



CIGARETTE PAPER

A useful tool for the design of a cigarette

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Introduction

- ↯ Cigarette paper is an integral part of the cigarette.
- ↯ It has not only the function of a wrapper for the tobacco rod, but
- ↯ influences the physical parameters of a cigarette and the smoke yield and
- ↯ has an impact on the taste of a cigarette.
- ↯ Cigarette paper determines the optical appearance.

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Structure

- κ Main ingredients of cigarette paper
- κ Influences of these ingredients on the physical parameters of cigarette paper
- κ Smoke yields
- κ Optical appearance
- κ Taste



Parameters for the characterisation of the physical properties of cigarette paper

Parameter	Description	Unit
Basis weight	Weight of the paper	$B.W. = [g/m^2]$
Porosity	Permeability of the paper; Air flow trough the paper at 1 kPa	$CU = \frac{ml}{cm^2 \cdot min}$
Opacity	Propensity of the paper to cover the tobacco rod; measured as the reflectance R_0 of light of the paper sheet compared to the reflectance R_∞ of an opaque layer	$Opacity = \frac{100 \cdot R_0}{R_\infty}$
Brightness	White grade of paper compared to $BaSO_4$ (= 100%) $\lambda = 457 \text{ nm}$	% to $BaSO_4$
Tensile Strength	Maximal force that paper will withstand before breaking at a paper width of 15 mm	$T.S. = \frac{N}{15mm}$
Burn speed	Velocity with which paper burns	$B.S. = \frac{sec}{15cm}$



Main ingredients of cigarette paper

PULP

- Long fibre wood pulp (spruce, pine, larch)
- Short fibre wood pulp (eucalyptus, birch, aspen)
- Annual plant pulp (hemp, flax, sisal)

Influence on: Basis weight, brightness, tensile strength, porosity, opacity, taste;



Filler - CaCO₃

Only CaCO₃ is allowed as filler in cigarette paper TiO₂ is not allowed as a paper ingredient because of toxicological reasons.

Influence on: Opacity, porosity, brightness, burn speed, tensile strength, basis weight;



BURNING ADDITIVES

- Na/K-Citrate
- Na/K-Acetate
- Monoammonium Phosphate
- Disodium Phosphate
- Na/K-Malate
- Na/K-Tartrate

Influence on: Burn speed, taste;



PROCESS AIDS

- Starch
- Guar gum
- Carboxymethylcellulose

Influence on: Runnability of paper machines and
cigarette makers

Retention of fibre and CaCO_3 ,
tensile strength;



Summary

Influence of paper ingredients on physical properties of cigarette paper

	<i>Pulp</i>	<i>Filler</i>	<i>Burning additives</i>	<i>Process aids</i>
Basis weight	☹	☹	☹	☹
Porosity	☹	☹	☹	☹
Opacity	☹	☹	☹	☹
Whiteness	☹	☹	☹	☹
Tensile strength	☹	☹	☹	☹
Burn speed	☹	☹	☹	☹
Taste	☹	☹	☹	☹



Influence of porosity and citrate on smoke yields

Porosity, Citrate
VS

CO
Tar
Nicotine
Puffs
Burn Rate



Design

Experimental design + analysis

↖ Response surface design

↖ Parameters:

Citrate: 0 - 2 % (5 steps)

Porosity: 20 - 60 CU (7 steps)

35 papers



Cigarette design

<u>Test cigarette design:</u>	Circumference	24,8 mm
	Tobacco rod.	63,0 mm
	Filter segment	21,0 mm
	Rod weight	0,790 g
	Filter weight	0,160 g
	Tipping dilution	0,3 %
	Filter PD	57

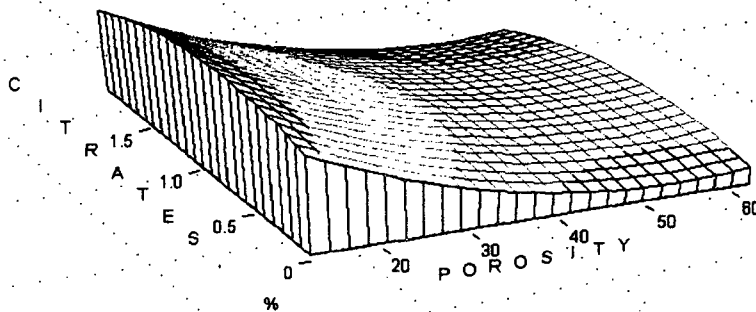
<u>Tobacco:</u>	Long	~ 33 %
	Mid	~ 52 %
	Fines	~ 15 %
	Exp. Tob.	8 %
	Nicotine	2 %



Results CO [mg/cig]

14.258 15.165 16.071 16.977 17.883 18.789

Response Surface



CO versus CU ci..., Y-var. MG CO

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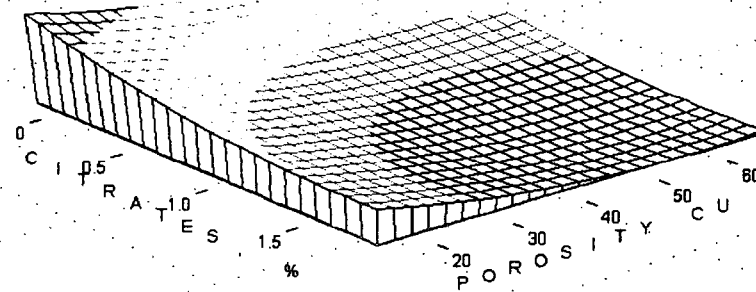
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Results nicotine [mg/cig]

0.974 1.047 1.119 1.192 1.264 1.337

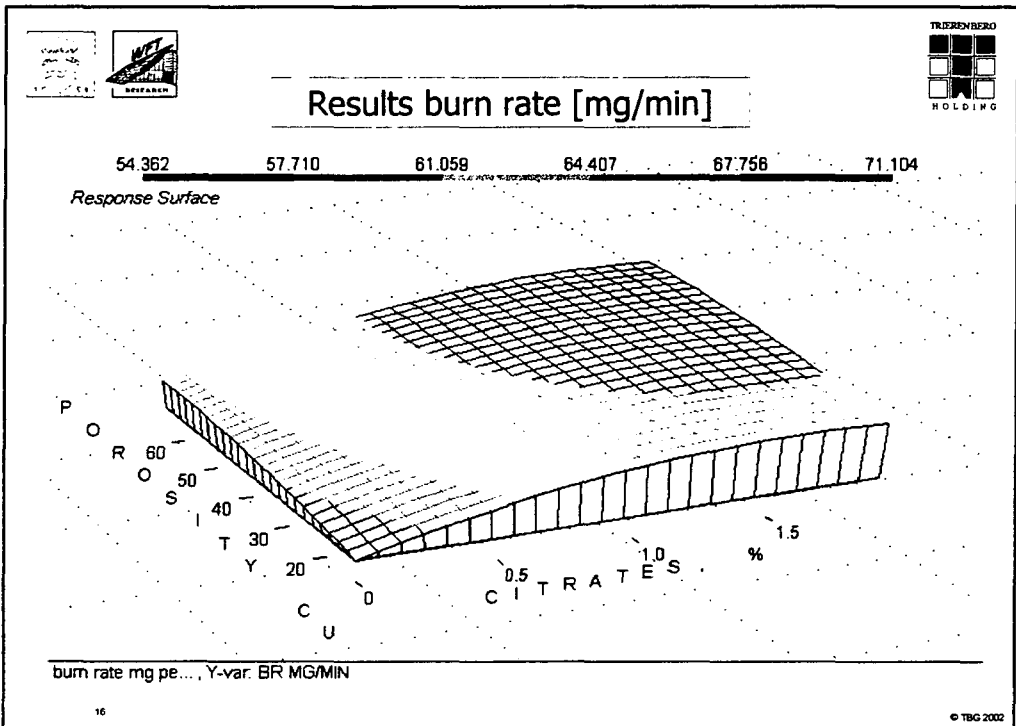
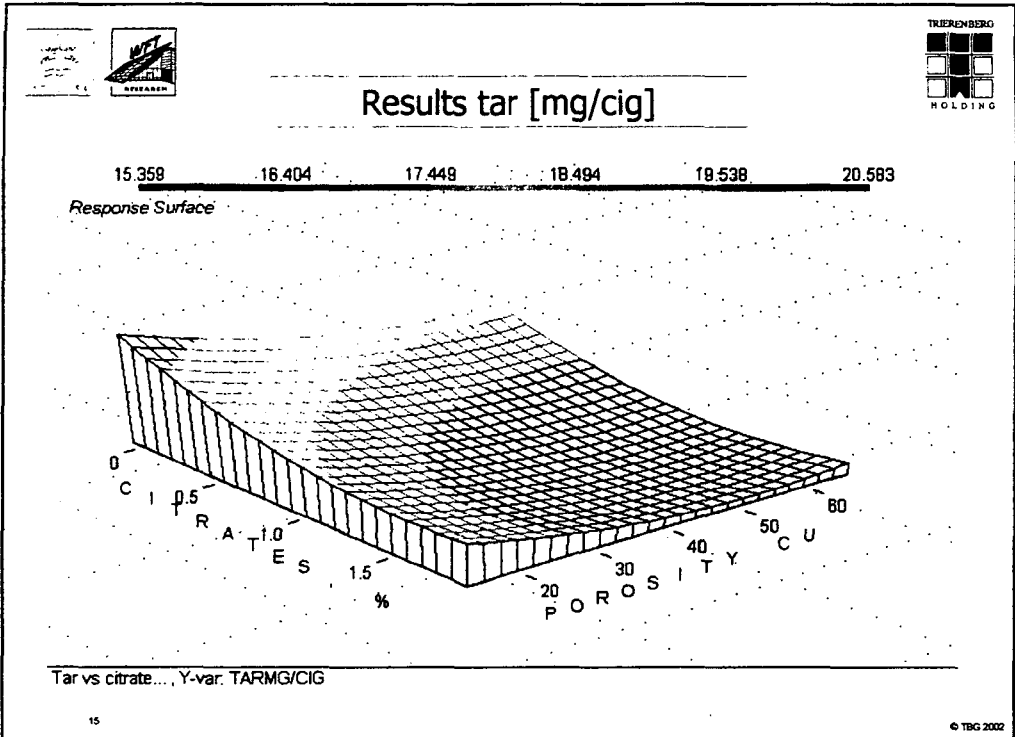
Response Surface



Nicotine vs cig..., Y-var. NICMG/CIG

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How to reduce smoke yields

Low smoke yields can be achieved with:

- High porosity of the paper
- low puff count, good diffusion through the paper
- Low basis weight
- good diffusion through the paper
- Citrate as burning additive
- because of catalytic activity; increases burning speed
- High amount of burning additive
- increases burning speed; reduces puff number
- High filler content
- low puff count



Puff count: - Filler
- Porosity

CO: - Porosity
- Fibre-base weight

Nicotine: - Porosity
- Fibre

Tar: - Porosity
- Filler



Optical appearance

Beside the paper itself the ash appearance is essential for the customer acceptance of a cigarette.



Evaluation of ash appearance

- Ash colour
- Ash cohesiveness
- Crack formation
- Flake formation



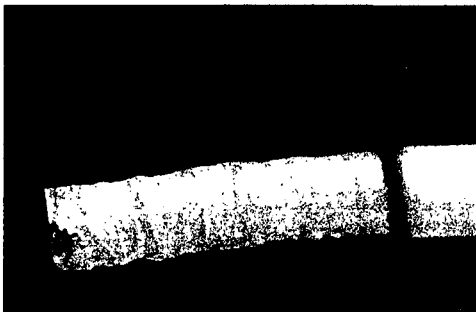
Which parameters can be used to quantitatively compare ash picture

- Number of cracks
- Colour of cracks
- Whiteness of ash
- Flakes - "fractal dimension"
- Burning line width
- Burning line characteristics
- Number of flakes
- Holes; area + number + colour

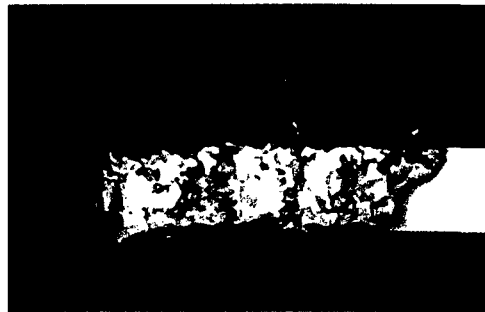


Examples of optical image analysis

Good ash appearance



Bad ash appearance





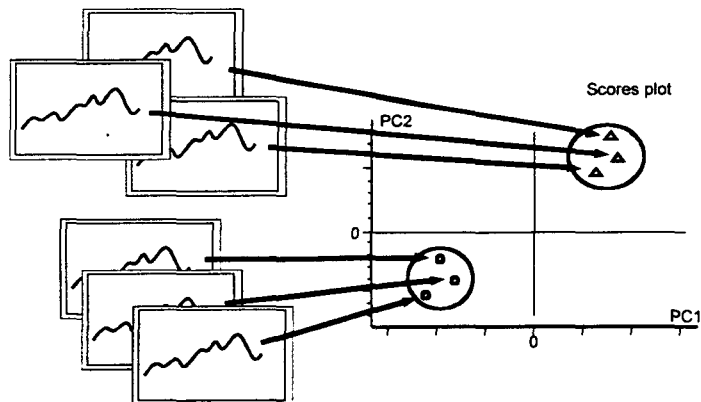
Taste

- Cigarette paper influences the taste of a cigarette
- Taste is influenced by the degradation pattern of the paper
- All fragments of the paper formed during thermal degradation are part of the taste of the cigarette
- Comparison of different pulps
- Influence of burning additives



Principal component analysis

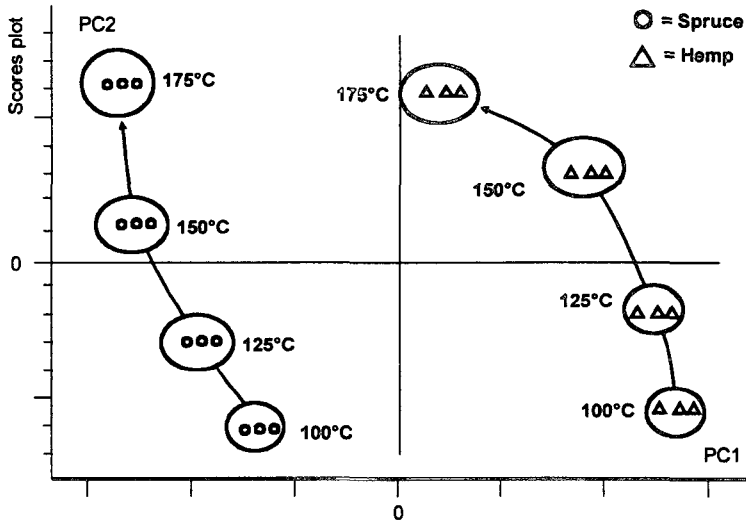
Statistical evaluation





Results of measurements

Thermo-extraction/GC: Pulp results

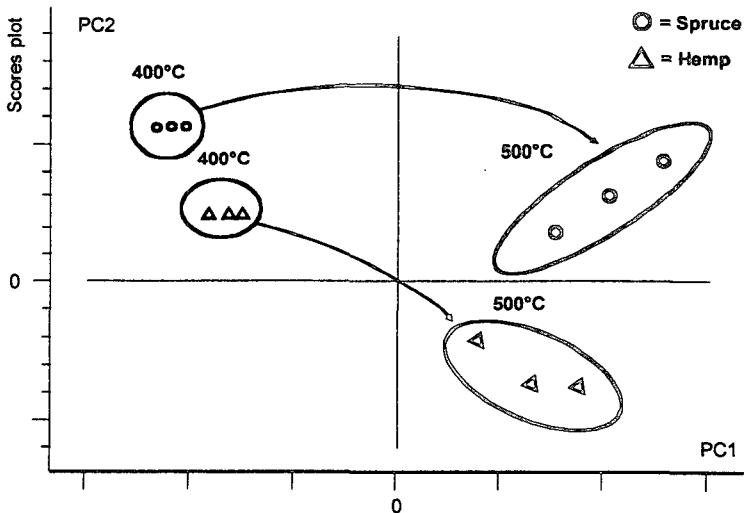


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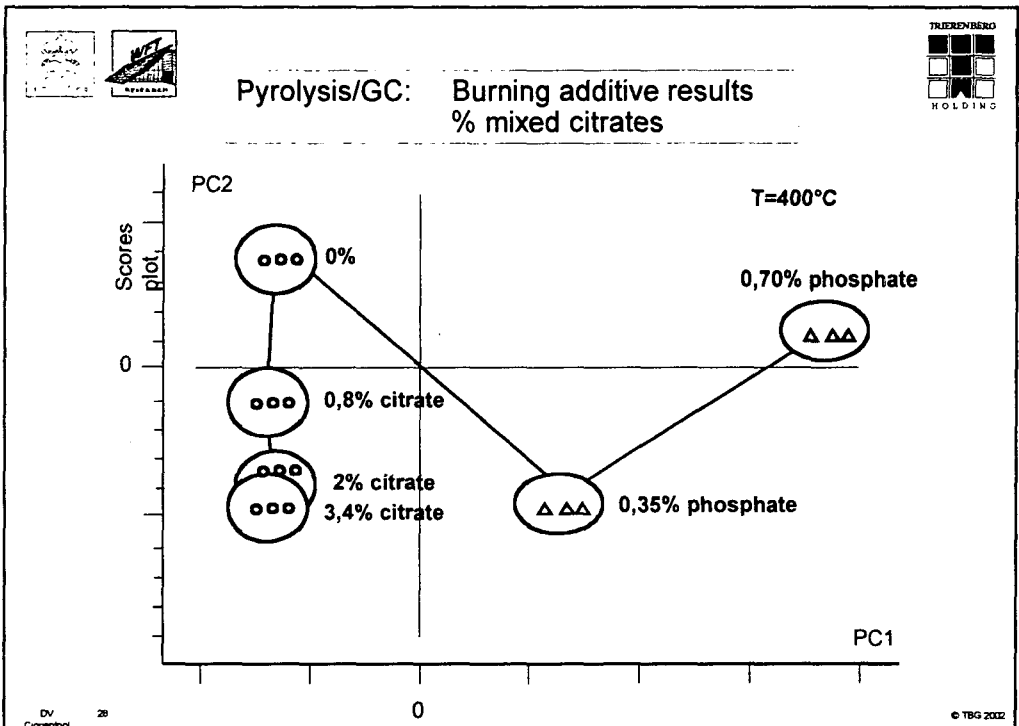
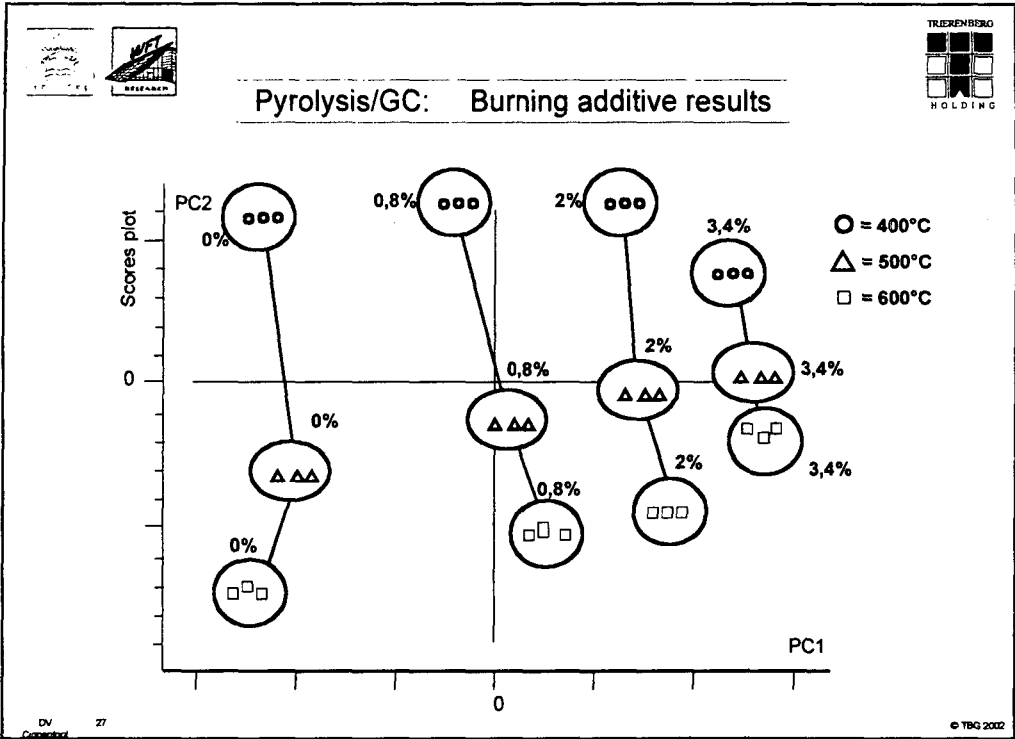


Pyrolysis/GC: Pulp results



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Conclusion

- ↯ The main ingredients and physical parameters of cigarette paper have been presented
- ↯ It could be shown how the smoke yields of a cigarette can be influenced by these parameters
- ↯ The aspect of optical appearances has been shown with the a few examples
- ↯ Influences on the degradation pattern of cigarette paper which is related to the taste of a cigarette could be shown