FILTRATION EFFICIENCIES AND DISTRIBUTION PATTERNS OF NICOTINE IN FILTERS OF DIFFERENT STRUCTURE

Wen Jianhui[1], Du Wen[1], Peng Bing[2], Zhang Xiaobin[2], Li Yanping[1], Xie Fuwei[2], Liu Huimin[2]
1. Technology Center of China Tobacco Hunan Industrial Co., Ltd., Changsha 410007, China. 2. Zhengzhou Tobacco Research Institute of CNTC, Zhengzhou 450001, China

Abstract

Nicotine filtration efficiencies in filters of different structure and retaining nicotine distribution patterns in filters as well have been investigated. By quantitatively analyzing nicotine contents in mainstream smoke and filters and taking the ratio of filter retaining nicotine to total nicotine release as nicotine filtration efficiency, nicotine filtration efficiencies of four kinds of filters were presented. While using the same raw & assistant materials and all cigarette samples have same parameters such as filter length and pressure drop, nicotine filtration efficiencies of four filters, i.e., regular filter, outer grooved filter, inner grooved filter and cavity filter, are 39.06%, 45.45%, 39.63% and 31.75%, respectively. In nicotine distribution research, filters were transversely and homocentric lengthways cut firstly using an accurate laser cutting machine, and then nicotine in those divided filter parts were quantitatively analyzed. The nicotine distribution data were calibrated firstly and then treated by polynomial fitting and interpolation analysis. Retaining nicotine distribution patterns, including longitudinal, cross sectional radial and tridimensional, of different filters were obtained. Nicotine retaining contributions of individual longitudinal parts were analyzed based on the retaining nicotine longitudinal distribution patterns and the distribution pattern differences were explicated by filter structural effect on smoke flow.

Materials and Methods

•Materials: Isopropyl alcohol, n-heptadecane, absolute ethyl alcohol, nicotine standard. Five cigarette samples with different structures are shown in table 1.

•Nicotine filtration efficiency: Cigarette samples were smoked under the standard smoking conditions with 1puff/min of 35 ml and 2 seconds duration. The nicotine retained in filter and cambridge filter were analyzed by gas chromatography. The nicotine filtration efficiency of filters is the ratio of nicotine quantity retained in filter to total nicotine release.

•Filter cutting: Filters after smoking were cut by the ILS-IIINM accurate laser cutting machine. In transversely cutting, filters were independently cut many times at different positions, and then nicotine in two cut filter sections was analyzed. In vertical concentric circle cutting, filters were firstly cut into three sections, three sections were then independently vertical concentric circle cut at different radius (r1=1.26 mm, r2=2.52 mm). Nicotine in inner and outer sections was analyzed.

•Nicotine analysis and calibration: Nicotine in filters was analyzed by GC. Laser cutting causes nicotine loss for the laser line's high temperature. The relational models of nicotine loss percent in transverse cut and vertical concentric circle cut with cutting area were experimentally built for nicotine analysis data calibration (details not shown).

•Nicotine distribution patterns: The nicotine concentration distribution in different filter parts were treated by polynomial fitting and interpolation analysis using MATLAB software. Retained nicotine distribution patterns, including longitudinal, cross sectional radial and tridimensional, of filters with different structure could be obtained.

Table 1 cigarette samples with different filter structures for test

No	Filter structure		Tip length (mm) and ventilation (%)
1	Regular AF	AF	28/0
2	Outer grooved AF + regular AF	CVD AF	28 (18+10)/0
3	Regular AF +inner grooved AF	AF CVD	28 (10+18)/0
4	AF + cavity +AF	AF cavity AF	28 (11+6+11)/30
5	AF with cavity + AF	Cavity AF	25 (7+18)/0

Results

•Nicotine filtration efficiency of different filters: The results are shown in table 2. Filter structure has significant influence on nicotine release as well as nicotine filtration efficiency. Filters with special structures can reduce total nicotine release as well as nicotine release in mainstream smoke in different degree.

Table 2 Nicotine release and filtration efficiency of different filters

Samples	Nicotine in mainstream smoke (mg/cig)	Nicotine in filter (mg/cig)	Total nicotine release (mg/cig)	Filtration efficiency (%)
No.1	1.17	0.75	1.92	39.06
No.2	0.96	0.80	1.76	45.45
No.3	0.99	0.65	1.64	39.63
No.4	0.86	0.40	1.26	31.75

•Longitudinal distribution patterns of retaining nicotine in filters with different structure: In figure 1. A, B, C and D stand for nicotine longitudinal distribution patterns in regular filter, outer grooved filter, inner grooved filter and cavity filter(No.5 sample) respectively. a, b, c and d in figure 1 are corresponding color scale longitudinal distribution map.

•Cross sectional radial distribution patterns of retaining nicotine in filters with different structure: In figure 2, A, B, C and D stand for nicotine cross sectional radial distribution patterns in regular filter, outer grooved filter, inner grooved filter and cavity filter(No.5 sample) respectively. a, b, c and d in figure 2 are corresponding color scale cross sectional radial distribution map.

•Tridimensional distribution patterns of retaining nicotine in filters of different structure: Retaining nicotine tridimensional distribution patterns in regular filter, outer grooved filter, inner grooved filter and cavity filter were shown in figure 3 to figure 6 respectively.

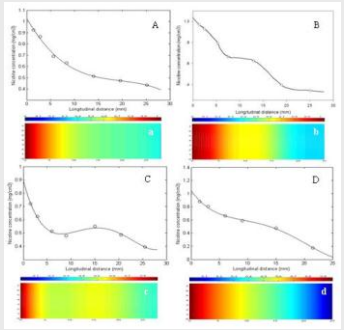

Figure 1 Retaining nicotine longitudinal distribution patterns in filters of different structure.

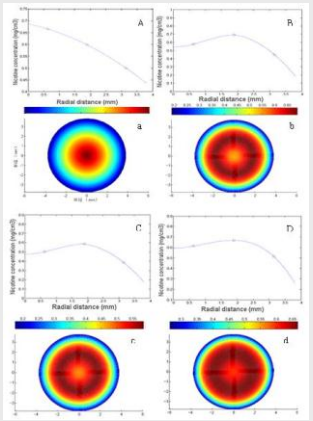

Figure 2 Retaining nicotine cross sectional radial distribution patterns in filters of different structure.

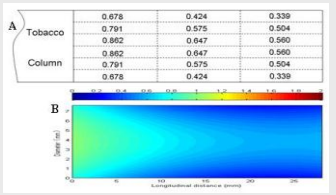

Figure 3 Retaining nicotine tridimensional distribution patterns in regular filter.

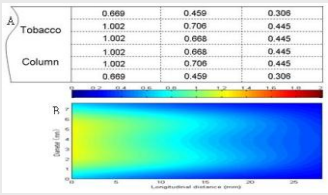

Figure 4 Retaining nicotine tridimensional distribution patterns in outer grooved filter.

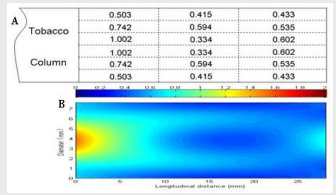

Figure 5 Retaining nicotine tridimensional distribution patterns in inner grooved filter.

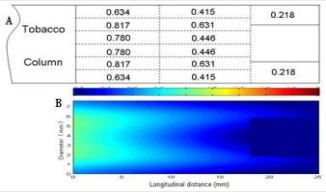

Figure 6 Retaining nicotine tridimensional distribution patterns in cavity filter.

Conclusions

•Filter structure has effect on its nicotine filtration efficiency. Under the same conditions of materials, filter length and pressure drop, nicotine filtration efficiencies of filters with different structure are: outer grooved filter＞inner grooved filter≈regular filter＞cavity filter.

•A method to investigate retaining nicotine distribution in filter was presented. By transversely and homocentric lengthways cutting to filters, quantitatively analyzing nicotine in those divided filter parts, and data treatment with polynomial fitting and interpolation analysis, Retaining nicotine distribution patterns, including longitudinal, cross sectional radial and tridimensional, of filters with different structure were obtained.

•Filter structural change can markedly alter mainstream smoke flow. The nicotine distribution pattern differences among filters with different structure were explicated by smoke flow changes

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