Asian Journal of Medicine and Health
1(3): 1-7, 2016, Article no.AJMAH.29129

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Effect of Draw Resistance on NNK and Its Contribution on Cigarette Hazard Index

Wang Hao[1*+], Zhan Jianbo[1+], Ji Yafeng[2+], Fu Rongrong[3+], Li Muyan[4+], Chen Chen[5], Wang Xiuxiu[6], Perin Deniz[7], Li Zhiqiang[1], Gao Li[1], Li Tinghua[1], Cheng Liang[1], Yu Tingting[1], Xie Jiao[1], Ding Haiyan[1], Li Liwei[1], Yu Jiang[1], Yu Yao[1], Li Gen[1], Yu Zhenhua[1], Zhang Ying[1], Yue Baoshan[1], Zheng Han[1], Ding Wei[1], Zhang Jing[1], Wang Tao[1], Gong Weimin[1] and Gui Yongfa[1]

[1]R&D Center, China Tobacco Yunan Industrial Co., Ltd., Kunming 650231, China.
[2]Heavy Industry Engineering Center of China Ministry of Education, Taiyuan University of Science and Technology, Taiyuan 030024, China.
[3]Measurement Technology and Instrumentation Key Laboratory of Hebei Province, Yanshan University, Qinhuangdao 066004, China.
[4]Honghe Cigarette Factory, Hongyunhonghe Tobacco (Group) Co., Ltd., Honghe 652399, China.
[5]School of Mechanical Engineering, Shenyang University of Technology, Shenyang 110870, China.
[6]College of Chemistry, Liaoning University, Shenyang 110036, China.
[7]Department of Physics, Balikesir University, Balikesir 10145, Turkey.

Authors' contributions

This work was carried out in collaboration among all authors. Authors WH, Zhan Jianbo, JY, FR and LM designed the study, wrote the protocol and interpreted the data. Authors CC, WX, PD, LZ, GL and LT anchored the field study, gathered the initial data and performed preliminary data analysis. Authors CL, YT, XJ, DH, LL, YJ, YY, LG, YZ, ZY, YB, ZH, DW, Zhang Jing, WT, GW and GY managed the literature searches and produced the initial draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJMAH/2016/29129
Editor(s):
(1) Kishore Kumar Jella, Department of Radiation Oncology, Winship Cancer Institute, Emory University, Atlanta, GA, USA.
(2) Giuseppe Murdaca, Clinical Immunology Unit, Department of Internal Medicine, University of Genoa, Italy.
Reviewers:
(1) Milan Bimali, University of Kansas School of Medicine, Wichita, KS, USA.
(2) Anirudh Bhattacharya, VYWS Dental College & Hospital, Amravati 444601, India.
(3) Luiz Claudio Lacerda Rodrigues, School of Medicine Santa Marcelina, German Hospital Oswaldo Cruz, Brazil.
(4) Jerzy Bełtowski, Medical University, Lublin, Poland.
Complete Peer review History: http://www.sciencedomain.org/review-history/16655

Original Research Article

Received 24th August 2016
Accepted 5th October 2016
Published 25th October 2016

**Corresponding author: E-mail: neuwanghao@gmail.com;*
*+ : equal contributors and Co-first authors; * : Corresponding author*

ABSTRACT

Effect of cigarette draw resistance between 860-1130Pa on deliveries of NNK in mainstream cigarette smoke（MCS）was investigated, and contribution degree of cigarette hazard index was proposed for the first time to study how the contribution degree could be affected by 7 harmful components. Effect of NNK with different draw resistance on contribution degree of cigarette hazard index was also investigated. The results showed that contribution degree of NNK is uniform, which is different from variation of Benz [a] Pyrene, ammonia and phenol, meanwhile, 1000Pa could be viewed as critical draw resistance, and there is an obvious mainstream cigarette smoke variation below and above 1000Pa. Analysis of contribution degree of cigarette hazard index separately is a feasible tool to study variation of smoke harmful components, which lays foundation for further changing trend and roles of different harmful components while the cigarette hazard index changes.

Keywords: NNK; draw resistance; mainstream cigarette smoke; harmful components; cigarette hazard index.

1. INTRODUCTION

In 1998, a modified Hoffmann list was widely recognized by the medical profession and the tobacco industry, causing a great impact in the world. Most countries concentrate more stringent restrictions on the release of Hoffmann in cigarette products, and consumers are increasingly concerned about the Hoffmann components. Now filtering function of the filter is mostly based on tar and nicotine, and there is little study on filtering efficiency on harmful ingredients such as tar and nicotine. At present, product design philosophy targeting on release amount of Hoffmann components (CO, NNK, ammonia, HCN, Benz [a] Pyrene, croton aldehyde and phenol) has been widely accepted. Hoffmann components (CO, NNK, ammonia, HCN, Benz [a] Pyrene, croton aldehyde and phenol) were applied by China's tobacco industry as a significant standard of the target products [1]. NNK is a strong carcinogen, is one of the most important chemical carcinogens, is one of the four major food contaminants. Nitrite is contained in food, cosmetics, beer and cigarettes. Smoked cured food contains a lot of nitrosamines, some digestive system tumors, such as esophageal cancer incidence and the number of the dietary intake of nitrosamines associated. When smoked food and wine were taken together, the harm to human health will increase exponentially.

Xie Jianping provided a characterization method of harmful ingredients including CO, NNK, ammonia, HCN, Benz [a] Pyrene, croton aldehyde and phenol. This method is widely applied in the design and evaluation of cigarettes [2]. Some researchers investigated the effect of cigarette paper, tipping paper and other materials on the release of cigarette smoke components [3-7], and some scholars dwelled on the harmful components and the release of mainstream smoke [8-13]. Some scholars investigated the effect of the design parameters on harmful components of cigarette smoke [14-18]. Some researchers dwelled on the effects of different pumping conditions on harmful gas emissions and the main harmful substances emission and hazard assessment [19-23]. Peng Bin et al. proposed a cigarette hazard assessment system based on the multi objective decision making [24]. Some scholars researched on the relationship between the physical indicators of cigarettes and draw resistance [25-26]. Although the influence of auxiliary materials parameters on the harmful components has been reported, the influence of the draw resistance on the harmful components of cigarette smoke has not been systematically studied and reported. The research provides the basis for the optimization of the design parameters to decrease harm cigarette process, which provides theoretical reference for follow-up study on variation of the harmful components and design of cigarette products while the H value changes.

2. EXPERIMENTAL

Cigarette samples with different draw resistance were provided by China Tobacco Yunnan Industrial Co. Ltd. The chemical products applied in the experiments are all chromatographic pure.

Main instruments applied include cigarette ignition device, a cigarette by mouth suction collection system; RM20H smoking machine; Research N1 infrared thermal imaging instrument; Agilent 1200 HPLC, Agilent 7890A gas chromatograph, Agilent7890-5975 gas chromatography mass spectrometry combined with analyzer; IC3000 ion chromatograph; AA3 continuous flow analyzer; Gas Trace2000 phase chromatography -TEA610 type thermal energy analyzer.

According to national standard GB/T 23356-2009, GB/T21130-2007, YC/T253-2008, GB / T23228-2008, YC / T377-2010, YC / T255-2008, YC / T254-2008, harmful components of CO, Benz [a] Pyrene, HCN, NNK, ammonia, phenol and crotonaldehyde in the cigarette smoke were tested [27-33].

3. RESULTS AND DISCUSSION

3.1 Critical Draw Resistance and Its Effects on NNK

NNK varies obviously with the draw resistance. Draw resistance between 860-1130Pa was selected to analyze NNK variations shown in Fig. 1.

As shown in Fig. 1, when the draw resistance is less than 1000Pa, NNK has obvious fluctuating value between 5.5-6.9 ng/cig, as the draw resistance continues to rise to above 1000Pa, variation of NNK tends to be stable and maintained between the 5.7-7.3 ng/cig.

From the discussion above, 1000 Pa can be regarded as the critical draw resistance of NNK. There is an obvious change of harmful components at 1000 Pa, and the critical draw resistance has important effect on harmful smoke components. In the design process of cigarette parameters, including punching location, which are related to draw resistance, the effect of critical draw resistance should be considered in detail.

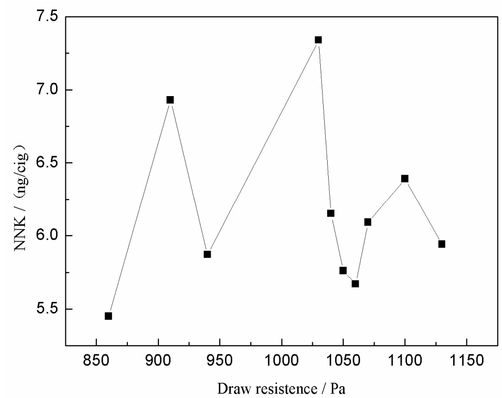

Fig. 1. Variation of NNK with different draw resistance

3.2 Calculation of H Value Contribution Degree

Xie Jianping put forward to calculate flue gas of H value index [2].

$$H = \left(\frac{X_{CO}}{C_{CO}} + \frac{X_{HCN}}{C_{HCN}} + \frac{X_{NNK}}{C_{NNK}} + \frac{X_{\text{ammonia}}}{C_{\text{ammonia}}} + \frac{X_{\text{Benz [a] Pyrene}}}{C_{\text{Benz [a] Pyrene}}} + \frac{X_{\text{crotonaldehyde}}}{C_{\text{crotonaldehyde}}} + \frac{X_{\text{phenol}}}{C_{\text{phenol}}} \right) \times \frac{10}{7} \quad (1)$$

Where H is the hazard value index, X_{CO}, X_{HCN}, X_{NNK}, X_{NH_3}, $X_{\text{Benz [a] Pyrene}}$, $X_{\text{crotonaldehyde}}$ and X_{phenol} are the harmful components emission quality respectively, C_{CO}, C_{HCN}, C_{NNK}, C_{ammonia}, $C_{\text{Benz [a] Pyrene}}$, $C_{\text{crotonaldehyde}}$ and C_{phenol} are responding the calculation reference value from the national standard, and C_{CO} = 14.8, C_{HCN} =126.7, C_{NNK} = 4.7, C_{ammonia} = 7.8, $C_{\text{Benz [a] Pyrene}}$ = 8.2, $C_{\text{crotonaldehyde}}$ = 22.1, C_{phenol} = 19.4 respectively..

To further study different harmful components, authors proposed H value contribution degree, and the definition is as follows [34],

$$\gamma_i = \frac{X_i}{H \cdot C_i} \times \frac{10}{7} \times 100\% \quad (2)$$

where γ_i is the H value contribution degree of harmful component type ***i*.**

$$\gamma_{\mathrm{NNK}} = \frac{X_{\mathrm{NNK}}}{H \cdot C_{\mathrm{NNK}}} \times \frac{10}{7} \times 100\% \quad (3)$$

where γ_{NNK} is the H value contribution degree of NNK.

H value contribution degree reflects the contribution of each harmful smoke to the total H value. H value is influenced by different harmful smoke components. The greater the value is, the greater effect of the harmful smoke on H value index is. Different harmful smoke components can be divided into two groups according to the similar change trend of the seven kinds of harmful gas. Resistance to suction effect on Benz [a] Pyrene, ammonia and phenol values are similar.

Comprehensive comparison of the three types of smoke harmful components' contribution degree to the H value and the other four types of harmful components are as shown in Fig. 2 [34].

As can be seen from the analysis on H value contribution degree variation of harmful smoke components, when the draw resistance is lower than 1000Pa there is an obvious fluctuation of three kinds of harmful smoke components. When the draw resistance is higher than 1000Pa, H value contribution degree of NNK maintained at 13.3% - 16.7%. At the same time, in contrast to H value contribution degrees of CO, crotonaldehyde, HCN and NNK, it can be found that H value contribution degrees of Benz [a] Pyrene, ammonia and phenol is significantly lower than that of the NNK. Although H value contribution degree of NNK is consistent with three harmful components of croton aldehyde, HCN and CO, it occupies greater proportion and plays a more significant contributing role. Classifying harmful ingredients according to the similar variation as another group is a reasonable division [34].

3.3 Linear Relationship among H Value Contributions of NNK, Aldehyde, HCN and CO

Linear relation and fitting degree of H value contribution of NNK, aldehyde, HCN and CO, were verified by Origin 8.0 software, which can be seen in Fig. 3.

Among H value contribution degree of NNK, aldehyde, HCN and CO there is a linear relationship. Most of the data still satisfy linear distribution and fitting degree is greater than 0.70, which also proves that linear relationship among NNK, aldehyde, HCN and CO H value contribution exists, as discussed in Section 3.2. Meanwhile authors also analyzed the linearity between H value contribution degrees of these harmful components and contribution degree of another group of Benz [a] Pyrene, ammonia and phenol. Analysis above showed that the method of classifying NNK, aldehyde, HCN and CO according to the variation of H value contribution degree from another group is feasible, and H value contribution is effective when used as a tool to analyze harmful smoke components.

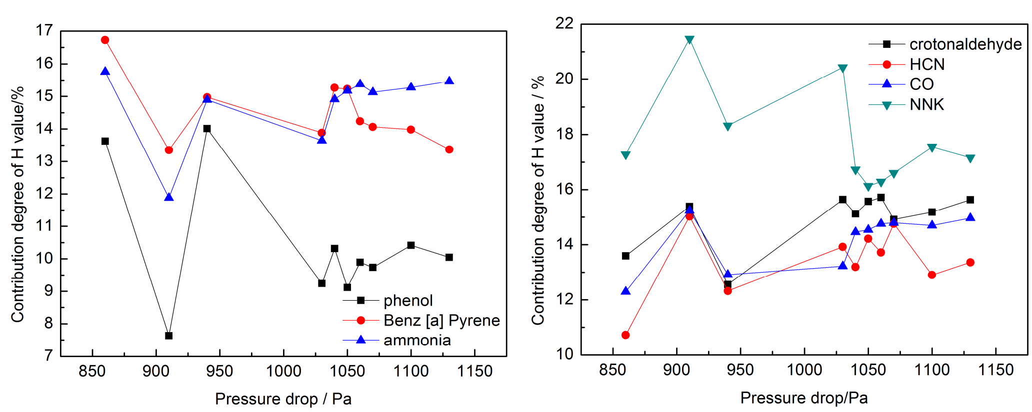

Fig. 2. Variation of H value contribution of 7 types of harmful flue gas components under different pressure drops [34]

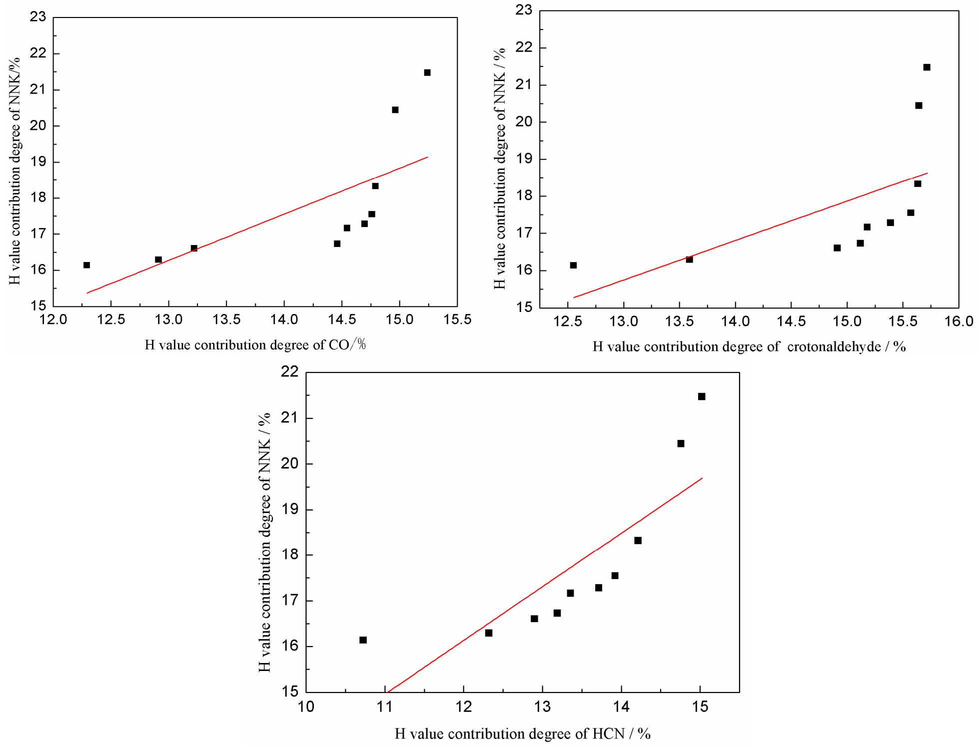

Fig. 3. Relation among H value contributions of NNK, aldehyde, HCN and CO

4. CONCLUSIONS

The concept of H value contribution degree reflects the contribution of the main harmful smoke components to the H value, which is an effective tool to measure and calculate the variation of the harmful smoke components. 1000 Pa can be viewed as the critical draw resistance of NNK, and draw resistance is an important standard definition of corresponding smoke and its H value variation. Variation of H value contribution of NNK, aldehyde, HCN and CO is consistent, and there is a linear relationship. Analysis on H value contribution of the harmful smoke is a feasible method to study smoke variation, which also provides a theoretical basis for the changes of the harmful components for further study of H value.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this paper and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

ACKNOWLEDGEMENTS

The financial support of National Natural Science Foundation of China (Grant No.51404159), Science and Technology Project of Hebei Province (Grant No. 152177180) and Science and Technology Project of Qinhuangdao City (Grant No. 201502A037) are greatly acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hoffmann D, Hoffmann I, El-Bayoumy K. The less harmful cigarette: A controversial issue. A tribute to Ernst L. Wynder [J]. Chemical Research in Toxicology. 2001;14(7):767-790.
2. Xie JP, Liu HM, Zhu MX, et al. Development of a novel hazard index of

mainstream cigarette smoke and its application on risk evaluation of cigarette products [J]. Tobacco Science & Technology. 2009;42(2):5-15.
3. Wei YL, Xu JH, Miao Z, et al. Effects of cigarette materials on ventilation rate and filtration efficiency of cigarette [J]. Tobacco Science & Technology. 2008;41(11):9-13.
4. Christophe LM, Lang LB, Gilles LB, et al. Influence of cigarette paper and filter ventilation on Hoffmann analytes [C]. TSRC; 2004.
5. Zheng Q, Cheng ZG, Li HR, et al. Effects of cigarette paper on deliveries of seven harmful components in mainstream cigarette smoke [J]. Tobacco Science & Technology. 2010;43(12):49-51.
6. Liu JF, Jin Y, Li K, et al. Influences of tipping paper on tar and 7 harmful components in cigarette smoke [J]. Tobacco Science & Technology. 2013;46(8): 67-70.
7. Zhai YJ, Tian H, Zhu XY, et al. Effects of permeability of tipping paper and plug wrapper on basic aroma components in mainstream cigarette smoke [J]. Tobacco Science & Technology. 2012;45(2):56-60.
8. Liu XJ, Zhang Y, Xiong XM, et al. Effect of some chemical and physical factors on carbon monoxide in mainstream smoke of flue-cured tobacco [J]. Chinese Tobacco Science. 2013;34(4):83-87.
9. Li QJ, Yang CL. Advance in effect of selenium on the ingredients in tobacco leaf and the nocuous components in smoke [J]. Chinese Tobacco Science. 2007;28(2):10-13.
10. Yu XH, Zhao JT, Xu HT, et al. Yield of chemical components in the mainstream smoke under two smoking methods [J]. Chinese Tobacco Science. 2012;33(5):90-92,103.
11. Yu XH, Zhao JT, Dong YZ, et al. Study on reducing the phenolic harmful ingredients in mainstream smoke with various carbon hollow material [J]. Chinese Tobacco Science. 2013;34(6):108-112.
12. Du YM, Zhang HB, Zhang ZF, et al. Solanesol content in flue-cured tobacco leaves and its correlations with main chemical components of leaf and mainstream smoking [J]. Chinese Tobacco Science. 2014;35(6):54-58.
13. Fu QJ, Liu JH, Zhang HB, et al. Relationship between appearance quality and deliveries of main harmful compounds in mainstream smoke from flue-cured tobacco leaves [J]. Chinese Tobacco Science. 2015;36(6):94-99.
14. Cai JL, Han B, Zhang XB, et al. Effects of filter ventilation rate on deliveries of some aromatic components in mainstream cigarette smoke [J]. Tobacco Science & Technology. 2011;44(9):54-60.
15. Li YQ, Zong YL, Qv Z, et al. Effects of ventilation dilution and filter elongation on delivery of volatile and semi-volatile acidic components in mainstream smoke particulate matters [J]. Acta Tabacaria Sinica. 2011;3:7-10.
16. Yang HY, Yang L, Zhu WH, et al. Investigation into the effect of cigarette design on emission of 7 harmful chemicals in mainstream smoke [J]. Acta Tabacaria Sinica. 2011;17(1):8-13.
17. Yu CF, Luo DS, Wang F, et al. The effects of paper and filter on smoke components and taste (1) [J]. Acta Tabacaria Sinica. 2001;3:6-10.
18. Yu CF, Luo DS, Wang F, et al. The effects of paper and filter on smoke components and taste (2) [J]. Acta Tabacaria Sinica. 2001;4:14-17.
19. Pang YQ, Huang CH, Chen ZG, et al. Effects of cigarette materials on mainstream smoke delivery and filtration efficiency of cigarette with 27 mm filter rod [J]. Acta Tabacaria Sinica. 2008;14(5):15-21.
20. Chen H, Jiang XY, Wang Y, et al. Relationships between filter ventilation rate and deliveries of harmful components in mainstream cigarette smoke under ISO and HCI smoking regimes [J]. Tobacco Science & Technology. 2015;48(9):45-49.
21. Zhang X, Xu Y, Liu W, et al. Effects of smoking regime on ammonia delivery in mainstream cigarette smoke [J]. Tobacco Science & Technology. 2012;45(6):63-71.
22. Kong HH, Pang YQ, Zhou R, et al. Effects of design parameters of cigarette materials on deliveries of carbon monoxide, phenol and NNK in mainstream cigarette smoke under intensive smoking regime [J]. Tobacco Science & Technology. 2013;46(4): 41.
23. Qiu Y, Wang J, Lu W, et al. Study on the emission of main harmful substances from flue gas of paper making method tobacco sheet at home and abroad and its hazard assessment [J]. Modern Scientific Instruments. 2013;23(3):85-88.

24. Peng B, Zhao L, Sun XH, et al. Risk evaluation of cigarette based on multi-objective decision [J]. Tobacco Science & Technology. 2010;43(12):31-35.
25. Wu ZY, Li L, Li DL, et al. Correlation analysis between cigarette weight, draw resistance, ventilation rate and sensory evaluation of cigarette [J]. Chinese Tobacco Science. 2010;31(2):49-53.
26. Sun DL, Wang KM, Wei FM, et al. Statistical relations between cigarette physical indices and draw resistance [J]. Chinese Tobacco Science. 2008;29(4):42-45.
27. GB/T 23356. Cigarette- Determination of carbon monoxide in flue gas by non scattering infrared method [S]; 2009.
28. YC/T 253. Cigarette- Determination of hydrogen cyanide in mainstream flue gas continuous flow method [S]; 2008
29. GB/T23228. Cigarette- Determination of tobacco specific N- in main flue gases by gas chromatography thermal energy analysis [S]; 2008.
30. GB/T 21130. Cigarette- Determination of benzene and pyrene in total particulate matter of flue gas a [S]; 2007.
31. YC/T 255. Cigarette- Determination of major phenolic compounds in mainstream smoke by high performance liquid chromatography [S]; 2008.
32. YC/T 254. Cigarette- Determination of major carbonyl compounds in mainstream smoke by high performance liquid chromatography [S]; 2008.
33. YC/T 377. Cigarette- Determination of ammonia in mainstream smoke by ion chromatography [S]; 2010.
34. Wang H, Zhan JB, Yu ZH, et al. Effect of draw resistance on phenol and its contribution degree of cigarette hazard index [J]. Archives of Current Research International. 2016;4(4):1-7.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/16655