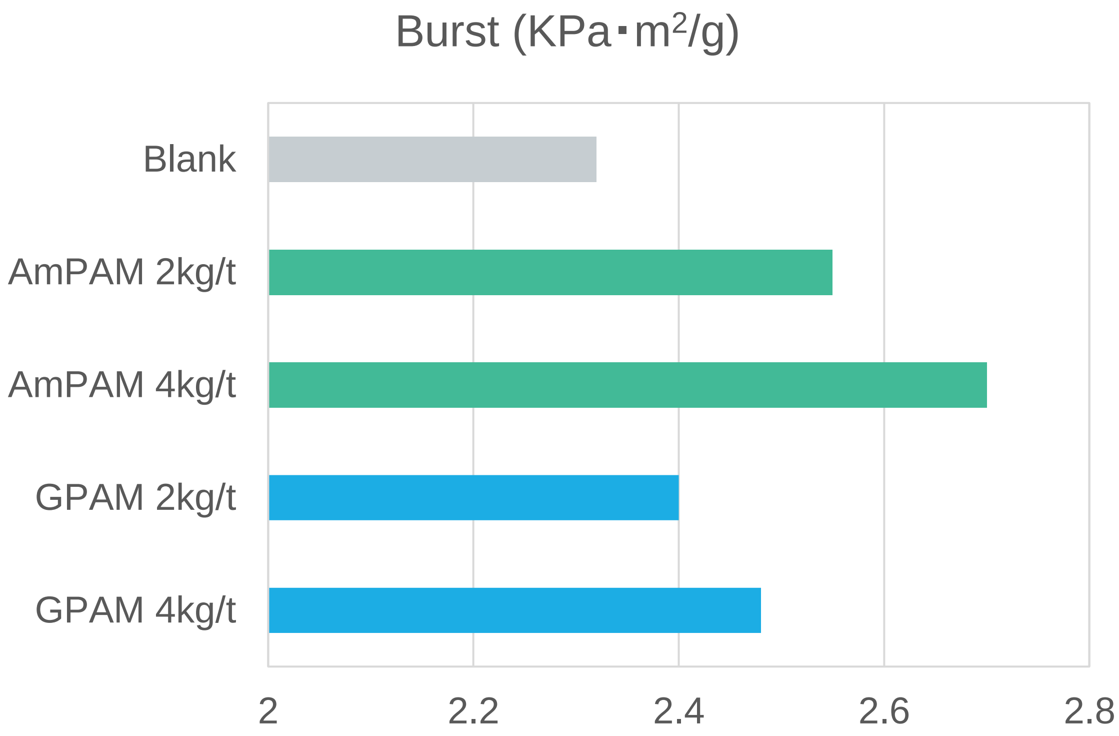


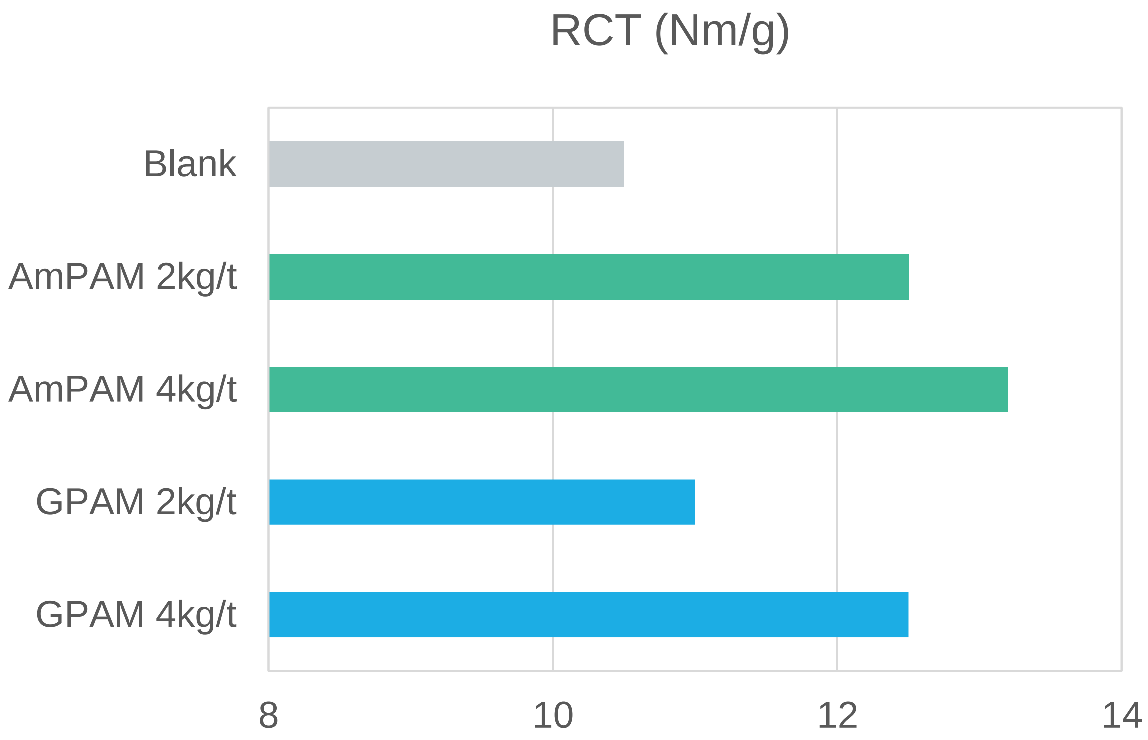

Associative character – 3D structure, better patch shape and extension

| Appearance | Solid (%) | Viscosity (mPa·s/25℃) | Specific gravity | pH (1%) | Ionicity | Solubility |
|---|---|---|---|---|---|---|
| Slightly white-turbid viscous | 15%min. | 7,000～13,000 | 1.05 (25℃) | 3.0-5.0 | +/- | Soluble in water |

# Performance of AmPAM and GPAM – laboratory work

Furnish: OCC 100%, pH: 6.5-7.0, Conductivity: 2,000μS/cm, Basis weight: 37lbs (180 g/$m^2$)

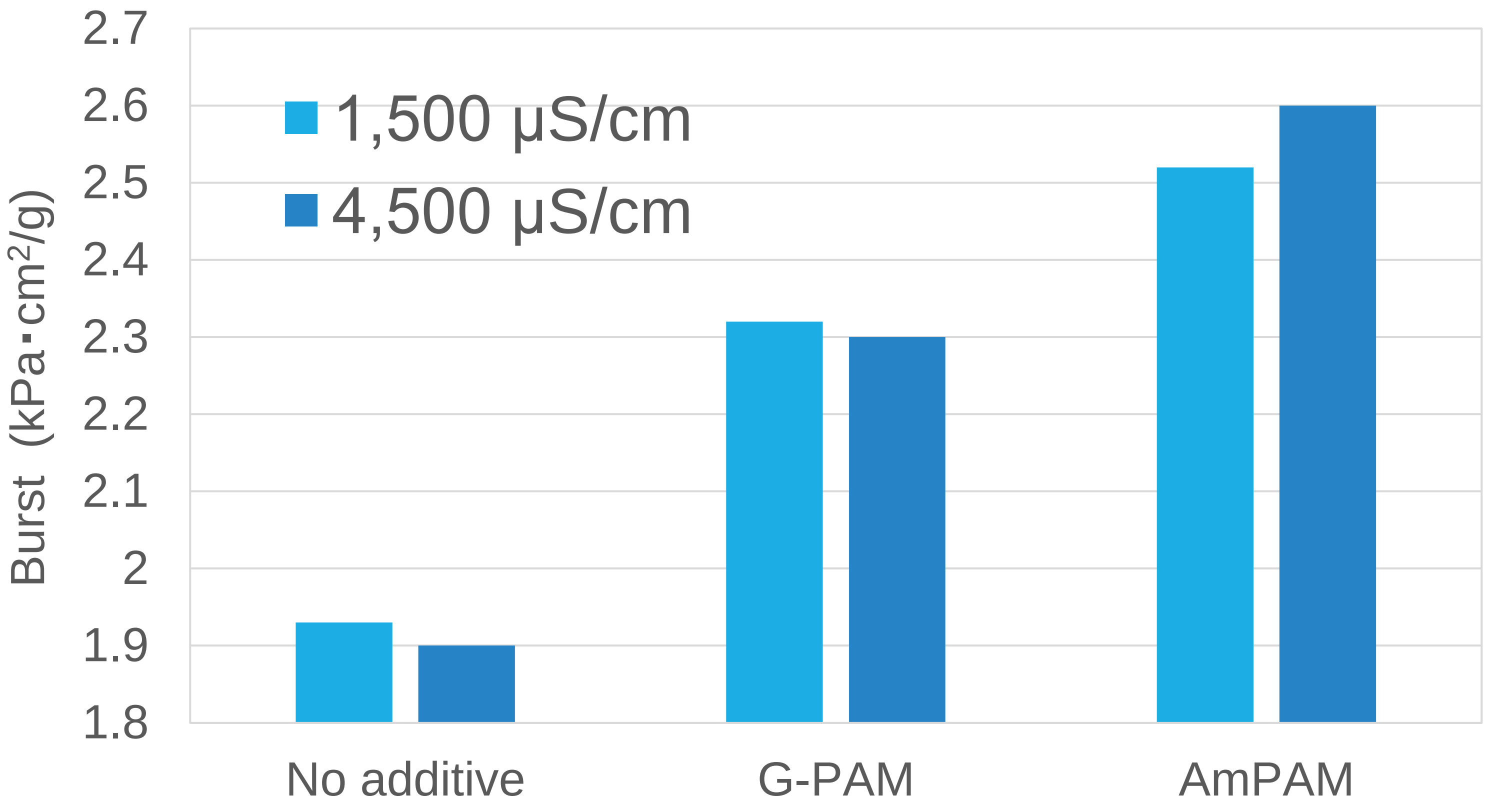



- AmPAM has higher strength effect than GPAM

# Burst strength in different conductivity conditions – laboratory work

Furnish: OCC 100%, pH: 6.5-7.0, Dosage rate: 8.8#/t, Basis weight: 29lb (140 g/m$^2$)




- AmPAM show higher strength effect than GPAM in high conductivity condition.

# Mill Case A – new product development

**Mill:** Linerboard 36lb (175g/m²)
**Furnish:** 100% OCC (LOCC/AOCC/HOCC = 1/1/1）
**pH:** Neutral
**Starch:** 4.4 lb/t (internal) and 13.2 lb/t size press
**Goal:** Reach strength target for new product developed

| | No. | AmPAM (lbs/t, as dry) | Basis weight (lb) | Density (g/cm³) | Burst index (kPa・m²/g) |
|---|---|---|---|---|---|
| Initial condition | 1 | 0 | 46.1 | 0.80 | **3.01** |
| | 2 | 0 | 45.5 | 0.80 | **2.97** |
| Trial condition | 3 | 13.2 | 45.9 | 0.80 | **3.70** |
| | 4 | 13.2 | 46.9 | 0.82 | **3.62** |
| | 5 | 13.2 | 46.9 | 0.80 | **3.62** |
| | 6 | 16.5 | 46.5 | 0.81 | **3.76** |

- Burst strength increased from 3.0 to over 3.6 by adding AmPAM at **13.2lbs/t (dry)** (#1,2 vs #3~5)
- Burst strength increased from 3.0 to 3.76 by adding AmPAM at **16.5lbs/t (dry)** (#1,2 vs #6)

# Mill Case B – bypassing size press

**Mill:** Linerboard
**Furnish:** 100% OCC
**pH:** Neutral
**Starch:** 35 lb/t size press
**Goal:** More speed and less energy consumption by **bypassing size press**

| | No. | AmPAM (lbs/t) (as dry) | Surface Starch (lbs/t) | Burst index (kPa·m²/g) | Ash in paper (%) | Starch in paper (%) |
|---|---|---|---|---|---|---|
| Initial condition | 1 | 7.0 | 35.2 | **3.52** | 8.9 | 3.2 |
| | 2 | 7.5 | 24.2 | **3.50** | 9.9 | 2.5 |
| Trial condition | 3 | 10.1 | 0 | **3.45** | 10.6 | 1.4 |
| | 4 | 10.1 | 0 | **3.47** | 10.5 | 1.5 |
| | 5 | 11.0 | 0 | **3.49** | 10.7 | 1.7 |

- Size press bypass was achieved on PS dosage **10.1~11.0 lbs/t (dry)**
- Burst maintained at standard or higher level

# Mill Case C – sizing improvement

**Mill:** Kraft paper for packaging
**Furnish:** 100% Softwood pulp
**pH:** 4.2
**Starch:** 4.4 lb/t (internal)
**Goal:** Optimizing charge and **improve sizing** by changing current PAM to PS

| | No. | AmPAM (lbs/t) (as dry) | Current AmPAM (lbs/t) (as dry) | Stockigt size (Sec) | S.BOX ZP (mv) | Inlet ZP (mv) |
|---|---|---|---|---|---|---|
| Initial condition | 1 | 0 | 7.9 | **32** | **+1.3** | +2.1 |
| Trial condition | 2 | 7.9 | 0 | **39** | **-0.4** | +1.2 |

- ZP charge at Stuff Box and Head Box was optimized when sizing changed from current AmPAM (more cationic) to new AmPAM (with less cationic charge).
- Stockigt size value was improved from 32sec to 39sec.
- **Not all AmPAM are the same.**

# Mill Case D – cost improvement

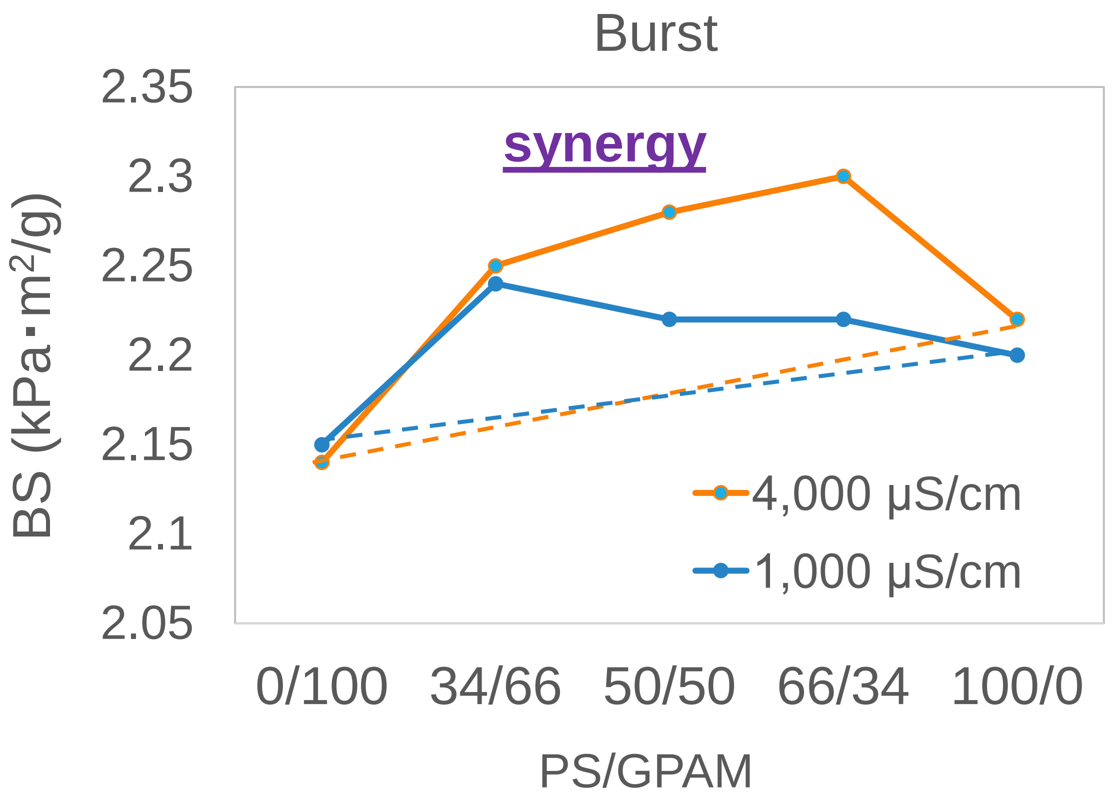
**Mill:** Linerboard
**Furnish:** 100% OCC
**pH:** 4.2
**Starch:** None
**Goal:** Cost reduction by decreasing DSR dosage

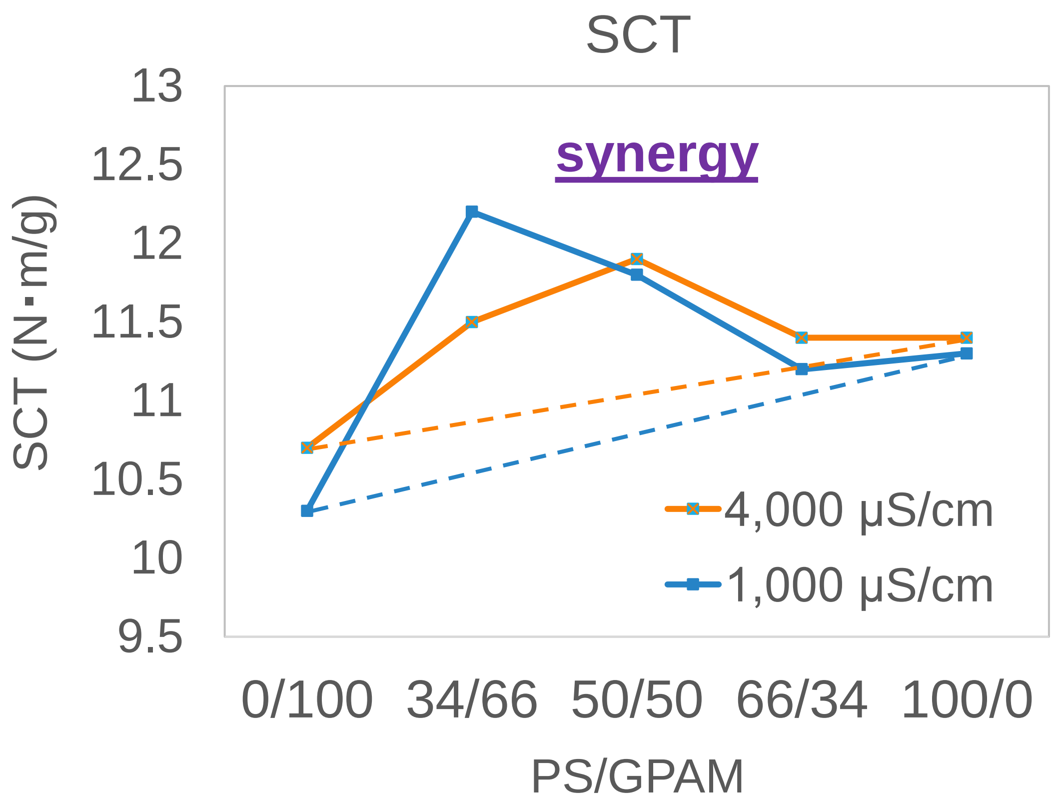
| | No. | AmPAM (lbs/t) (as dry) | Current AmPAM (lbs/t) (as dry) | Conductivity White Water (μS/cm) | Burst index (kPa·m²/g) | RC index (CD) (N·m²/g) |
|---|---|---|---|---|---|---|
| | 1 | 0 | 9.7 | 3,700 | **3.27** | 153 |
| Trial condition | 2 | 9.5 | 0 | 3,500 | **3.43** | 157 |
| Trial condition | 3 | 8.1 | 0 | 3,500 | **3.42** | 156 |
| Trial condition | 4 | 6.8 | 0 | 3,400 | **3.34** | 154 |
| Trial condition | 5 | **6.2** | 0 | 3,500 | **3.25** | 155 |
| | 6 | 0 | **8.1** | 3,500 | **3.20** | 152 |

➢ PS showed almost the same Burst and RCT even at the around 30% decreased dosage compared to the current DSR, 1st~2nd generation.

# Synergy between AmPAM and GPAM application for US OCC

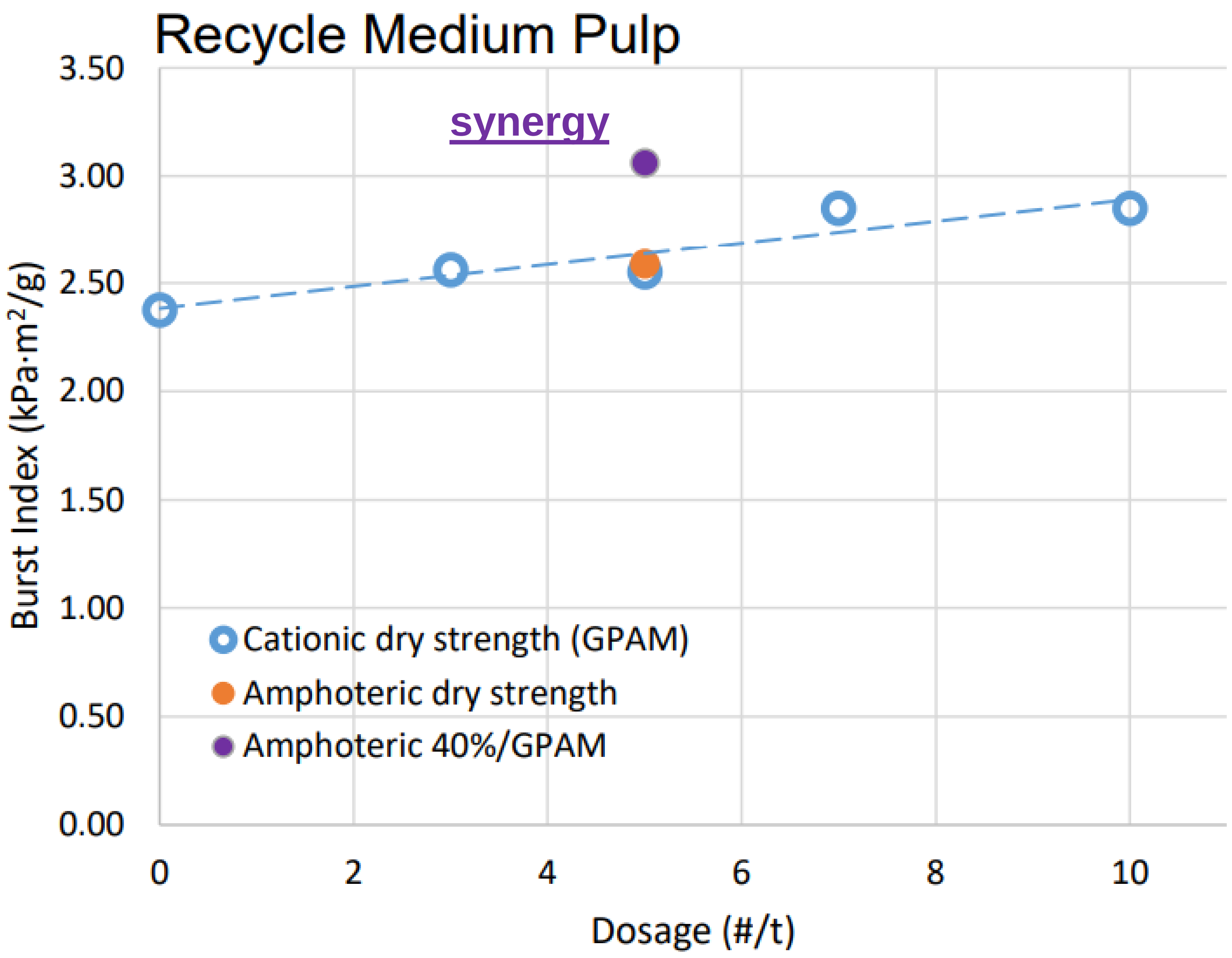
Furnish: OCC 100%, pH: 6.5-7.0, Dosage rate: 4.4#/t, Basis weight: 29lb




- AmPAM/GPAM > AmPAM > GPAM
- The synergistic effect of AmPAM and G-PAM  was confirmed.

# Synergy between AmPAM and GPAM application for US OCC



# Summary:

1. Lower fiber quality and increased closure of board mill systems create challenges in strength development.
2. Above trends are more advanced in Japan and other Asian regions, but may become relevant to North American market.
3. Amphoteric dry strength technology dominant in Japan and Asia.
4. Amphoteric dry strength technology may differ in molecular weight, crosslinking, net charge, and charge distribution.
5. Examples of lab experiments and mill cases were presented.
6. Synergy between GPAM and new AmPAM was observed.

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# Thank you for your attention!!

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