TOBACCO ADDITIVES

CIGARETTE ENGINEERING AND NICOTINE ADDICTION
A survey of the additive technology used by cigarette manufacturers to enhance the appeal and addictive nature of their product.
Summary

Introduction. In the European Union over 600 additives may be used in the manufacture of tobacco products under an extremely loose and de-centralised regulatory framework. Although tobacco additives are generally screened for their direct toxicity, there is virtually no assessment of the impact additives have on smoking behaviour or other undesirable external consequences. If a small quantity of a relatively benign substance added to a tobacco product can make the product more addictive, make it easier to start smoking or facilitate continued smoking then it may be causing great harm by ‘leveraging’ additional smoking. The additional smoking brings increased exposure to over 4,000 chemicals, including many that are highly toxic and carcinogenic. Given that over 500,000 people die prematurely in the European Union each year as a result of smoking-related disease, even a one per cent change in smoking attributable to the use of additives would have large absolute health consequences – tens of thousands of lives annually. For this reason, tobacco additives should be seen as major public health issue in their own right.

Evidence. This report draws on evidence from tobacco industry internal documents released during recent litigation in the United States and held on the Internet or in British American Tobacco’s document depository in Guildford, UK. The views of the UK Government’s scientific advisory committees since 1971 are also discussed – showing that the issue has been recognised and debated for more than twenty years.

Which brands use which additives? Though 600 additives are authorised for use in tobacco products, only the tobacco manufacturers can say which additives are used and in which brands. Not even the Government or the European Commission, which are responsible for the regulation of tobacco products have this information or the power to demand it.

Findings. Most additives are not necessary and few were used before 1970. The purpose of this report is to raise concerns about the impact of additives on smoking behaviour. The report suggests that there is a case to answer and that there is need for increased regulatory scrutiny. There is cause for concern in the following areas.

• Additives are used to make cigarettes that provide high levels of 'free' nicotine which increases the addictive 'kick' of the nicotine. Ammonium compounds can fulfil this role by raising the alkalinity of smoke.

• Additives are used to enhance the taste of tobacco smoke, to make the product more desirable to consumers. Although seemingly innocuous the addition of flavourings making the cigarette ‘attractive’ and ‘palatable’ is in itself cause for concern.

• Sweeteners and chocolate may help to make cigarettes more palatable to children and first time users; eugenol and menthol numb the throat so the smoker cannot feel the smoke’s aggravating effects.

• Additives such as cocoa may be used to dilate the airways allowing the smoke an easier and deeper passage into the lungs exposing the body to more nicotine and higher levels of tar.
• Some additives are toxic or addictive in their own right or in combination. When additives are burned, new products of combustion are formed and these may be toxic or pharmacologically active.

• Additives are used to mask the smell and visibility of side-stream smoke, making it harder for people to protect themselves and undermining claims that smoking is anti-social without at the same time reducing the health risks of passive smoking.

**Regulation.** The existing regulatory framework is based on the assumption that additives are useful to facilitate consumer acceptance of lower tar yield cigarettes. By facilitating the switch to lower tar products, it was hoped that tobacco additives would lead to *health gains*. No data is available to show that additives are in fact used only or predominantly in lower yielding brands. However, there is now good evidence that questions the value of low tar cigarettes. Low tar cigarettes have generally used perforated filters to dilute the smoke with air. Smokers learn to block the holes, often subconsciously, thus adjusting the dilution of nicotine in the smoke. The smoker may also compensate by smoking more intensely. With the primary rationale for a relaxed regime discredited, it is necessary to adopt a new approach.

**New regulatory framework needed.** A new regulatory framework is required in which the manufacturer is obliged to demonstrate that no additional harm arises from tobacco product design decisions such as the use of an additive. This should include the impact of additives on smoking behaviour, passive smoking and fire risks. While it is impossible to make safe cigarettes, it is perfectly reasonable to prevent the manufacturers doing things that lead to an *increase* in the harm caused by tobacco. Such a framework may have the following elements:

• **Disclosure.** As a first step, manufacturers should be required to disclose all additives used in tobacco products by brand to a regulator – in the UK this is the Department of Health. This approach has already been adopted in Massachusetts and British Columbia.

• **Public information.** Such information should not be confidential, but made available to the public through publications, the Internet or on request from the regulator.

• **Packaging.** There may be some additives that should be listed as ingredients on tobacco product packaging. This is a separate decision to a requirement for disclosure and making the information public in other ways – the right approach will depend on assessment of the direct value of such information to consumers.

• **Disclosure of purpose.** Tobacco companies should be required to disclose the purpose of an additive and any secondary consequences – whether intentional or unintended.

• **Conduct and disclosure of research.** Tobacco companies should be required to undertake extensive toxicology and pharmacological testing of all additives.

• **Regulatory challenges.** Regulators should have the power to challenge any of the existing 600 additives currently allowed and to have them removed until the
manufacturer is able show that no extra harm to the public arises as a direct or indirect result of the additive. If it is impossible to supply evidence, for example because of restrictions on animal testing, then under a precautionary approach the additive should be banned.

- **Focus on pharmacologically active.** There should be an automatic challenge to any additive thought to have a direct or indirect pharmacological influence. New additives should be permitted only if the manufacturer can show that no extra harm or other net negative consequences arise from use of the additive.

- **Permit essential additives.** Any regulatory framework should permit additives necessary for the manufacture and storage of tobacco products providing these are safe, but should challenge all additives that may influence smoking behaviour.
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1 Introduction: tobacco products and additives

Cigarettes as nicotine delivery systems
To understand the role of additives, it is important first to have a grasp of how cigarettes work. The long-term success of the tobacco industry is the direct result of the addictive nature of nicotine and tobacco use. As those in the industry were first to recognise, the cigarette - marketed as a lifestyle accessory - is in fact a delivery device for an addictive drug. There are many tobacco industry documents that show tobacco products acting in this role, essentially as sophisticated, highly engineered nicotine delivery systems. For a more detailed survey see ASH’s report Tobacco Explained (Chapter Two)\(^1\). Two examples are given below:

Philip Morris explains...

“'The cigarette should be conceived not as a product but as a package. The product is nicotine. Think of the cigarette pack as a storage container for a day’s supply of nicotine....Think of the cigarette as the dispenser for a dose unit of nicotine....Smoke is beyond question the most optimised vehicle of nicotine and the cigarette the most optimised dispenser of smoke.’”\(^2\) (Philip Morris 1972)

RJR recognises it is in the drug business

“'In a sense, the tobacco industry may be thought of as being a specialised, highly ritualised, and stylised segment of the pharmaceutical industry.’”\(^3\) (RJR 1972)

Impact of additives on smoking behaviour
Additive technology is a major tool used by the tobacco industry in the production of this nicotine ‘package’. While some cigarettes have been marketed as additive free, according to the verbal testimony of JL Pauly of the Santa Fe Natural Tobacco Co, the modern U.S. cigarette contains about 10 percent additives by weight, mostly in the form of sugars, flavourants, and humectants\(^4\). But there are others – present in smaller quantities – which may have a more profound influence on the product. Evidence suggests that additives are actually used by manufacturers to influence the pharmacological effects of nicotine, make individual brands taste more appealing to young and ‘aspirational’ smokers and mask the taste and immediate discomfort of smoke.

How nicotine addiction works – additives play a subtle role
At the simplest level, a cigarette delivers a dose of the main active ingredient, nicotine, into the smokers’ lungs in a mixture of smoke particles and gases. The nicotine is rapidly absorbed into the blood through the large surface of the lungs (and mouth and throat) and reaches the brain within ten seconds. Receptors in the brain respond to nicotine stimulation by producing chemicals (dopamines and other neurotransmitters) that give the user what is variously described as a ‘hit’, ‘kick’ or ‘impact’ – the drug effect of nicotine. Over time the receptors become conditioned to expect nicotine (tolerance), and when deprived, the smoker experiences nicotine withdrawal – a very unpleasant sensation for many. This pharmacological impact and withdrawal, enhanced by psychological and social factors related to smoking, create dependency on tobacco products. Nicotine is the main reason why tobacco products are addictive. As this report shows, there are a number of subtle ways in which the delivery of nicotine to the brain’s receptors can be influenced by additives.

Harm caused by smoking
The smoke particles and gases in which the nicotine is transported contain thousand of chemicals, many being toxic or carcinogenic. Though nicotine itself is the reason people smoke, the other chemicals do the bulk of the
damage to health. The other chemicals are often collectively referred to as ‘tar’ and also provide flavour and other taste sensations. This tar and the gases produced by combustion such as carbon monoxide, cause cancer, heart disease and respiratory illnesses and many other conditions. Regulators aimed to reduce tar exposure by insisting that tar yields should be decreased.

**Low tar cigarettes in theory**

The rise of additives in tobacco products is intimately linked with the strategy to reduce tar yields. The amount of tar and nicotine in smoke is measured by a standard smoking machine in which the cigarette is smoked with a fixed puff volume and frequency with tar and nicotine residues collected on a filter and weighed. Governments have insisted on reducing tar levels as measured by this approach, hoping that this would reduce tar exposure to smokers – and therefore lead to reduced harm.

**Low tar cigarettes in practice**

In practice, low tar cigarettes have been produced by the addition of filters and most importantly, by the use of filter ventilation (Kozlowski et al, 1998). Holes in the filter allow air to be drawn in to dilute the smoke and this reduces the amount of tar and nicotine residues collected by the machine. In the lowest tar cigarettes, 80% of the ‘smoke’ is air drawn in through ventilation holes. Ventilation also means that the smoke might taste ‘weaker’ because the agents that give rise to flavour are diluted with air. However, smokers do not smoke like machines. Faced with diluted smoke, smokers will tend to ‘compensate’ by smoking the lower-tar cigarette more intensively, in order to obtain a satisfactory dose of nicotine. Compensation may take the form of deeper or more frequent puffs, or blocking of ventilation holes – often sub-consciously. The result is that smokers of low-tar cigarettes do not consume less nicotine (Benowitz et al, 1983, Bates and Jarvis, 1999). A survey of tobacco company documents by ASH and Imperial Cancer Research Fund (*Low Tar: why low tar cigarettes don’t work and how the tobacco industry fools the smoking public*) gives greater detail on why low tar cigarettes do not work and what the tobacco companies knew privately and said publicly.

**Low tar cigarettes and additives**

One of the prime justifications for the addition of artificial flavourings is to replace the lost flavour of the diluted smoke. This has in theory been done to facilitate the switch to low-tar. However, any hoped-for health benefits from low-tar cigarettes have largely failed to materialise. At the same time an extremely lax regulatory regime for additives has emerged. Although smokers of lower tar cigarettes may be consuming as much tar and nicotine in total, they will be consuming greater volumes of diluted smoke to do it. This is perhaps analogous to drinking watered down wine – it is possible to become intoxicated, but drinkers will have to consume more and the flavour will be weaker.
2 Scientific advisory committee reports on tobacco additives

Scientific advice to government

The Government takes advice on smoking and health from a long-running scientific standing committee. Guidelines for the monitoring of tobacco additives were initially published in the First Report of the Independent Scientific Committee on Smoking and Health (ISCSH) in 1975. The ISCSH was established in 1973, primarily to prepare guidelines for the testing of tobacco substitutes which were being developed at the time. This section gives an overview of the conclusions regarding tobacco additives.

Arrangements before 1970

Prior to 1970, the use of additives in tobacco products was prohibited without special permission from the Commissioners of Customs and Excise, under Section 176 of the Customs and Excise Act, 1952. This permission was given only within very strict limits and mainly in respect of flavourings in tobacco products other than cigarettes. The prohibition extended to the importation of tobacco products containing additives as well as a ban on the production of cigarettes with additives for export.

2.1 First Report of the ISCSH (1975)

The Finance Act of 1970 changed the rules and allowed for tobacco duty to be charged on additives and tobacco substitutes, thus paving the way for the restrictions on additives to be removed. Statutory control over the materials used in the manufacture of cigarettes finally ceased with a revision of the tax system in 1978. The First Report of the ISCSH stated that the Committee was concerned that these changes in the law should not increase the health hazards of smoking and concluded that:

"Other means have to be found to guard against the possible risk to health."

The "other means" resulted in a voluntary agreement between the tobacco manufacturers and the Government whereby the companies would supply details of proposed additives. Only those approved by the ISCSH would be permitted. Guidelines for the testing and use of tobacco products containing additives were included an appendix to the First Report of the ISCSH, published in 1975. In the Second Report, the guidelines were amended to include the general requirement for an acute inhalation toxicity study and data on transference to smoke for any new additive.

2.2 Second Report of the ISCSH (1979)

The Second Report of the ISCSH expresses concern that no additional "dependence-inducing" compounds should be incorporated into tobacco. Paragraph 13 states:

"The concept of adding flavouring ingredients to cigarettes might not lessen the incentives to smoke and could indeed have the opposite effect." 10

The tobacco industry argues that one of the key purposes of additives is to
make lower tar cigarettes more palatable. The ISCSH accepts this and notes:

"Some smokers find existing low and low to middle tar brands unsatisfying, but if those who smoked middle or middle to high tar cigarettes could switch to low tar brands whose acceptability was improved by additives, the dangers of smoking could be reduced. The Committee recognises the potential value of using flavouring additives in this way."  

The Second Report of the ISCSH expresses satisfaction with the use of other additives not covered by the guidelines. These include additives in filters, cigarette papers, filter wrappers, tips and overwrappers. Thus, such additives could be used without reference to the Committee. Between 1979 and 1983, the Committee revised the guidelines to include an assessment of "all substances added to those parts of tobacco products intended to be burnt". Thus any substances added to cigarette papers were included in the revised guidelines as appended to the Third Report.


The Third Report of the ISCSH concluded that the system of providing information on additives had been working well and recommended that the system should continue. The Fourth Report, published in 1988, made a similar recommendation for the continuation of the voluntary system.

2.4 **SCOTH (1998)**

Official acceptance of the tobacco industry's arguments regarding the need for additives appears to have continued until the publication of the report of the Scientific Committee on Tobacco and Health (SCOTH) in 1998. SCOTH states:

"One of the effects [of additives] has been the maintenance of "taste" as tar yields have fallen with an ensuing reduction in natural flavour. The negative side of this has been the maintenance of the appeal of a product, which might otherwise have been rendered unacceptable through the adulteration of intrinsic flavour." 

SCOTH, which replaced the ISCSH, reviewed the tobacco additive guidelines and made recommendations for their revision in the light of scientific and technical advances. While the Committee expressed the clear reservation about the possibility that additives may prolong use of cigarettes by making them more palatable, SCOTH only recommends that the use of additives in tobacco products be closely monitored. Specifically, it recommends that the Technical Advisory Group, which reports to SCOTH, should regularly review the changing patterns and types of additives used.

At no stage in the 25 year period has the Department of Health or its advisory committees been provided with information as to which additives have been used in which tobacco product brands. There has therefore, never been evidence of whether the approved additives have actually been used in low-
yield brands, or more widely. There has also been no validation of the anticipated health benefits that the liberal regulatory regime for additives was supposed to offer.

2.5 The 1997 UK Voluntary Agreement

**Existing additives escape detailed scrutiny**
The 1997 Voluntary Agreement requires tobacco manufacturers to provide toxicological and other data for any *new* additives manufacturers wish to add to the approved list, but such information is not required for the 600 *existing* approved additives.

**Limited scope of evaluation**
Furthermore, even for new additives there is no requirement for companies to state the purpose of the additives, merely that it is *“desirable that the purpose of use should be detailed”*. While it is possible that some additives may be harmless or even beneficial, under the present voluntary agreement system there is no way of ascertaining the relative advantages and disadvantages of these substances. No broad criteria for acceptance or rejection are stated in the agreement. The criteria applied are only “the results of toxicity testing are unsatisfactory; or acceptability cannot be judged on the basis of the information provided.” The impact on smoking behaviour is not assessed.

**European loophole**
The final and fatal weakness of the Voluntary Agreement is that it can be side-stepped in its entirety. Directive 83/189/EEC requires the Department of Health to ‘raise no objection’ to the use of an additive permitted in any other EU member state provided that certain specified information is provided.

**Conclusion**
The regime established in the 1997 UK Voluntary Agreement is not retrospective, too narrowly focussed, can be avoided entirely. It therefore offers minimal safeguards and may be lending spurious legitimacy to practices that cause harm to health.
3 Enhancing impact – additives with a pharmacological effect

“The main technical challenge was to decrease the yield of tar in a cigarette while maintaining a level of nicotine acceptable to the smoker.”15

(Farone, W.A. 1996 former Philip Morris scientist.)

3.1 Free basing nicotine

Free-basing nicotine At least as far as its rivals are concerned, the success of Philip Morris’s Marlboro brand stems from greater ‘free’ nicotine resulting from higher alkalinity (pH) induced by the addition of ammonia technology (see section 3.2). Ammonia can speed the delivery of ‘free’ or unbound nicotine to smokers by raising the pH (alkalinity) of tobacco smoke using additives. This causes the smoker to ‘freebase’ the drug – much as a crack-user takes cocaine. Dr. Jack E Henningfield of the John Hopkins University School of Medicine explains the action of ammonia thus:

“A third thing that ammonia like compounds can do is increase the pH, increase the amount of free base nicotine, or what Dr Rickert earlier referred to as unprotonated nicotine….The free-based form of cocaine or the free based form of nicotine is more rapidly absorbed, has a more explosive effect on the nervous system. Ammonia is one of the ways that you can provide free-based cocaine or free-based nicotine.”16 (1997)

Nicotine in different forms Many documents explain the tobacco companies’ recognition that nicotine is available in different forms.

“Nicotine may be presented to the smoker in at least three forms: (I) salt form in the particulate phase, (ii) free base form in the particulate phase, (iii) free base form in the vapour phase. It has long been believed that nicotine presented as in (ii)/(iii) is considerably more ‘active’.”17 (BAT 1984)

“Nicotine is in the smoke in two forms as free nicotine base (think of ammonia) and as a nicotine salt (think of ammonium chloride) and it is almost certain that the free nicotine base is absorbed faster into the blood-stream.”18 (BAT 1964)

More free nicotine means higher ‘impact’ Once the relationship between pH, free nicotine and nicotine ‘impact’ was established, it became a research objective.

“The purpose of this project is to develop a method for increasing the smoke pH of a cigarette. A low smoke solids, low nicotine cigarette with an increased smoke pH would then have relatively more free nicotine in its smoke, and consequently, a higher nicotine impact.”19 (Liggett 1974)

Changing the chemical form of nicotine increases the ‘kick’ In a paper entitled, ‘Cigarette concept to assure RJR a larger segment of the youth market’ RJR talk about the ‘kick’ of nicotine:

“Still with an old style filter, any desired additional nicotine ‘kick’ could be easily obtained through pH regulation.”20 (RJR 1973)

The pH also relates to the immediacy of the nicotine impact. As the pH increases,
the nicotine changes its chemical form so that it is more rapidly absorbed by the body and more quickly gives a ‘kick’ to the smoker.” 21 (RJR 1976)

“When a cigarette is smoked, nicotine is released momentarily in the free-form. In this form, nicotine is more readily absorbed through the body tissue. Hence it is the free nicotine which is associated with IMPACT, i.e. The higher the free nicotine, the higher the IMPACT.”22 (BAT 1988)

**Making nicotine more potent**

“Increasing the pH of a medium in which nicotine is delivered increases the physiological effect of the nicotine by increasing the ratio of free base to acid salt form, the free base form being more readily transported across physiological membranes. We are pursuing this project with the eventual goal of lowering the total nicotine present in smoke while increasing the physiological effect of the nicotine which is present, so that no physiological effect is lost on nicotine reduction.”23 (Liggett 1971)

**Free nicotine fraction increases ‘physiological strength’**

“Since the unbound nicotine is very much more active physiologically and much faster acting than the bound nicotine, the smoke at a high pH seems to be strong nicotine. Therefore, the amount of free nicotine in the smoke may be used for at least a partial measure of the physiological strength of the cigarette.”24 (RJR 1973)

**Nicotine transfer increased as a result of ammonia treatment**

According to BAT, the addition of ammonia was a technical option to enhance nicotine transfer:

“...the results show that ammonia treatment caused a general increase in the delivery of bases including a 29% increase in nicotine. This result, despite the decrease in nicotine content and a 10% drop in the weight of tobacco burnt in puffing, is only partly due to a small decrease in nicotine filtration. In other words, the nicotine transfer has increased as a result of ammonia treatment...”25 (BAT 1965)

**‘Judicious’ use of additives to increase the free base nicotine**

The US tobacco company Lorillard accepts that additives can change the qualitative delivery of nicotine:

"It should be obvious that if the preceding goals of high physiological impact are to be realised, flavour profiles and their effect on physiological impact must be understood, even though measures of such perceived quantities are highly subjective... Hence judicious use of additives may increase the pH of the delivered smoke, thereby the apparent free base nicotine.” (Lorillard, 1976)26

**Additives to increase nicotine ‘kick’**

Ammonia can be used to increase the alkalinity of smoke and increase the amount of nicotine in the ‘free’ form rather than in the ‘bound’ form of nicotine salts. R J R explains:

“In essence, a cigarette is a system for delivery of nicotine to the smoker in attractive, useful form. At ‘normal’ smoke pH, at or below about 6.0, essentially all of the smoke nicotine is chemically combined with acidic substance hence is non-volatile and relatively slowly absorbed by the smoker. As the smoke pH increases above about 6.0, an increasing proportion of the total smoke nicotine occurs in ‘free’ form, which is volatile, rapidly absorbed by the smoker, and believed to be instantly perceived as nicotine ‘kick’.”27 (RJR 1973)
3.2 Ammonia Technology and The Marlboro Story

The Rise of Marlboro - the world's best selling cigarette

The myth is that Marlboro man made the Marlboro cigarette: The square jawed icon of American individualism lassoed a gullible public and herded them into the Marlboro corral. On the face of it Marlboro’s success appears to be a tribute to the power of advertising and iconography. However, the chemical history of the brand sheds interesting light on the subject.

In the early sixties Philip Morris was the smallest of America's six leading cigarette companies and RJR's brand Winston had annual sales nearly three times the size of Marlboro's. By 1978 there had been a seismic shift, Marlboro was the world's best selling cigarette accounting for one in five of all cigarettes sold and over fifty percent of smokers aged 17 and below.28

The search begins for the 'soul of Marlboro'

Not surprisingly this dramatic growth in Marlboro cigarettes instigated frenzied research by other tobacco manufacturers. Through analysis and reverse engineering of Marlboro cigarettes, industry competitors came to the conclusion that ‘ammonia technology’ was essentially the ‘soul’ of Marlboro.

“Philip Morris began using an ammoniated sheet material in 1965 and increased use of the sheet periodically from 1965 to 1974. This time period corresponds to the dramatic sales increase Philip Morris made from 1965 to 1974.”29 (RJR)

Ammonia technology is the key to Marlboro

“What product technology, then, makes Marlboro a Marlboro? Looking at all of the technology employed in Marlboro on a world-wide basis, ammonia technology remains the key factor.”30 (B&W 1992)

Brands that are selling well have high levels of free nicotine

The higher pH of Marlboro cigarettes helped to maintain the same level of free nicotine as high-tar cigarettes despite a two third reduction in overall tar and nicotine - and helped develop a 'US standard taste', enhancing the iconography associated with the quintessentially American 'Marlboro Man'.

“If our data, correlations and conclusions are valid, then what has emerged is a rather new type of cigarette, represented by Marlboro and Kool, with high nicotine ‘kick’, burley flavour, mildness to the mouth, and increased sensation to the throat, all largely the result of higher smoke pH. There is evidence that other brands, which are selling well also, have some of these attributes, particularly increased ‘free’ nicotine impact.31 (RJR, 1973)
Marlboro's growth follows introduction of ammonia technology

The graph shows how Marlboro's steady rise in sales follows increases in cigarette pH – which also has led to an increase in free nicotine content.

RJR, 1973

Brown and Williamson seeks to catch up

"It appears that we have sufficient expertise available to 'build' a lowered mg tar cigarette which will deliver as much 'free nicotine' as a Marlboro, Winston or Kent without increasing the total nicotine delivery above that of a 'light' product. There are products already being marketed which deliver high percentage 'free nicotine' levels in smoke, i.e. Merit, Now." (B&W 1980)

"It would appear that the increased smoker response is associated with nicotine
reaching the brain more quickly…On this basis, it appears reasonable to assume that the increased response of a smoker to the smoke with a higher amount of extractable nicotine (not synonymous with but similar to free base nicotine) may be either because this nicotine reaches the brain in a different chemical form or because it reaches the brain more quickly.”34 (BAT 1966)

Competitors understood the link between Marlboro’s sales and its alkalinity.

“The smoke pH for Kool and Marlboro are 7.12 and 6.98 respectively confirming the relationship between high smoke pH and cigarette sales increase.”35 (Lorillard 1973)

“As a result of its higher smoke pH, the current Marlboro, despite a two thirds reduction in smoke ‘tar’ and nicotine over the years, calculates to have essentially the same amount of ‘free’ nicotine in its smoke as did the early Winston.”36 (RJR 1973)

“Our data show that smoke from our brands, and all other significant competitive brands, in recent years has been consistently and significantly lower in pH (less alkaline) than in smoke from Marlboro and to a lesser degree Kool… All evidence indicates that the relatively high smoke pH (high alkalinity) shown by Marlboro (and other Philip Morris brands) and Kool is deliberate and controlled. This has raised questions as to: (1) the effect of higher pH on nicotine impact and smoke quality, hence market performance, and (2) how the higher smoke pH might be accomplished.”37 (RJR 1973)

3.3 Concealing the nicotine by increasing the vapour phase

The exploitation of ‘free’ nicotine and its enhanced effects helped cigarette companies cheat FTC machine measurements of tar and nicotine levels. Using additive technology they were able to build cigarettes which registered low tar readings on the machine but delivered high levels of nicotine to the smoker.

“If the desired goal is defined to be increased nicotine yield in the delivered smoke there appear to be only two alternatives: either increase the absolute yield of delivered nicotine, or increase the pH, which increases the ‘apparent’ nicotine content without changing the absolute amount.”38 (Lorillard, 1976)

The FTC machine measures overall levels of liquid and solid nicotine, but not its concentration in the vapour phase where ‘free’ nicotine is found. Additives allowed reduced tar and nicotine without compromising the pharmacological effects – legally required disclosure of tar and nicotine levels on billboards and cigarette packets showed a significant reduction while smokers were still being exposed to high levels of an addictive drug. Changes in the state of nicotine from liquid or solid to gas would have the effect of evading the standard measuring process which records the residues left on the filter in the standard smoking machine.
“The perfect example of that is that if you don’t take into account the gas phase, if I do something like increase the pH and the smoke drops so that I can put more of the nicotine from the liquid into the gas and I am not measuring the gas, then in fact, you don’t measure that nicotine which gets in the gas phase. This has been known since the late 1960’s and early 1970’s.”  

Farone, W.A. 6/12/97

The increase in the free nicotine fraction – a qualitative change in the form of chemical form of nicotine – means that the same ‘hit’ can be obtained from less nicotine. Put another way, there can be the appearance of a reduction in pharmacological impact without there being a real reduction.

“...The amount of nicotine in the vapour phase can be modified by changing the acidity (pH) of the smoke. Hence it is readily feasible to have two cigarettes which deliver the same amount of nicotine (as measured on a Cambridge pad (the FTC method) but which are easily differentiated on the sensory basis of impact since the acidity of the smoke (and hence amount of nicotine in the vapour phase) is different.”

B&W 1984

3.4 Other additives that may enhance the effect of nicotine

Although in the documents surveyed, ammonia emerges as the primary chemical tool used to enhance nicotine effects, other additives with similar functions are currently in use and more are being researched. Of particular note are Acetaldehyde, Levulinic Acid, Theobromine and Glycyrrhizin – Although described by the tobacco industry as ‘smoothers’ and ‘flavour enhancers’, all appear to have some pharmacological effect in controlling nicotine absorption levels and/or delivery.

In his testimony during recent litigation, W.A. Farone noted that, “the interactions (between additives and nicotine) may be the basis for the difference between the difficulty in giving up pipe or cigars compared to giving up cigarettes.”  

Farone WA 1997

3.4.1 Acetaldehyde

Acetaldehyde is produced by the burning of sugars (the most common tobacco additives). Industry scientists suspected that acetaldehyde could enhance the addictive effects of nicotine. Senior Philip Morris scientist Victor J. DeNoble began research in the early eighties, into the behavioural effects of nicotine and acetaldehyde in rats. He discovered that the two drugs worked synergistically to enhance the addictive nature of nicotine. DeNoble’s research papers for Philip Morris reveal the potential for acetaldehyde to act in this way:

“The results can be summarized as follows: 1 acetaldehyde does function as a positive reinforcer for rats. 2 acetaldehyde at equal doses (mg) to(-) nicotine is more effective at maintaining self-administration behaviour, 3 the endogenous opioid system is not involved in the maintenance of acetaldehyde self administration, and 4) combinations of nicotine and acetaldehyde produce supra-
additive effects when self administered.”43 (PM)

“Acetaldehyde alone maintained lever pressing at a greater rate than nicotine at equal mg/kg doses. This is consistent with other findings at this laboratory.” (Philip Morris, 1983)44

“Overall, the effects of acetaldehyde on EEGs were similar to those of nicotine.”45 (PM 1983)

“DeNoble detected a synergistic or “additive” effect with acetaldehyde-nicotine combinations. This experiment was extended, with a slightly different but acceptable protocol, with one rat again using doses less than one cigarette (8 ug/kg/dose) and again DeNoble detected a synergistic effect between acetaldehyde - nicotine.”46 (PM 1982)

Following this discovery DeNoble and his team were ordered to find the optimal ratio of the two compounds. According to DeNoble’s testimony, once the company had discovered the optimal ratio for addiction they increased the levels of sugar in Marlboro cigarettes to achieve the required increase in levels of acetaldehyde.

“How did they do it? Simple, they added sugar, because if you burn sugar you form acetaldehyde. Now I ask you this. If tobacco companies are reducing acetaldehyde as Philip Morris says why has Marlboro increased acetaldehyde by 40% in ten years and has maintained that increase today?47(DeNoble, Verbal Testimony 1997)

3.4.2 Levulinic acid

Adding straight nicotine to tobacco has two unwanted effects. One effect is to make the smoke harsh and difficult to smoke, and secondly it increases the FTC reading of nicotine. RJR patented a way round this by using a nicotine salt of an organic acid, (e.g., nicotine levulinate) which increases the impact of nicotine whilst keeping a low tar to nicotine ratio on the FTC reading:

The use of organic acid salts to mask the harshness of nicotine.

It would be desirable to provide a cigarette such as an ‘ultra low tar’ cigarette, which is capable of delivering a good tobacco taste, strength and smoking satisfaction characteristic of a ‘full flavour low tar’ cigarette while not being perceived as being overly harsh or irritating. In addition, it would be desirable to provide a cigarette such as a ‘full flavour low tar’ cigarette, which is capable of delivering a good tobacco taste, strength and smoking satisfaction characteristic of a ‘full flavour’ cigarette while not being perceived as being overly harsh or irritating. Cigarettes having incorporated therein a salt such as nicotine levulinate exhibit low FTC ‘tar’ to nicotine ratios while (i) having a smooth palatable, flavourful taste, and (ii) providing smoking satisfaction to the user. The cigarettes do not
exhibit a harsh or irritating character; and do not exhibit a non-tobacco or off taste.


RJR researches techniques for enhanced binding

Titled ‘Enhancement of nicotine binding to nicotinic receptors by nicotine levulinate and levulinic acid’, the following document shows how levulinic acid enhances the effects of nicotine.

“Nicotine levulinate and levulinic acid significantly increased the amount of L (3H) nicotine bound to nicotinic receptors in rat brain tissue. The observed increase ranged from 20 - 50 %, with a mean value of around 30 %. The total amount of radiolabeled nicotine bound to receptors was more than could be accounted for by binding to high affinity receptors alone. The maximal effect which was observed at concentrations of nicotine levulinate and levulinic acid in the low nanomolar range, was reversed at higher concentrations. A computer model consistent with the results was developed and tested. According to the model, levulinic acid binds to an allosteric site on a class of low-affinity receptors and increases the affinity of these receptors for nicotine. At higher concentrations, this effect is reversed by the levulinic acid itself, assuming that it also has a reasonable affinity for the nicotine binding sites.”

“Levulinic acid (4-oxopentanoic acid) is primarily a breakdown product of starch, cane sugar and other cellulosic materials.”

Are there other compounds which help nicotine bind to receptors?

The same document possibly describing other research.

“Similarly, it has been shown that there are some compounds which enhance the binding of nicotine to its receptors in brain tissue”

The above quotes illustrate the extent to which cigarette manufacturers can manipulate the chemistry of smoke and nicotine addiction. Levulinate and levulinic acid change the chemistry of the brain itself so it becomes more receptive to nicotine.

3.4.3 Cocoa and theobromine

Widely used as an additive, cocoa contains alkaloids, which may modify the effects of nicotine and have a pharmacological effect in themselves. Cocoa also contains about 1% theobromine, a 'bronchodilator' - encouraging expansion of the airways and facilitating increased smoke and nicotine intake.

The following quotes are from scientific and medical papers held by Philip Morris:

“Theobromine: The principal alkaloid of the cocoa bean which contains 1.5-3% of the base...bronchodilation effect in asthma.”
“The bronchodilator effect of a 10mg dose of theobromine was compared with that of 5mg of theophylline in young patients with asthma….In this single dose study the bronchodilatory effect produced by theobromine was clinically and statistically significant….improvement in all pulmonary function tests was noted after the ingestion of theobromine or theophylline.”

It should be noted that 'improvement' refers to a significant expansion of the airways within the smoker's lungs.

### 3.4.4 Glycyrrhizin

An ingredient of liquorice - another commonly used additive, glycyrrhizin also acts as a bronchodilator.

“What does a bronchodilator do? The bronchodilator makes it easier for you to inhale, so obviously if you are having difficulty putting smoke in your lungs, it’s good to have a bronchodilator in there. Now I was asked recently whether I knew whether the glycerizon being delivered is delivered in adequate concentration to cause that to happen. I do not know the answer to that question. It would be interesting to know whether that has been studied by the industry. If they have studied it, it would seem that that is the kind of information that should be shared with regard to ingredients. The point is, however, that we know it can happen, it is a bronchodilator. The probability that it happens is very high, but that would be related to studies that should be done.”

### 3.4.5 Pyridine

A testimony from WA Farone, a former Philip Morris employee, speculates on the impact of adding alkaloids other than nicotine to cigarettes:

“We normally think only of nicotine, but we have to remember there are other alkaloids in tobacco. As an example of that I have here a very old book on pharmacy and therapeutics. It was written in 1894, published in 1895, and I’d like to just read you one little thing. This is on the section under tobacco and it says, ‘It contains a very powerful and poisonous food alkaloid named nicotine’. It goes on to say, ‘It’s combustion gives rise to several products of which pyridine and its compounds of the sheath having the same action as nicotine but of less severity.’ So here we are back in 1894 knowing full well that pyridine acts like nicotine at least in some regard, and if you go to a modern book….you are going to find out that it is a central nervous system depressant, much the same as nicotine. So if I now add pyridine, either in the form of pyridine itself or in the form of some chemical, which when I combust it or pyrolyse it, it converts to pyridine, then I have increased the pyridine that the smoker gets if I put pyridine in with nicotine I increase the total central nervous system effect, and it becomes very, very important for us to understand the interactions between the additives the ingredients, and what is happening with the pharmacological effects of nicotine.”

(Farone WA 1997)
The following BAT report explores the absorption of pyridine and its synergy with nicotine. While the report says that the levels of pyridine found in tobacco smoke are ‘unlikely’ to be high enough to cause any effect, due to lack of disclosure it is difficult to ascertain whether current levels of pyridine are high enough to be pharmacologically active.

“Peripherally, i.e. the tissue of the body excluding the brain, whether acting similarly, by nicotine receptor stimulation, or by different mechanisms pyridine and nicotine act synergistically.” 55 (BAT)

“Centrally, pyridine and nicotine produce opposite antagonistic effects, nicotine being stimulant, pyridine depressant.”56 (BAT)

“…This is indicative that pyridine is producing this effect by stimulating a nicotinic receptor at this site.”57 (BAT)

“Discussion of the Interaction of Pyridine with Nicotine.
It would appear that in the majority of cases there is a degree of addition between the effects of nicotine and pyridine. It does not really matter if the two agents are producing their effects by different mechanisms, as with their effects on heart rate.

This conclusion seems to be true for the peripheral effects, but as can be seen from the results of the section concerned with the CNS effects of pyridine, and from the results of the mouse and rat toxicities in: the absorption section of the report, pyridine and nicotine have directly opposite effects on the brain, and thus will antagonise each other’s effects.”58 (BAT)
4 Masking the taste and immediate effects of tobacco

Is an ‘improved’ cigarette desirable?

Tobacco products enjoy widespread exemptions from consumer safety and product liability legislation through historical accident. Tobacco products are also the only consumer products that cause disease and death when used as intended by the manufacturer. Because of this unique anomalous status, additives to tobacco products present an unusual philosophical problem. For most products, the use of additives for ‘improvement’ does not lead to any harmful consequences arising from modest extra consumption. However, if the cigarette smoke is made to taste ‘better’ more people may start to smoke, continue to smoke or decide not to quit. This concern was reflected in the 1998 SCOTHC report:

"One of the effects [of additives] has been the maintenance of "taste" as tar yields have fallen with an ensuing reduction in natural flavour. The negative side of this has been the maintenance of the appeal of a product, which might otherwise have been rendered unacceptable through the adulteration of intrinsic flavour." 59

Additives are needed to modify the taste of nicotine

An ex Philip Morris employee explains in testimony one of the main functions of tobacco flavouring additives.

“It is widely known that harshness and bitterness of nicotine is not acceptable alone in a cigarette. There is strong scientific evidence to support both the need for nicotine in the products and the need to modify its flavour to make its delivery acceptable to the smoker.” 60 (Farone, W.A. Ex-Philip Morris employee. 1996)

The largest single additive used is sugar - around three percent of the total weight - masking the unpalatable taste of nicotine. Choosing a sweetened or flavoured cigarette brand allows smokers to inhale increased volumes of smoke, more easily absorbing the desired dose of nicotine. Over 80% of new smokers start below eighteen years of age - this is recognised by the industry and targeted in production and marketing strategies 61. The use of sugars, honey, liquorice, cocoa, chocolate and other flavourings make cigarettes more palatable and 'aspirational' - particularly to children and the young.

“Flavouring do effect smoking behaviour”

“Is it not the flavour that distinguishes the brands and cause some cigarettes to be more successful in the marketplace than others? The marketplace is probably one of the greatest proofs that flavourings do affect smoking behaviour.” 62 (Farone, W.A. 1996, Ex employee of Philip Morris.)

Use additives to replace lost flavours

Reducing tar levels, in an attempt to neutralise serious health concerns, caused manufacturers major problems - tar provides a strong flavour and mouth sensation, masking the harsher, bitter taste of nicotine - unpalatable to new smokers and uncomfortable to established smokers. The response was the use of additives to play the role of the missing tar.

“The Merit concept of utilising flavour technology to circumvent the tar problem by using flavour from additives instead of flavour from tar may represent the best compromise between the demand for a product with high flavour and/or
physiological impact and/or degree of nicotine satisfaction, and at the same time low tar and nicotine.” (Lorillard, 1976)63

Additives have multiple purposes

A BAT document gives some indication of the role of tobacco additives. Four of the seven reasons for additives are examples of additives masking the taste of tobacco.

“The Role of Tobacco Flavour Additives. Tobacco flavour additives of all types are gaining importance in manufacturing practice for a number of reasons. Additives may be required:

1. To introduce a u.s.p [unique selling point] to a product.
2. To modify the smoke sensory characteristics of poorer quality grades particularly where government or economic compulsion dictates that the better quality material is not available for manufacturing.
3. To achieve a satisfactory smoking quality in situations where league tables influence the design of the product.
4. To counter the effect on smoke quality of including synthetic smoking materials in the blend.
5. To maintain brand character.
6. To improve the smoking quality of an existing brand.
7. To improve side-stream smoke character.”64 (BAT)

Added ammonia reacts with sugar to create ‘milder’ smoke

Competing companies were obsessed with the success of Marlboro, and ran countless experiments to unravel its secrets. These are discussed in greater detail in the previous section. What they found was a cigarette packed full of additives.

“There is more to PM’s [Philip Morris’] ammonia processing than simple addition of ammonia, which leads to different results. They somehow force much of it to react with tobacco constituents in a manner such that pectin is released, while also forming sugar-ammonia reaction products that contribute to a mild and natural tasting smoke.”65 (BAT 1985)

Additives enable PM to use cheaper tobaccos in there cigarettes

“PM people often state in public that additives are important to them with regard to controlling smoke chemistry and taste. Indeed, their leaf people have been known to say that the additives are one reason that they can buy some cheaper tobaccos. Casings are an obvious choice of a vehicle for use of such additives.”66 (BAT 1985)

“The wide scale use of sugars in casing formulas (adopted originally on the basis of smoker acceptance) and the general observation that most blends which have
received wide scale consumer acceptance have significant sugar levels would certainly suggest that sugar level is important to quality.”67 (BAT 1963)

**Liquorice boosts the sweetness of tobacco**

According to BAT,

“There are sugar levels of 1.5% and above in certain tobaccos which are difficult to achieve by means other than by the addition of an ingredient. The sugar level may be increased up to 3% in the tobacco leaf, and sugar can also be added to the casing mixture.”67 (BAT 1963)

“Although each tobacco manufacturer carefully guards the secrets of his casing (and flavour) formulas, it is well known that casings for smoking products often contain sugar, liquorice, cocoa, or chocolate liquor and sometimes natural extracts. Of these, liquorice deserves special mention. Just as sugar is used in ‘casing’ the tobacco to mellow and smooth the smoke, liquorice is used as an adjunct to boost the sweetness of tobacco products. The taste of liquorice to the smoker is that of a mellow sweet woody note which, at proper use levels, greatly enhances the quality of the final product.”68 (BAT)

**Additives may be flavour enhancers or flavour suppressers**

“The greater use of reconstituted tobaccos presents two major problems to the flavour industry. Stems have higher nicotine content. You run into a second problem with them that you don’t run into with the blend tobaccos. Reconstituted tobaccos will start off with a bad character. You’ve got a twofold problem. You’ve got to suppress a bad flavour and neutralise harshness, and you’ve go to put a good flavour back in. So, in some cases, we make suppressants ----- flavourings that, in effect, neutralise and diminish a bad flavour. On top of that, we have to add a flavour to bring it to a point where it’s acceptable. One is an eraser and one is a writer.”69 (Tobacco Reporter 1979)

“Although by no means conclusive, the results now presented lend some support to the claim that treatment of tobacco with cocoa butter reduces the harshness of the smoke.”73 (BAT 1967)

BAT adds around 1250 tonnes of cocoa to its cigarettes per year.

“I have circulated all Companies in the Division, and from their replies, estimate...
that the Company uses about one and a quarter million kilos of Cocoa in its tobacco products each year.”74 BAT 1978

4.1 Additives and ‘low tar’ cigarettes.

**Low tar cigarettes** have low desirability without additives

“Low delivery cigarettes are commonly judged to lack acceptable levels of flavour. Attention is increasingly being focussed upon novel methods of incorporating flavours in cigarettes so that the desirable flavour level can be re-established.”75 (BAT 1982)

“As attempts are made to go lower in both tars and nicotine, flavour additives are needed to bring taste levels up to par.”76 (Tobacco Reporter 1979)

“Tobacco companies are concerned with putting something into a low yield cigarette to compensate for the loss of flavour and bring the taste partially back to the level of a higher delivery product.”77 (Tobacco Reporter 1979)

**Ethics questioned…**

Although there were concerns about lost taste, the priority was to ensure that smokers could continue to receive enough nicotine.

“Compensatable Filters.

Strategic Objective:

To make it easier for smokers to take what they require from a cigarette. This means in effect that the filter will be compensatable and implies a high taste to tar rates.”

Constraints:

Is this the ethical thing to do?”78 (BAT 1985)

In effect this means that the cigarette is designed to allow smokers to take a much higher level of tar and nicotine from the cigarette than is registered on official machines.

4.2 Front end ‘lift’

**The cigarette is designed around smoker’s vulnerabilities**

BAT uses additives and design to play to the smokers largely unconscious smoking desires. The very first puff on a cigarette can be engineered to have the greatest impact – both relieving the pent up nicotine withdrawal symptoms and providing the best taste.

“Front-end lift.

Strategic objectives:
To improve the taste and flavour of the first few puffs on cigarettes.

It is assumed that smokers are most likely to make judgements about the cigarette quality in the first few puffs.

It is assumed that ‘need’ for smoking is highest when a cigarette is lit.”79 (BAT 1985)
5 Additive Toxicity

The limited regulation of tobacco additives has tended to concentrate on the toxicity of the additive itself. This has tended to draw upon food regulation—however, it is quite likely that the toxicity of an additive when ingested as food may differ from its effect when inhaled in smoke. There should, therefore, be caution in accepting the effectiveness of even these limited safeguards:

"Because the delicate respiratory system lacks the powerful enzymes and detoxifying metabolic pathways of the digestive system, these compounds may be significantly more toxic when inhaled than when ingested. Pyrolysis of additives may also produce novel toxic constituents, thereby creating additional health risks to the smoker."[80] (Connolly, Lymperis, 1998)

Coumarin

Health concerns surrounding the use of a highly toxic flavouring compound called coumarin (which causes severe liver damage) began to emerge in the late fifties. Cigarette manufacturers voluntarily removed coumarin from the permitted list in September 1997. Although the controversy is almost four decades old, it serves as a reminder of the bias towards sales over health concerns within the tobacco industry as a whole.

“In the meantime we think you would be interested to know that in America the manufacturers of all food products intended for human consumption abandoned the use of coumarin during 1953/54 ‘until such time that adequate tests and investigations were completed wherein the use of coumarin may be considered to be deleterious and injurious to health.’[81](BAT, 1959)

Cigarette manufacturers have been subject to a relatively liberal legislative framework, partly on the grounds that the industry should regulate themselves—evidence shows they are unlikely to do so:

BAT test additives for carcinogens

“Mutagenic Activity of Flavour Compounds: Some 270 compounds have been assayed for mutagenic activity in Ames test …… In these experiments a number of flavour compounds have been shown to be positive mutagens……

Acetaldehyde: Is a positive mutagen, it is embryotoxic, teratogenic and induces respiratory tract tumours in hamsters when inhaled.

Furfural: This is confirmed by complementary work as a clear mutagen and, in conjunction with other respiratory tract carcinogens, e.g. benzo(a)pyrene, it may act in a concerted way to increase the yield of tumours.

Furfural Acetate: The work of Mortelmans et al. is the only mutagenic study on this compound. However, the experiments on fufural and furfuryl alcohol would seem to indicate a general mutagenic reactivity of this family of compounds.

Maltol: The positive mutagenic activity is confirmed by other studies in vitro; however, the compound does not seem to have been tested in vivo.

O-Methoxycinnamaldehyde: Does have the potential to be a positive carcinogen.
Recommendations:

Acetaldehyde, furfural and furfural acetate……..If these agents are to be added to tobacco, it would appear prudent to review the levels of addition in the light of the above evidence. For maltol and o-methoxycinnamaldehyde, the evidence indicates a possible carcinogenic potential of these agents. This would again suggest reviewing the use of such agents for human use.”82 (BAT 1986)

A dilemma: reduced toxicity or reduced sales?

There is evidence to suggest that the tobacco companies do not have adequate internal controls over potentially harmful additives:

“We were quite well aware that Eugenol is a phenol …We also agree with you that phenol is a dirty word at present.”

“Really this comes down to a point of asking ourselves this question: Would we be willing to accept a possibly slightly undesirable means to accomplish a desirable end?”

“It has occurred to us that whereas there would be no reason to fear any health danger from the use of Eugenol if the question of phenols had never been raised, yet now that it has been so raised we have got to take it into account since Eugenol is itself a phenol.”

“Is the chemical evidence adequate to justify immediate sale of the cigarettes to the public subject to further chemical and/or biological tests being carried out with reasonable despatch.” 83 (BAT 1982)
6 Changing the Perception of side-stream smoke

Additives to reduce the appearance of passive smoking

Additives are also used to mask the effects of environmental tobacco smoke (ETS), primarily to undermine the negative image of smoking and remove some of the social pressures that make smokers more likely to quit.

Environmental tobacco smoke is a big problem for the industry. Since the 1970s scientific evidence has accumulated proving that exposure to ETS is a serious health hazard (in the UK alone several hundred deaths are attributable to ETS each year)\(^6\). This discovery had a profound effect on the politics of smoking - moving from an issue of individual choice to one of social responsibility - and encouraging even more smokers to reassess their habit.

The tobacco industry response was twofold; firstly research was conducted specifically to find evidence countering claims that exposure to ETS was a health hazard, and secondly chemical additives were identified to reduce its anti-social and irritating effects - making it harder for non-smokers to avoid or criticise. There were also some attempts to reduce overall ETS, however the primary concern was modifying perception of the smoke rather than its properties.

Choose the result then find the proof

“Strategic objectives (of sidestream smoke research) remain as follows: 1. Develop cigarettes with reduced sidestream yields and/or reduced odour and irritation. 2. Conduct research to anticipate and refute claims about the health effects of passive smoking.”\(^8\) (BAT 1984)

Reducing the visibility of ETS may increase its toxicity

“It was thought prudent to ensure that the Company could show no adverse effects on sidestream toxicity for a product designed to have a lower visibility sidestream.”\(^8\) (BAT 1984)

Worryingly this opens up the possibility that work on lowering the visibility of side-stream smoke was increasing its overall toxicity.

“Studies into alternative burn additives that reduce visible sidestream: As a result of these studies sodium acetate has been used to replace tri-potassium citrate in low visibility sidestream papers...Potassium salts give greater reductions in sidestream visibility.”\(^8\) (BAT 1987)

“BAT reduce...Smoke control: sidestream reduction: Visibility. RD&E is interested in work...
dealing with sidestream smoke reduction, but is not interested in the biological testing of products produced. David will explain this to Allen Herd and ask whether projects could be run without biological testing.” (BAT 1986)

It appears that while reducing the visibility of side-stream smoke is considered important, the toxicity of the resultant vapour is not.
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