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조연제가 궐련지 연소성에 미치는 영향에 관하여

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Effect of burn additives on the combustibility of cigarette paper

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초 록

조연제종류 및 함량 변화가 궐련지의 연소성과 회색상에 미치는 영향을 연구한 결과 flax와 kenaf의 연소속도 및 회고결성이 NBKP보다 양호하였으며 탄산칼슘 함량이 증가함에 따라 각 펄프 공히 연소속도는 빨라지나 회고결성은 저하되었다.

구연산·초산·주석산나트륨은 첨가량이 3%까지 증가되어도 연소속도에는 큰차가 없으나 4%이상부터 빨라지는 경향이었다. 인산나트륨은 함량이 증가하면서 연소속도는 늦어진 반면 회고결성은 양호해졌다.

구연산나트륨에 요소·푸말산나트륨·인산암모늄·인산·말레인산나트륨 및 guanyl urea phosphate를 첨가시 인산암모늄의 회편변동율이 170%로 회고결성이 가장 양호하였으나 연소속도는 대체로 늦어지는 경향이다. 조연제의 함량이 증가함에 따라 회의 백색도는 55전후에서 30으로 감소하는 경향이다.

Introduction

It is generally accepted that the static burning rate of cigarette is affected by the paper, the tobacco and cigarette construction.[1] Even though the weight of cigarette paper, one of these factors, is only about 5% of the total tobacco column, the static burning rate of

cigarette paper is influenced by the porosity, the type and the content of burn additives and the raw material composition. A little amount of burning chemicals is present as very fine crystal on the surface of the filler and fibers and then have a great influence on the static burning rate, ash firmness and ash color of the cigarette paper.

Burning chemicals have been placed into accelerators, ash conditioners and retardants. However, the relationships between burning rates and the chemicals were not clearly understood.

Owens and Townsend[2,3] reported that the addition of an ash conditioner such as mono ammonium phosphate(MAP) has little influence on the static burning rate or puff count, but did cause the increased tar and CO deliveries, while the production of CO_2 may not be increased. On the other hand, the increasing amount of the citrate did increase the static burning rate and CO and CO_2 deliveries.

It shows from Bradbury et al's paper[4] on cellulose that oxygen chemisorption on chars that result from pyrolysis was highly exothermic, and that the heat release due to this process provided the major deriving force for smolder propagation.

Degroot et al.[5] indicated that additives could alter the rate of oxygen chemisorption on cellulose chars and the total oxygen uptake, whereas the presence of MAP resulted in chars with lower rate of chemisorption but higher oxygen uptake.

Many researchers have reported the mechanisms of pyrolysis of cellulose and the flame retardant concerning to the fire prevention,[6,7,8,9,10] especially textile and wood; but, little literature has been published on the function of burn additives in cigarette paper.

The strip burn rate, ash color, and ash firmness of cigarette paper were affected by some major parameters—pulp composition, filler content and burning chemicals.

This study was undertaken to investigate the effect of these parameters on the physical properties of cigarette paper.

Materials and Methods

1. Materials

Pulps used in this study were flax, kenaf and NBKP and filler was precipitated calcium carbonate. The burning chemicals added were reagent-grade and dissolved in distilled water for preparing solutions of various concentrations.

2. Sample preparation

The basis weight of hand-sheet made of flax(77°SR), kenaf(62°SR) and NBKP(79°SR) and various calcium carbonate levels was 25g /㎡ based on the KSM 7030.

Commercial cigarette paper (kenaf 60% and NBKP 40%, porosity 70 c·u.; CORESTA Unit) was examined simultaneously.

3. Experimental method

Hand sheet and commercial cigarette paper were treated with the various levels of additives in all experiments.

The burining rate of paper strip was measured by checking the burning time of the strip, size 27×100 mm suspended vertically with the combustion tester designed by KGTRI. (Korea Ginseng and Tobacco Research Institute)

The size of ash flakes was measured every three second and its coefficient of variation (C.V) was calculated. If the C.V. value of ash size was high, the ash firmness was considered desirable. Whiteness of paper ash treated with

burn additives was tested by Hunterlab Tristimulus colorimeter (Model K251-9, Hunter associates laboratory Inc., USA)

Results and discussion

1. Paper strip burn rate and ash firmness

Various chemical compounds can be added to cigarette paper to alter the paper strip burn rate.

Paper strip burn rate and the coefficient of variation of ash size are shown in Fig. 1 and 2 as function of sodium citrate levels and various pulps. It was found that the increasing concentration of sodium citrate appeared to speed up strip burn rate. As indicated in Fig. 2, C.V. of ash size of flax and kenaf was slightly higher than that for NBKP. These results are in agreement with Samfied's report[11] which describes that bast fiber speeded up the burning rate.

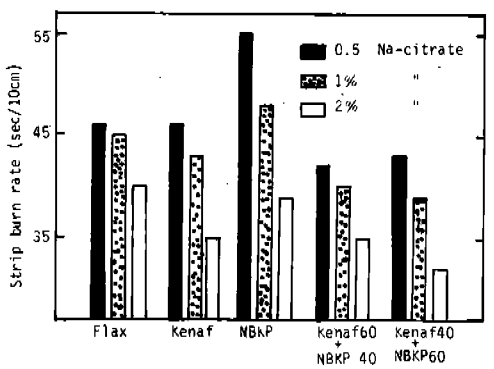

Fig. 1. Relation between the strip burn rate and the concentration of sodium citrate.

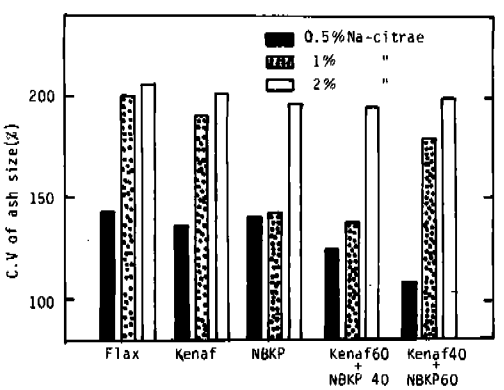

Fig. 2. Relationship between the coefficient of variation of ash size and the concentration of sodium citrate.

In case of NBKP, fiber is rigid and thermal degradation was resisted due to small amount of remaining lignin as reported by Hornof and co-workers,[12] considering the reason of retardment of burning rate.

On the other hand, in case of mixed pulp (Kenaf+NBKP) paper strip burn rate was faster than those of bast fiber or NBKP alone but C.V. of ash was similar to that of NBKP.

Meantime, Fig. 3 and 4 illustrate relationships between porosity and paper strip burn rate as well as coefficient of variation of ash size versus content of calcium carbonate.

As given in Fig. 3, paper strip burn rate was faster with increasing amount of calcium carbonate and this reduces us to think that

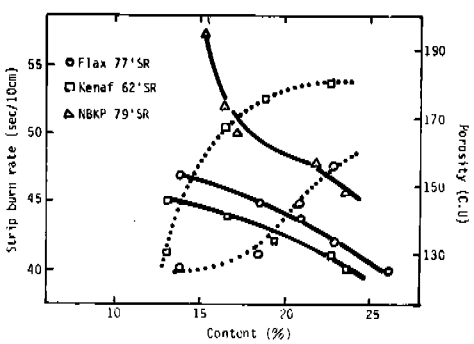

Fig. 3. Influene of the centent of calcium carbonate on the strip burn rate and the porosity of hand sheet. The concentration of added burn additive was 1% Na-citrate. *-; strip burn rate, --; porosity

paper strip burn rate was not affected by the porosity of cigarette paper.

This was confirmed by the report of Schur[13] that calcium carbonate was used to regulate the porosity and burning rate of the paper.

Added sodium citrate present on the surface of the filler seemed to enhance the strip burn rate.

The content of calcium carbonate has an inverse effect on C.V of ash size with various pulps as shown in Fig. 4.

In agreement with the result by Heath et al.[14] that the addition of filler reduced tensile strength, increased amount of calcium carbonate reduces fiber-bonding followed by affecting ash strength. It is believed that C.V of ash size of NBKP lowered due to the difference of fiber length among pulps after beating.

The effect of sodium salts of organic acid on the paper strip burn rate is summarized in Table 1.

Sodium salts of citric acid, acetic acid and tartaric acid similar to the decomposition

Table 1. Changes in strip burn rates and coefficients of variation of ash size as a function of the concentration of burn additives.

Burn addivtives	Concentration (%)	Strip burn rate (sec/10cm)	C.V of ash size(%)
Na-citrate	0.5	40	87
	1	39	115
	2	40	120
	3	40	128
	4	38	156
Na-Tartrate	0.5	41	80
	1	40	91
	2	40	110
	3	40	116
	4	39	134
Na-Acetate	0.5	39	85
	1	39	112
	2	39	117
	3	39	149
	4	35	159
Na-phosphate	0.5	-	-
	1	42	-
	2	43	99
	3	44	159
	4	47	162

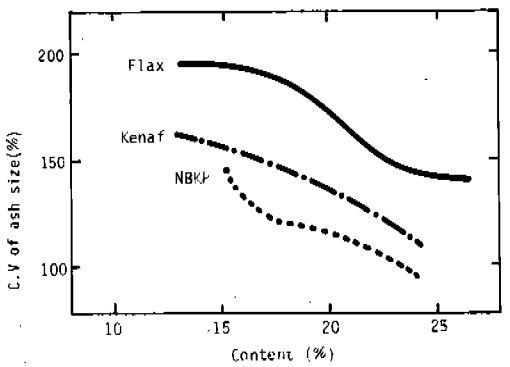

Fig. 4. Relationship between the content of calcium carbonate and the coefficient of variation of ash size. The concentration of added burn additive was 1% Na–citrate.

temperature of cellulose in pyrolysis are seen to be not so much different in the strip burn rate until 3% of those burn additives added, having the high strip burn rate with the addition of more than 4%.

Sodium phosphate, regardless of the content, might retard the burn rate of the paper strip.

According to the report of Bradbury et al.,[4] oxygen chemisorption on chars resulted from pyrolysis was highly exothermic, and that the heat release provide the major deriving force for smolder propagation. Sodium salts of organic acid enhance levoglucosan formation of an easy burning compound and then decomposed to produce flammable gases which increased the heat of combustion and thus increased burning.

Phosphate interacted with the hydroxyl groups of cellulose, prevented forming levoglucosan, and thus inhibited burning.

Coefficients of variation of ash size increased with increasing concentrations of burn additives. Owens[2] reported that burn additives incresed the weight of remaining char and that the increase of C.V of ash size was due to the increase of remaining char. The strip burn rate and C.V of ash size for several ash conditioners mixed with sodium citrate are shown in Table 2.

According to the results above ammonium phosphate led to the highest C.V of ash size, 170%. This was demonstrated by Tang,[8] Huang,[7] Hendrix[9], and Stephenson.[15] It is presumed that ammonium phosphate acted as an acid through the decomposition to phos-

Table 2. Changes in strip burn rates and coefficients of variation of ash size as a function of various ash conditioners.*

Ash conditioners	Strip burn rate (sec/10cm)	C.V of ash size(%)
Na–citrate	39	87
Urea	42	127.9
Na–fumarate	44	162.0
Ammonium phosphate	44	170.0
Phosphoric acid	43	140.8
Guanyl urea phosphate	42	140.2
Na–maleate	46	163.1

* 0.5% Na–citrate +0.5% ash conditioner

phoric acid and ammonia gas and that the resultant acid esterified the glucose unit to produce glucose-6-phosphate.

The phosphoric acid also promoted the formation of a solid carbonaceous char in the cellulose which did not support combustion and forms a film of condensed acid over the surface of the cellulose, thereby preventing access of oxygen to the burning site.

Patil et al.[10] had reported that P-N bonds facilitated the phosphorylation of the hydroxyl groups of cellulose. The coefficient of variation of ash size in phosphoric acid was 140% and ash firmness show poorer than that of ammonium phosphate but the strip burn rate was fast.

2. Variance of ash color

Fig. 5 illustrates the relationship between

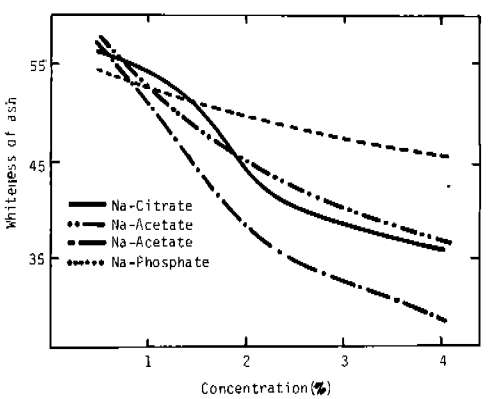

Fig. 5. Relationship between whiteness of ash and the concentration of burn additives.

whiteness of ash and burn additives. Most paper ash was getting darker with increasing concentration of burn additives except sodium phosphate. The dark color of the ash resulted from the incomplete combustion of fiber and ash color was related to the paper strip burn rate.

Conclusion

The effect of types and content of some burn additives on the combustibility and the ash color of cigarette paper have been studied. The paper strip burn rate and the ash firmness of flax and kenaf were better than those of NBKP.

The high concentration of calcium carbonate in cigarette paper made of these pulps appeared to speed up the strip burn rate and to make the ash firmness poor.

Among the papers containing the sodium salt of citric acid, acetic acid and tartaric acid, there was not so much difference in the strip burn rate up to 3% of the additives added. When the concentrations of the additives were higher than 4%, the strip brun rate was increased. On the other hand, regardless of the amount used, the decreased strip burn rate of paper containing Na-phosphate and better ash firmness were observed.

Sodium citrate mixed with ammonium phosphate known as an ash conditioner showed the highest coefficient of variation of ash size, 170%, while the cigarette paper with ash conditioner generally exhibited a lower strip burn rate than that of Na-citrate alone.

An increased amount of burn additives in cigarette paper decreased the whiteness of ash from 55 to 30.

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