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Addition of Nicotine to Synthetic Smoking Materials.

Nicotine can be added in several forms:-

(a) as the "free" base
(b) as a specific salt at its natural pH
(c) in combination with a mixture of acids at a defined pH level
(d), admixed with materials such as bentonite.

It is assumed that the transfer of nicotine to smoke will be optimized and the principal factors which should be considered are:

1) The final state of the nicotine in the composite smoking material; this will be dependent on the form of the added nicotine, the nature of the synthetic sheet and of any other additives.

2) The synthetic sheet and any additives can also effect the form of the nicotine in smoke. The latter should be considered to give efficient usage by the smoker.

3) A good "shelf-life" will be one basic requirement for a commercial process.

4) Similarly safety in handling the addition of nicotine may, by the nature of the processing, be of considerable importance.

1) Nicotine Transfer to Smoke.
Review and comments on previous work

The form of addition does not affect the transfer of nicotine when it is added to tobacco which contains an excess of acid (1), but when added to a more or less neutral base material the transfer increases with the final pH of the material (2). An increased transfer of nicotine can also be obtained by the addition to tobacco of alkaline materials such as ammonia (3) and potassium carbonate (4). In contrast the addition of various sodium salts to tobacco indicated (5) that the increase in nicotine transfer was small even if the pH was increased from pH 5.0 to 6.5.

On the other hand the addition of acidic materials or salts of strong acids e.g. metallic chlorides (6), ammonium sulphate and sodium nitrate (7) lead to a pronounced reduction in nicotine transfer.

A similar effect has been noted (8) on the addition of a neutral material, sugar, to Burley tobacco.

Two synthetic smoking materials SM64 (9) and SM65 (10) have been examined and in both cases the transfer of nicotine was poor. This may have been due to the additives used, sulphate in SM64 and small proportions of chlorides and nitrates in SM65, but if it was due to the base material (80% cellulose on a dry weight basis) it underlines the importance of distinguishing between the effect of the combustion additives and that of the synthetic sheet material.

The transfer of nicotine from materials such as ion-exchange resins (10) and Bentonite (13) appears to be poor.

Although most of the information available relates to the transfer of nicotine from tobacco to smoke it appears likely that in general the transfer increases with pH while acidic materials and even some neutral additives can lead to a pronounced reduction in nicotine transfer. The effect of additives may be different when used in conjunction with synthetic sheet materials but examination of SM64 and SM65 indicates that a serious problem remains. It is possible, however, that the treatment of synthetic smoking materials with ammonia could produce an increase in nicotine transfer without the disadvantageous changes in smoke flavour found following treatment of flue-cured tobacco.

2) Efficient Usage of Nicotine by the Smoker.

To obtain efficient use of nicotine in cigarette smoke it is desirable that the pH of the smoke is not too acidic i.e. not less than 5.0 and preferably somewhat above this lower limits Thus it has been shown (12) that the "strength" or "impact" of cigarette smoke is related to the amount of extractable nicotine in smoke and that, in this respect, this factor is more important than the absolute nicotine content of the smoke. This work indicates that a high ratio of nicotine to acids is desirable and where possible this factor should be considered in the choice of acid radical associated with the nicotine and other additives. Thus the use of a non-volatile acid or acid which is decomposed during pyrolysis may be preferable to the use of a weak acids, and certainly to the use of a strong volatile acid.

3) Shelf-Life.

The shelf-life will be determined principally by the final pH of the product - a high pH will lead to a poor shelf-life and vice-versa. Ammonia treated tobacco with a pH of 7.5 (dropping to about 6.5) lost nicotine at a rate of about 1% per week over a 13 week period. At the end of that period the nicotine delivery was still 28% higher than the control (3). Shelf-life, therefore, has to be balanced against efficient nicotine transfer and there must be an optimum point or range.

4) Safety.

Nicotine is a toxic hazard. Although limits have been laid down for the maximum permissable vapour concentration in the atmosphere (13) (0.5 mg/cu. meter), the situation with nicotine solutions is not particularly clear. This is probably due to the differences between nicotine base, which is very readily absorbed by the skin, and acidic nicotine solutions from which nicotine is not readily absorbed.

Unlike the shelf-life and nicotine transfer to smoke, which would be dependent on the final pH of the material, the safety factor will be dependent on the pH of the nicotine solution added. Good safety precautions will be required but a factor of about 10 can be achieved by using nicotine solutions with a pH about 6.5.

5) Other Methods of Obtaining Efficient Transfer and Usage of Nicotine.

a) Displacement of Nicotine from Filters. Previous work suggests that the proportion displaced is very small and the method is not very attractive.

b) Addition of Nicotine to Cigarette Paper. I.T. Co. (Bristol) have done a considerable amount of work on this technique which is the subject of provisional patent applications (14). It may be summarised as follows:-

Nicotine added to chalk loaded cigarette papers has a poor shelf-life due to the high pH value. The shelf-life is poor even if the nicotine is added as the oxalate or sulphate, and the addition of excess acid results in a glycine type paper which is brittle and difficult to handle.

The only practical solution appears to be the use of a double paper; the nicotine being added, as a salt, to the inner wrapper.

The shelf-life of nicotine added to the paper should not be confused with that of the total product. Thus it appears probable that the poor shelf-life of nicotine salts added to paper could be due to the transfer of nicotine from the alkaline paper to acidic tobacco in close proximity and not necessarily to a loss of nicotine from the whole product.

Conclusions.

To optimize nicotine transfer to the smoke and absorption from the smoke by the smoker it will be necessary to consider very carefully the nature of the synthetic sheet material and the various additives. The degradation products of these components are almost of equal importance.

Although alkaline materials do not always lead to an increase in nicotine transfer all the work on additives emphasises that the use of acids or the salts of strong acids certainly reduces nicotine transfer. Thus the major factors would appear to be:-

1) to avoid the use of a base sheet materials with a high acidic residue (not necessarily a low pH).

2) To avoid additives which contain strongly acidic salts.

There are some indications that the heat stability of the acid radical, as distinct from the pH, may be important.

In general, however, it must be emphasised that most of the information available relates to the transfer of nicotine from tobacco and the effect of various additives on such transfer. Very little is known about the transfer from synthetic smoking materials and previous work on the release of nicotine from "nicotine salts" on cellulose was carried out using a slow temperature program. In this work the pyrolysis products of the acid radical were not examined. Thus it is suggested that further work with more complex nicotine salts, and the effect of addives on nicotine release from possible synthetic materials, should be carried out using a pyrolysis furnace.

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