Mlicronized Cellulose as a Paper Additive and a Carrier for Papermaking Chemicals

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제32회 펄프·종이기술 국제세미나

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Abstract

This article portrays special cellulose fibers, which are designed to be a functional additive and a carrier for papermaking chemicals.

The first part of the presentation deals with the micronized ARBOCEL® cellulose fibers, which are used as a functional paper/paperboard additive. In particular as a bulk and speed aid. The detailed description of the micronized ARBOCEL® fibers, their function and effects on papermaking process and paper products are given.

The second part of the study describes the concept of fiber-based papermaking chemicals.
A new generation of fiber-based papermaking chemicals were presented for the first time at the PTS Pulp Technology Symposium 2005, and then several articles were published in various magazine in Asia ("Paper Asia"), the US ("Pulp & Paper"), and Europe ("Wochenblatt fuer Papierfabrikation"). The information generated quite an interest in the paper industry.
Extensive studies of these papermaking additives have been made recently, new information obtained, and the compounds have gained more recognition in the industry.

The company J. Rettenmaier und Soehne developed a group of fiber-based papermaking additives. They include combination of fibers with sizing agents, starch, fluorochemicals, minerals, biocides and some others.
This article presents in-depth study of the AKD modified micronized cellulose as an example of the fiber-based papermaking chemicals concept.

The material of the present paper is based mostly on the results of the pilot paper machine study at the Paper Research Institute PTS (Heidenau, Germany), and includes case studies from the mills, which used ARBOCEL*PLUS*® - AKD compounds.

It should be noted that the ARBOCEL*PLUS*® compounds were not designed to replace traditional additives in paper industry. They should rather be used in those areas, where application of "normal" chemicals is especially problematic

Micronized cellulose as a paper additive

The general function of papermaking cellulose fibers is described by its name – to make paper products.
Since various paper and paperboard grades have different function and properties, a variety of papermaking fibers not only fabricate paper but also build these properties in paper.

메모: Run On sentence

As diversity of paper/paperboard grades and requirements to their quality increase, it becomes more difficult to optimize selection of general-purpose pulps, which fulfill these requirements. Papermakers are challenged when choosing from a variety of pulps, which could satisfy all, often contradictory, requirements of paper products and papermaking process.

One possible solution is designing special cellulose fibers with particular distinctive properties, and designated for special applications. Then adding small amounts of such "intensive" fibers into papermaking furnish.
Micronized cellulose fibers ARBOCEL®, designed particularly as bulk and speed additive primarily for recycled paperboard, exemplify this concept.
Figure 1 shows appearance of the ARBOCEL® fibers (C 320), and *Figure 2* – particles size distribution of different ARBOCEL® grades.

How does it work? It is explained on the *Figure 3.*
Formation. The micronized particles prevent early close contact by fiber surfaces so that premature flocculation cannot occur, which translates into improved formation.
Drainage. The particles act like spacers and increase micro-void level allowing free water-flow through non-obstructed fiber network, which increases the porosity of the sheet and drainage rate.
Pressing. Providing more open fibrous structure, the micronized cellulose enhances pressing efficiency.

Drying. Creating more open channels in the fibrous matrix the particles increase steam diffusion rate.
The bottom line is that ARBOCEL® improves both the dewatering and the drying rate... thus increasing productivity and reducing energy cost.
Final product. While being positioned between papermaking fibers, the micronized cellulose increases caliper/bulk of a final paperboard sheet and thus its stiffness and formation.

Figure 4 demonstrates scanning electron microscope image (cross section) of paperboard with and without ARBOCEL®
Figure 5 shows comparative effect of mechanical pulp and ARBOCEL® fibers on various parameters of paperboard, and *Figure 6 – 10* are more detailed demonstrations of this comparison.

ARBOCEL® have being successfully used at the paperboard mills around the world. Some case studies are demonstrated on the *Figure 11*.

Micronized cellulose as a carrier for papermaking chemicals

1 Introduction

ARBOCEL*PLUS*® - AKD compounds exemplifies the concept of fiber-based chemicals.
The essence of the idea is as follows: to fix chemicals on fibers outside of the papermaking process, and then to add these modified fibers into the main papermaking stream.
Figure 12 illustrates the general mechanism of fiber-based additives compared with traditional papermaking chemicals.

The idea of oversizing papermaking fibers with AKD (alkyl ketene dimer) and adding a small amount of these modified fibers to unsized furnish, was pronounced by Weyerhaeuser some thirty years ago.

Though the concept sounded attractive and was successfully tested on a pilot scale, it was not used in the paper industry.

As the leading producer of cellulose fibers for all imaginable areas from food and pharmaceutical to chemistry, filtration, road construction, etc., JRS made a bold move to bring back the idea of fiber-based papermaking additives.

The company started development of the whole group of such additives. They included combination of fibers with sizing agents, starch, fluorochemicals, minerals, biocides and some others.

2 Experimental. Materials and equipment

The general principle of the ARBOCEL*PLUS*® - AKD compound is as follows. AKD wax is deposited, melted and spread over the surface of ARBOCEL® fibers. In such a way the fibers are in essence the carrier for AKD.
The AKD modified fibers are added at the wet end.
Sizing is provided by two major factors: high hydrophobicity of the fiber net and emission/migration of AKD from carrier fibers to the rest of papermaking furnish within the paper sheet.

ARBOCEL*PLUS*® - AKD compounds C100-60AKD and C100-120AKD were made on industrial equipment at JRS, Holzmühle with the use of standard AKD wax.
The compounds C100-60AKD and C100-120AKD contain 6% and 12% of AKD wax respectively.

As reference, commercial AKD emulsion containing 30% of AKD wax was used in the trials.

Diagrams of the pilot paper machine (PTS, Heidenau, Germany) with the addition points of the ARBOCEL*PLUS*® - AKD compounds and AKD emulsion are shown respectively in *Figures 13* and *14*.

As a furnish for making paper (120 gsm) a linerboard with the ash contents of 14% was used.

3 Results and Discussion

Before turning to the main point of this chapter, its important to mention effect of ARBOCEL® and ARBOCEL*PLUS*® - AKD fibers on the electrokinetic's of the furnish, to which the fibers were being added. Zeta potential is quite a concern of papermakers while considering the use of any additives.
The tests were carried out with use of furnish (for making liner) from Palm, Aalen, Germany and took place at their lab.
Figure 15 shows that addition of ARBOCEL® and ARBOCEL*PLUS*® - AKD fibers practically don't affect the zeta potential.

- Retention of AKD is the primary concern of its use.

The following tests proved good retention of the ARBOCEL*PLUS*® - AKD fibers in furnish.
The papers made with the addition of the compounds C100-60AKD, 3%, C100-120AKD, 1.5%, and standard AKD emulsion (30% AKD), 0.6% has the equivalent amounts of active AKD – 0.18%. Retention aid PEI, 0.15% was used in all these cases.

The following trial confirmed lower AKD level in white water from production of paper with AKD compounds.

White water samples were withdrawn during the production of paper on the pilot machine. Handsheets (100 gsm) were then made with use of these white water samples. The sizing level of the handsheets was estimated by measuring water penetration time through the sheets. Higher sizing level indicates a higher content of AKD in white water, or in other words, the higher sizing level of the handsheets points to lower retention of AKD on paper machine.

Figure 16 illustrates that in the case of the ARBOCEL*PLUS*® - AKD compounds, white water contains considerably less AKD than in case of the regular emulsion.

The papers made with addition of the compounds C100-60AKD, 6%, C100-120AKD, 3%, and standard AKD emulsion (30% AKD), 1.2% has the equivalent amounts of active AKD – 0.36%. Sizing levels with use of the retention aid – PEI, 0.15% (measured 10 days after making the paper) are approximately equal (*Figure 17a*).

Figure 17b shows that sizing level without retention aid is higher for paper with the AKD compounds than for paper with "normal" emulsion.

- Fillers in papermaking furnish, absorb a disproportional amount of AKD size due to their high surface area.
It is known from literature that obtaining permanent AKD sizing requires that the dimer react with the cellulose fiber. The portion of the dimer that coats the carbonate gives only a temporary sizing effect. A quick and effective test for differentiating permanent sizing from temporary sizing is to dip the paper in water and oven dry the sheet. We immersed paper samples into water; oven dried, conditioned and measured their sizing degree.

Figure 17c clearly illustrates that permanent sizing for papers containing ARBOCEL*PLUS*® - AKD compounds is significantly higher than permanent sizing of papers with standard AKD emulsion.

- The well-known "cure in the roll" is a general drawback of AKD.

A mill, which has been using AKD compound for a few months, reported a higher "off machine" sizing level of the AKD compound in compare with standard AKD emulsion.
To verify this fact we measured sizing levels (Cobb) of papers immediately from the pilot paper machine and then after one and ten days.
Figure 18 demonstrates dynamics of paper sizing with the addition of the compounds C100-60AKD, 3%, and standard AKD emulsion (30% AKD), 0.6% (both have the equivalent amounts of active AKD – 0.18%). Though AKD emulsion and AKD compounds (containing equal amount of active AKD) provide about the same sizing level after one and ten days, the compounds give higher "off machine" sizing level.

- AKD sizes have generally been found to work effectively over the pH 7-9 with optimum conditions pH 7.5 – 8.0. Below pH 6, AKD ceases to be effective; high alkalinity cause loss of sizing.

We tested sizing level of the handsheets made with the standard AKD emulsion and the C 100-120AKD (both contain 12% of AKD wax) at different pH. The results (*Figure 19*) show that the AKD compound provided more stable sizing in wide range of pH than the AKD emulsion.

4 Conclusions

ARBOCEL*PLUS*®-AKD compounds exemplify the concepts of fiber-based papermaking additives, and were successfully tested on the pilot paper machine and are being used in the industry.

- The compounds do not affect zeta potential of furnish.
- The compounds have higher "off machine" sizing degree than standard AKD emulsion.
- The compounds have better retention than standard AKD emulsion.
- The compounds have better permanence than standard AKD emulsion, particularly in the case of furnish with high ash content.
- The compounds are effective over all practical pH range.
- The compounds have longer shelf time than standard AKD emulsion and are not affected by freezing – thaw conditions.

Figure 20 shows above-mentioned conclusion in the form of the price – performance comparative analysis of the standard AKD emulsion and ARBOCEL*PLUS*®-AKD compounds.

Figure 21 demonstrates case studies from some of those mills, which used ARBOCEL*PLUS*® - AKD compounds. Taking into account the fact that JRS have non-disclosure agreements with these companies, the information is presented in general and limited form.

As mentioned earlier, the ARBOCEL*PLUS*® - AKD compounds presents one of the products from a range of the fiber-based papermaking additives developed by company J. Rettenmaeir and Soehne.

J. RETTENMAIER & SÖHNE GMBH+CO KG JRS Fibers designed by Nature

Micronized cellulose as a paper additive and a carrier for papermaking chemicals

Fibers designed by Nature J. RETTENMAIER & SÖHNE GMBH+CO KG JRS

J. RETTENMAIER & SÖHNE GMBH+CO KG JRS Fibers designed by Nature

Part 1

Micronized cellulose as a paper additive

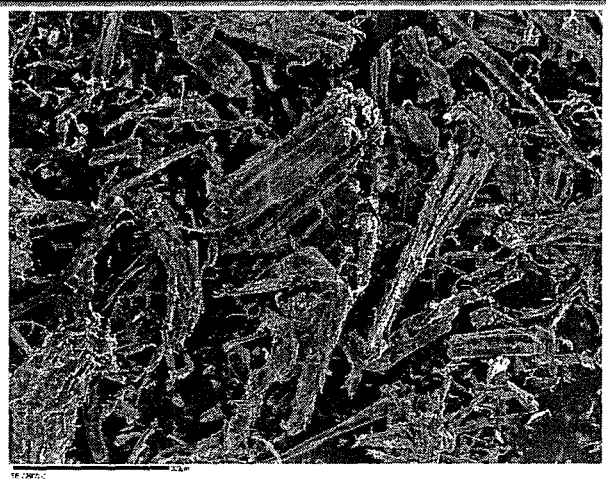


FIGURE 1. Micronized Cellulose Fibers ARBOCEL® C320. Appearance

Fibers designed by Nature J. RETTENMAIER & SÖHNE GMBH+CO.KG JRS

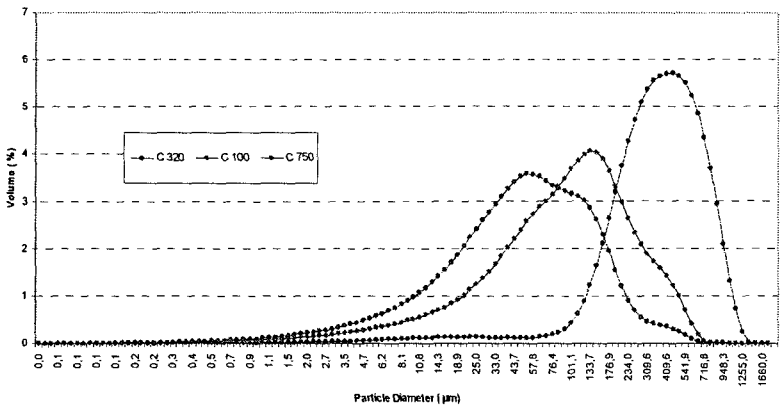


FIGURE 2. Particle Size Distribution of different ARBOCEL® Grades

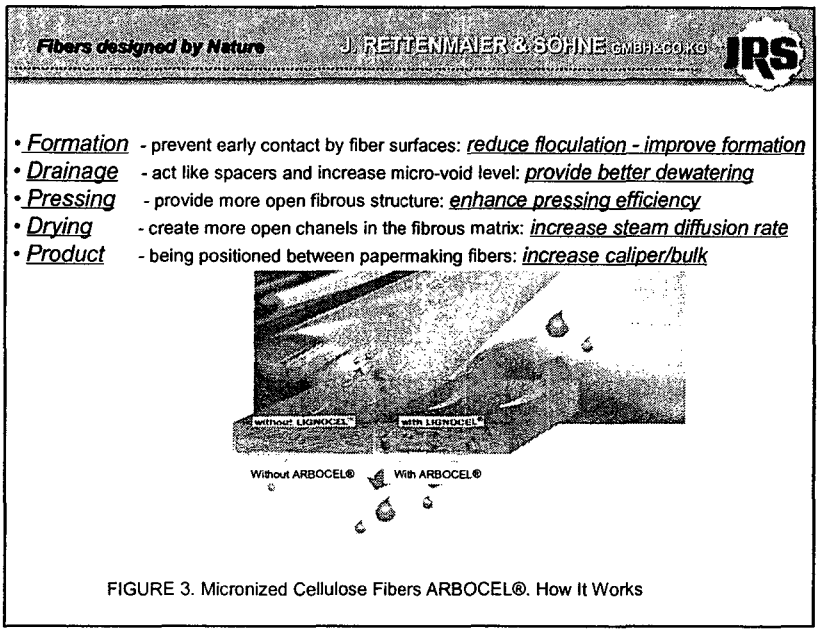


FIGURE 3. Micronized Cellulose Fibers ARBOCEL®. How It Works

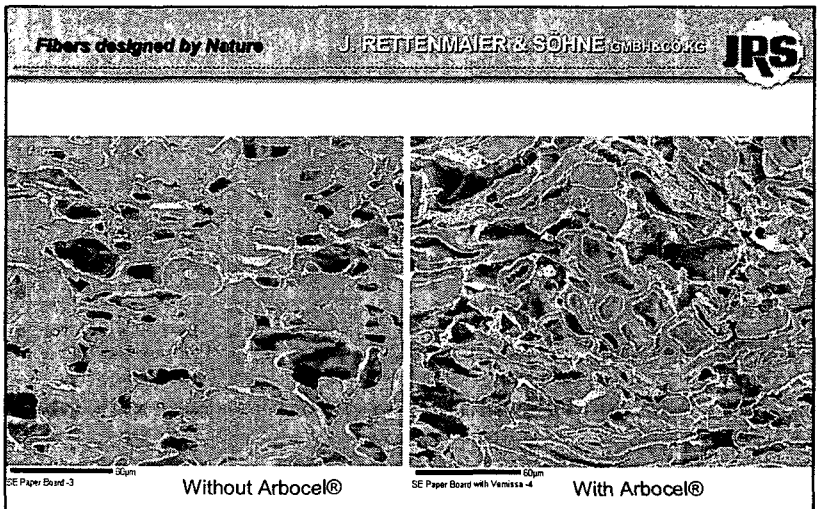


FIGURE 4. Paperboard: SEM Cross Sections

Parameter	Mechanical Pulp	ARBOCEL®
Bulk	↑	↑
Drainage	↓	↑
Formation	↓	↑
Runnability	↓	↑
Porosity	↓	↑
Stiffness	↑	↑
Burst	↑	→
Opacity	↑	↑

FIGURE 5. Additives to Recycled Furnish: ARBOCEL® vs. Mechanical Pulp

Fibers designed by Nature J. RETTENMAIER & SÖHNE GMBH + CO KG JRS

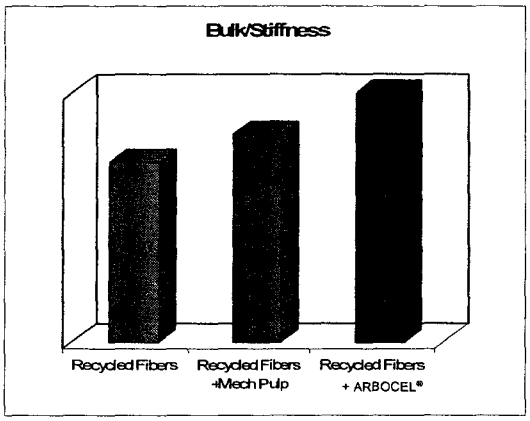


FIGURE 6. ARBOCEL® vs. Mechanical Pulp. Bulk/Stiffness Effect

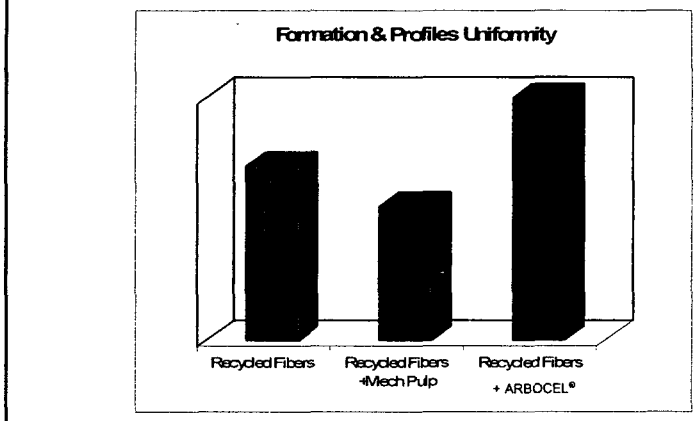


FIGURE 7. ARBOCEL® vs. Mechanical Pulp. Formation & Profile Uniformity

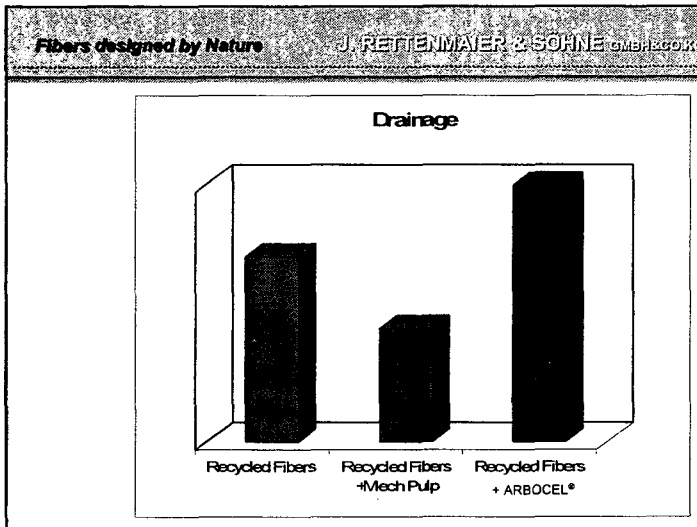


FIGURE 8. ARBOCEL® vs. Mechanical Pulp. Drainage Effect

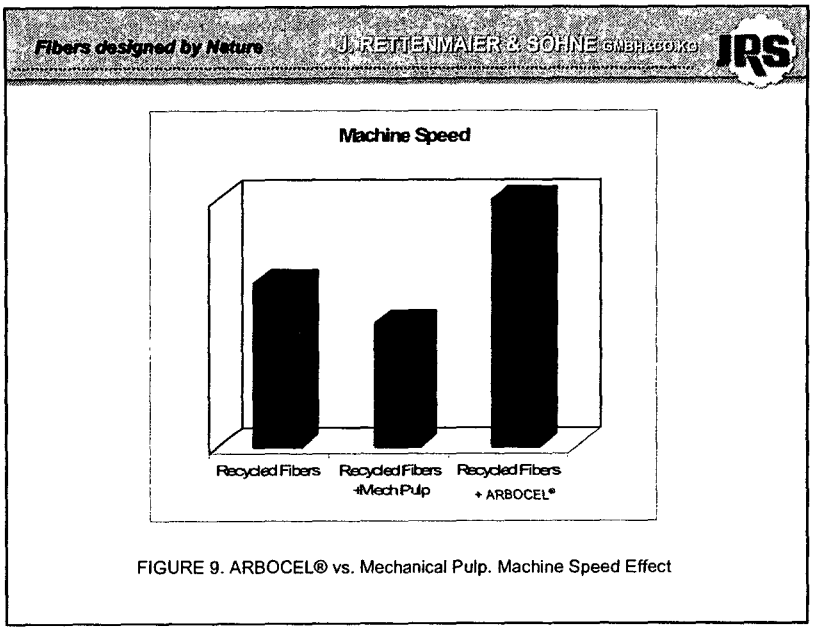


FIGURE 9. ARBOCEL® vs. Mechanical Pulp. Machine Speed Effect

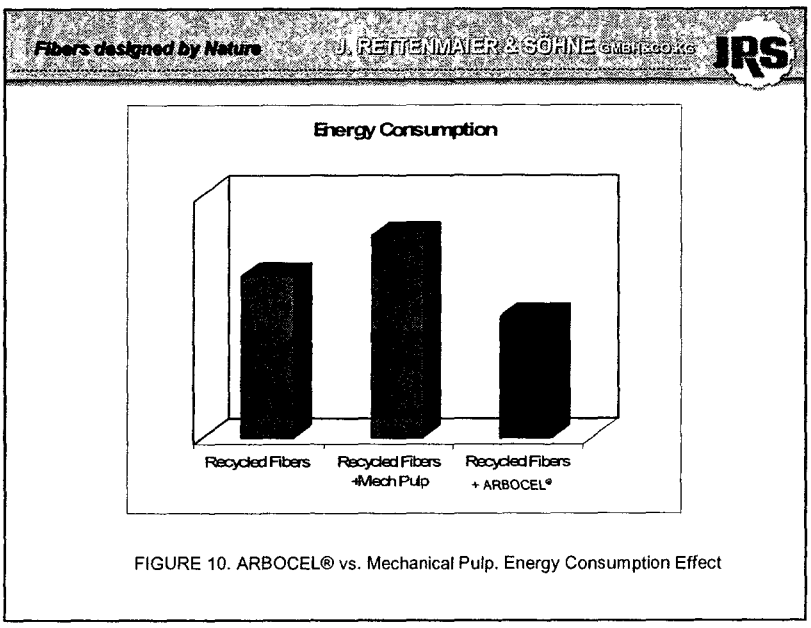


FIGURE 10. ARBOCEL® vs. Mechanical Pulp. Energy Consumption Effect

Mill, Product	Standard Paperboard Parameters	Arbocel, rate %	Paperboard parameters with Arbocel	Benefits
Europe, Recycled Multiply Folding Boxboard, five layers 350 gsm	Bulk, cm^3/g – 1.40 Stiffness Lorentz, mNm MD – 39, CD – 14 Machine speed, m/min - 165	C100, 5% Into three middle layers	Bulk, cm^3/g – 1.49 Stiffness Lorentz, mNm MD – 44, CD – 16 Machine speed, m/min - 175	Bulk, cm^3/g + 6.4% Stiffness Lorentz, mNm MD + 13%, CD + 14% Machine speed, m/min - + 6%
US, Recycled mat paperboard, eight layers Caliper 0.042" BW 130MSF	Density – 3.1 Mullen burst – 120 Ply Bond – 140 Caliper variation, 2 sigma 0.85 Machine speed, fpm 300	C320, 5% Into all plies	Density – 2.8 Mullen burst – 115 Ply Bond – 140 Caliper variation, 2 sigma 0.60 Machine speed, fpm 330	Density - 7% Mullen burst - 4% Ply Bond – 0% Caliper variation, 2 sigma – 42% Machine speed, + 11%
Europe, Recycled Chip Boxboard, 600 gsm	Bulk, cm^3/g – 1.42 Stiffness Taber, mNm MD – 19, CD – 8.5 Scott Bond, J/m^2 – 190 Machine Speed, m/min – 220	C32-10, 6%	Bulk, cm^3/g – 1.42 Stiffness Taber, mNm MD – 20, CD – 9 Scott Bond, J/m^2 – 200 Machine Speed, m/min – 230	Bulk, cm^3/g + 5% Stiffness Taber, mNm MD + 5%, CD + 6% Scott Bond, J/m^2 + 5% Machine Speed, m/min – + 4%

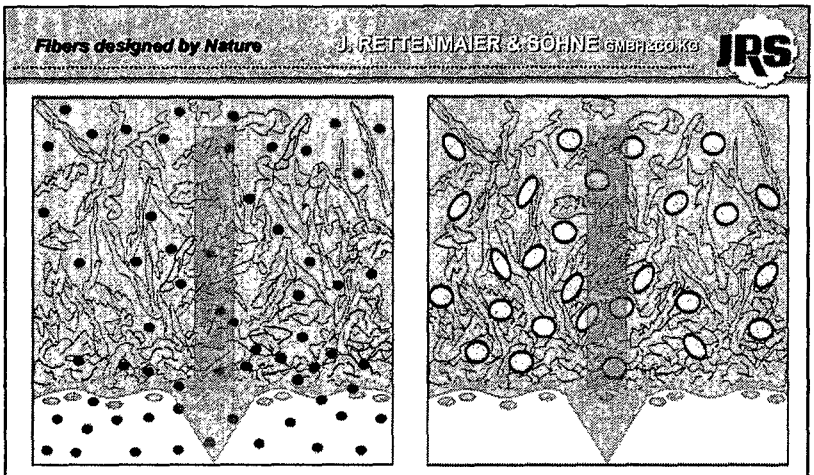
Figure 11. Case Studies. ARBOCEL

Fibers designed by Nature J. RETTENMAIER & SÖHNE GMBH+CO KG JRS

J. RETTENMAIER & SÖHNE GMBH+CO KG JRS Fibers designed by Nature

Part 2

Micronized cellulose as a carrier for papermaking chemicals



a. Traditional papermaking additives

b. Fiber – based papermaking addtives. The chemicals are fixed on cellulose „carrier"

FIGURE 12. General principle of „traditional" and fiber – based papermaking additives

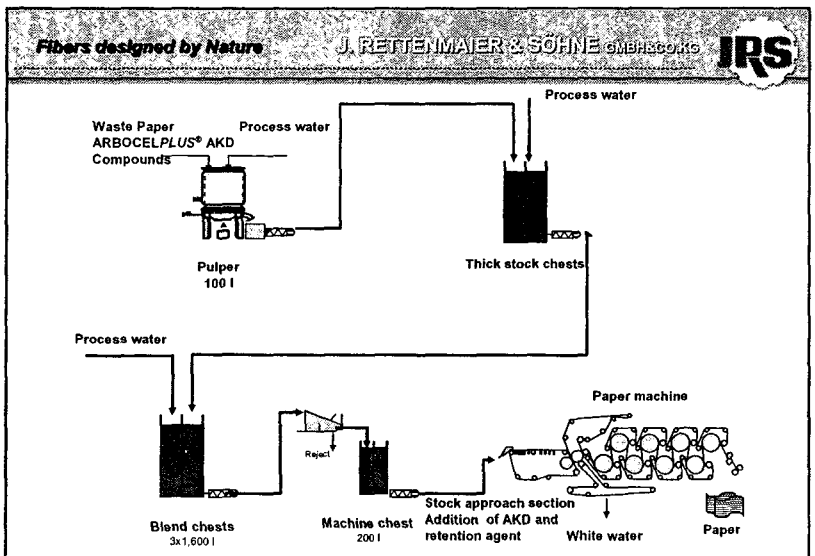


FIGURE 13. Pilot paper machine. Addition of the ARBOCEL*PLUS*® - AKD compounds

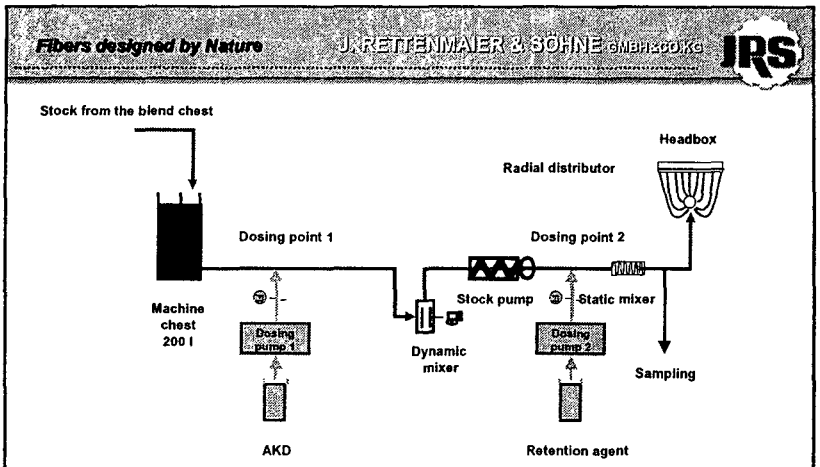


FIGURE 14. Stock approach system. Addition of the AKD emulsion and retention aid

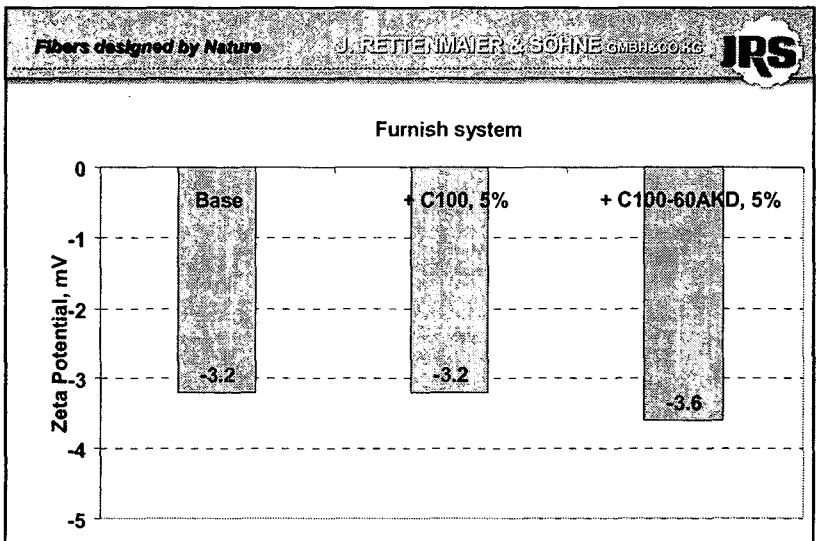


FIGURE 15. Effect of the ARBOCEL® and ARBOCEL*PLUS*® AKD fibers on zeta potential

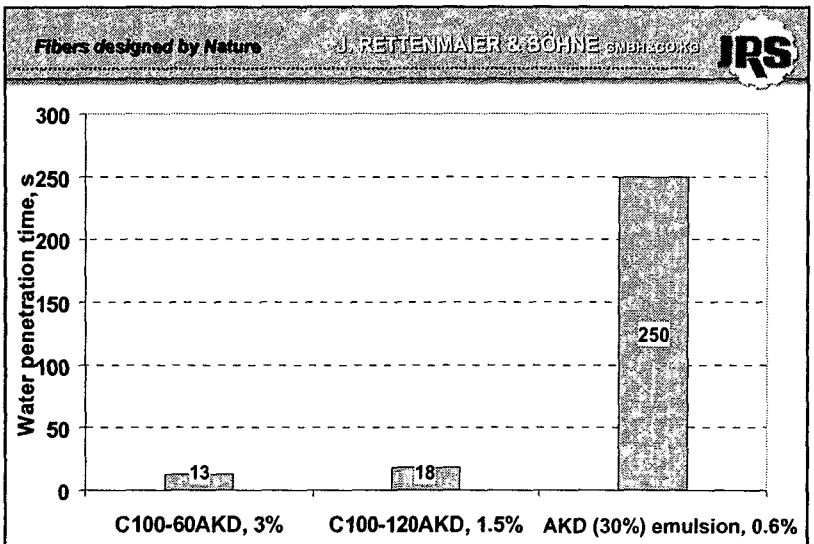


Figure 16. Water penetration time through paper made with use of white water from the pilot paper machine

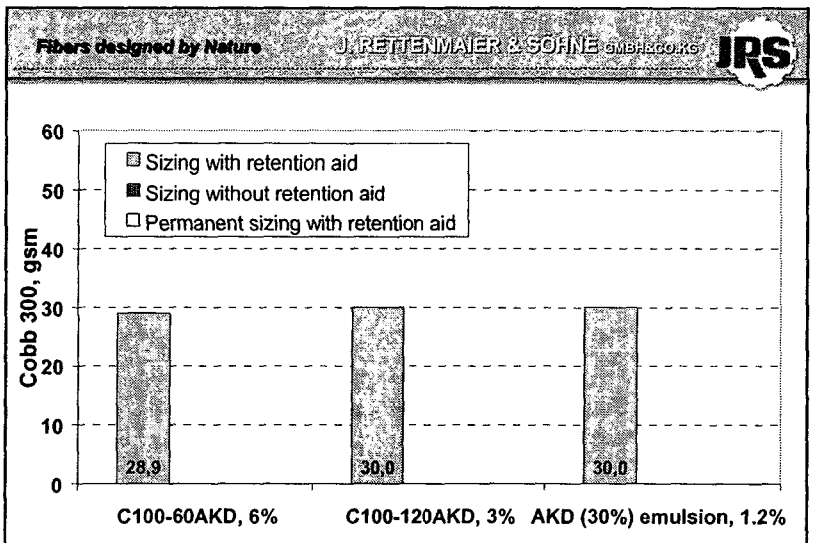


FIGURE 17a. Sizing level of papers made with the ARBOCEL*PLUS*®-AKD compounds and AKD emulsion (measured after 10 days) *„High" active AKD dosage - 0.36%*

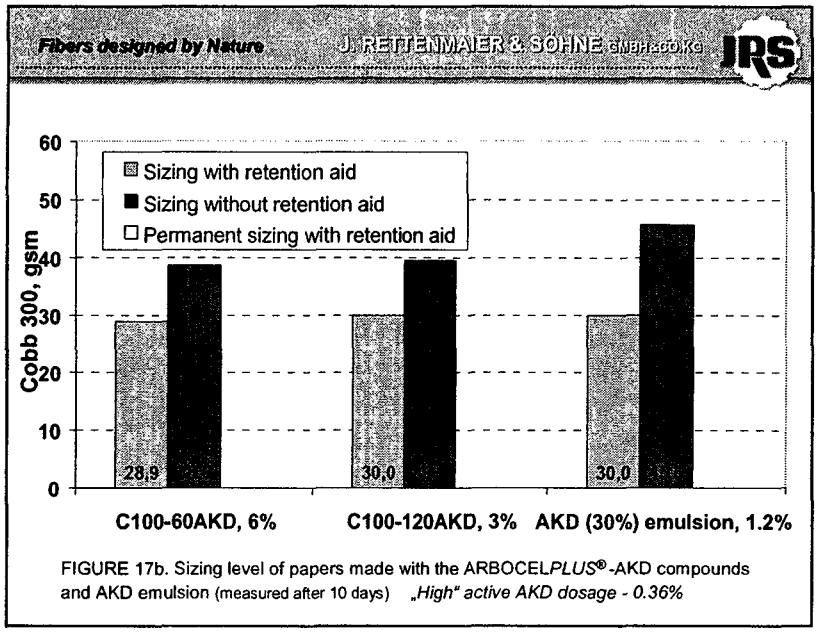


FIGURE 17b. Sizing level of papers made with the ARBOCEL*PLUS*®-AKD compounds and AKD emulsion (measured after 10 days) *„High" active AKD dosage - 0.36%*

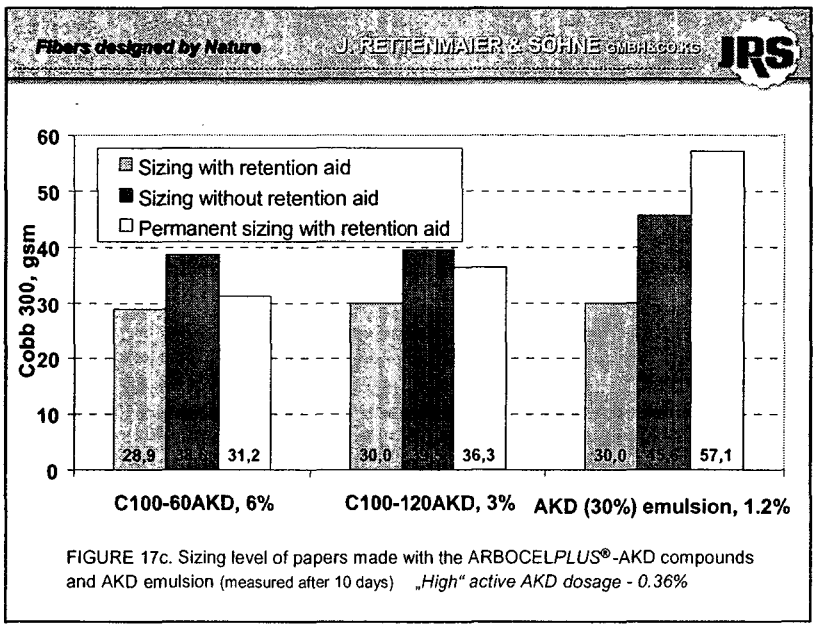


FIGURE 17c. Sizing level of papers made with the ARBOCEL*PLUS*®-AKD compounds and AKD emulsion (measured after 10 days) *„High" active AKD dosage - 0.36%*

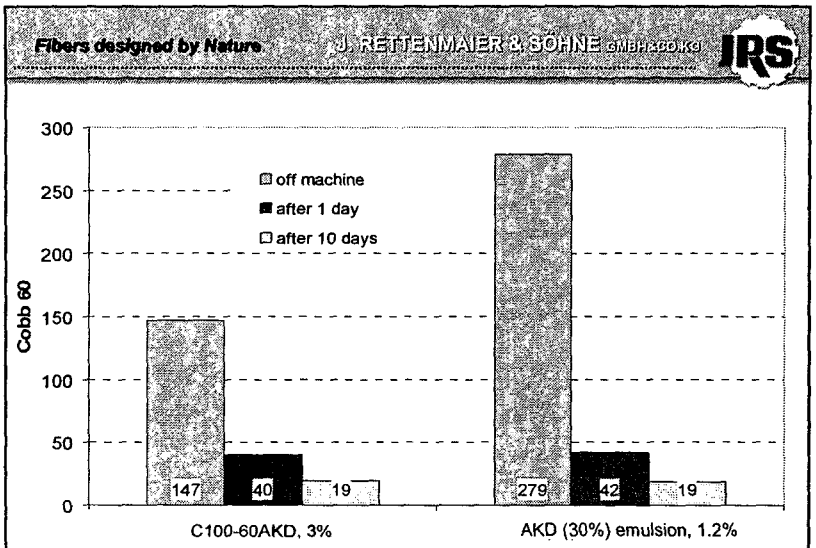


FIGURE 18. Sizing level of papers made with the ARBOCEL*PLUS*®-AKD compounds and AKD emulsion (measured off machine, after one and ten days). *„Low" active AKD dosage - 0.18%*

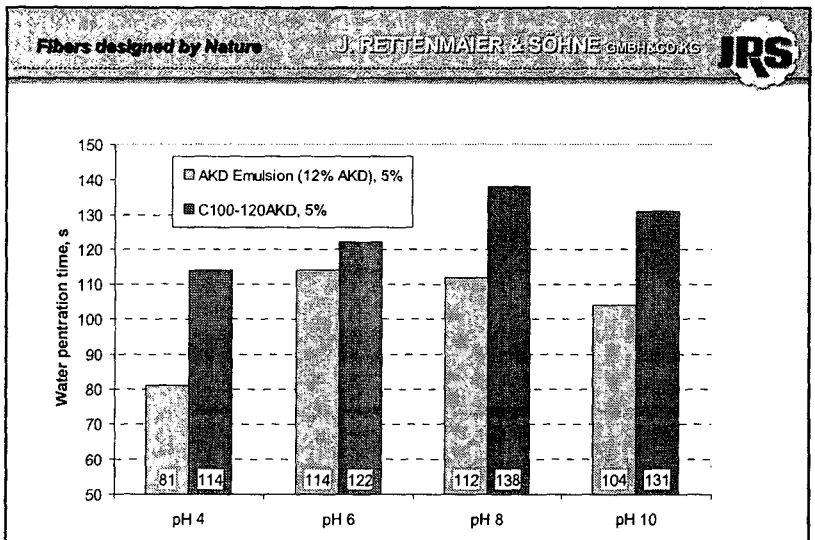


Figure 19. Water penetration time through paper made with the ARBOCEL*PLUS*®-AKD compounds and AKD emulsion at different pH

Conclusions

- ***The compounds do not effect zeta potential of furnish***
- ***The compounds have higher "off machine" sizing degree than standard AKD emulsion***
- ***The compounds have better retention than standard AKD emulsion***
- ***The compounds have better permanence than standard AKD emulsion***
- ***The compounds are effective over all practical pH range***
- ***The compound have longer shelf time than than standard AKD emulsion and are not affected by freezing – thaw conditions***

Fibers designed by Nature J. RETTENMAIER & SÖHNE GMBH+CO.KG IRS

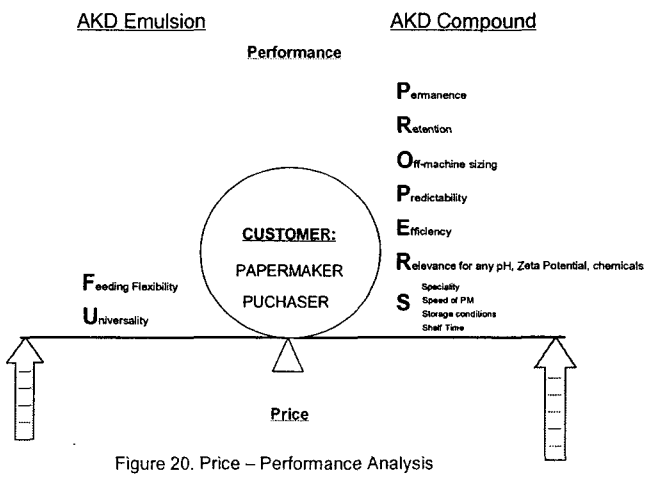


Figure 20. Price – Performance Analysis

Mill, Product	Standard Sizing Agent	Problems	Compound, rate %	Benefits
Europe, Shank Board, 2070 gsm	Rosin Emulsion	Insuffcient sizing level, Foaminig	C100 – 120AKD, 4%	-Required sizing level: water absorption < 10% for 30 min; -Steam consumption decrease about 5%; -No foaming
US, Frozen food packaging paperboard, about 600 gsm	AKD Emulsion	-Low on-machine sizing; -Insuffcient permanence	C100 – 40AKD, 5%	-Improved on-machine sizing; -Higher permanence; -Machine speed increase 7%
Europe, Liquid packaging board (filler 150 gsm)	AKD emulsion	Migration of the AKD in z-direction and sizing change	CTMP – 60AKD, 3%	-Higher retention of the AKD; -Improved on-machine sizing; -Better sizing permanence
Europe, Specialty papers	AKD emulsion	High amount of the AKD in white water and deposit problems	CottonLinters – 60AKD, 3%	Hight retention of the AKD, no deposit problems

Figure 20. Case Studies. ARBOCEL*PLUS*®-AKD compounds