

Dr M J Taylor, Scientific Services Manager at the Filtrona Technology Centre, considers the role of filter technology in reduced yield cigarettes.

In recent years there has been a growing interest in a wide range of chemicals in cigarette smoke, in particular those chemicals considered toxic or carcinogenic. Some authors have speculated that reducing the amounts of such compounds in smoke may give rise to cigarettes that could be considered to be lower risk products. While no clear definition of a lower risk product exists, such products would be expected to give lower (or zero) yields of harmful compounds. This has led to an increasing focus on the role of the filter in overall cigarette performance, particularly with reference to its ability to selectively remove or reduce toxic compounds from smoke.

Cigarette smoke can be divided into four main phases all of which contain compounds that can be considered harmful or toxic. These are gasses, vapours, semi-volatiles and non-volatiles. An ideal solution would be to produce a cigarette that is acceptable to the consumer but also a potentially lower risk product. This could be achieved if it were possible to selectively reduce the harmful compounds in smoke, while allowing those responsible for smoker satisfaction to pass through the filter. The complexity of cigarette smoke makes it extremely difficult to identify all harmful compounds, but those identified on the Hoffmann list would make a good starting point for removal.

The only way to selectively remove or reduce individual compounds is if they can diffuse to the removal medium and then undergo some adsorption or reaction and hence, be removed from the smoke-stream. As diffusion is critical to selective filtration, volatile and gaseous compounds are available for selective reduction whereas non-volatile compounds are not.

Having established which compounds can be reduced, how can filter technology be used to develop reduced risk products? Filter technology can offer a variety of cost-effective solutions to the cigarette designer. These include filters with higher tar and nicotine retentions per unit pressure drop than standard acetate filters, more effective carbon filters, the carrying of alternate adsorption or chemisorption

materials and constructions which allow the use of ventilation for gas/vapour phase compound reduction.

Filter options do exist to give higher tar and nicotine reductions than a standard filter at the same pressure drop. A filter that is being used on many brands in China, perhaps because of its compatibility with the tobacco blends used, is the CPF™ filter. This consists of a cellulose acetate filter wrapped with a partially fluted special paper. The flutes can be orientated so they are either at the tobacco end of the filter or the mouth end (see pic 1). The main advantage of this filter is the cross flow filtration achieved by the special fluted paper, which increases the retention of the filter (up to 10%) when compared to a cellulose acetate filter at the same pressure drop.

Orientating the flutes to the mouth end of the cigarette, thus giving a unique appearance, is an option which has been frequently employed with this type of filter to provide brand differentiation and a counterfeit deterrent. A further option to enhance the unique end appearance would be to use coloured inner wraps (see pic 2). The CPF™ filter has also been constructed with a flavour delivery system to allow the extra retention to be used in conjunction with flavour release. Another development of this filter has been its use as a segment in a dual filter product. This allows a combination with, for example, a traditional Active Acetate Dual (AAD) filter to give the product a distinct appearance for brand differentiation, while simultaneously utilising the properties of carbon and increased retention efficiency. This would be suitable for a possible reduced risk product as the carbon would give significant reductions in toxic compounds.

Activated carbon can significantly reduce 23 of the compounds on the Hoffmann list. The main drawback is that current commercial carbon filters are relatively complex to manufacture. For example, three manufacturing processes are required to produce the AAD filter. Despite advances in production technologies, a carbon product that can be produced in a single manufacturing process is of great interest to the industry. Such a product is now available.

Patch work

This is called the Active Patch Filter (APF™) and consists of a patch of carbon printed on the inner surface of a standard plugwrap on a monoacetate filter (see pic 3). The product is also available with a split patch, to allow ventilation through the gap in the carbon. At the moment, this can only be achieved by on-line laser, but a version with a porous wrap should be available in 2005. Other granular adsorbents can be added to the plugwrap such as silica gel, sepiolite or a selective filtration medium. The main benefit of this filter is the higher reductions in vapour phase and semi-volatile components when compared to an equivalent monoacetate filter. The APF™ is also a clean run filter as no carbon bearing portions are cut during cigarette manufacture.

A broader target

True selectivity could be considered as the total removal of one particular compound from smoke. However, removing only one compound may be considered to give a lower contribution to overall risk reduction than the removal of a wider number of toxic compounds. One solution may be the combination of carbon with an additive to target a particular compound, that is to combine the removal of a range of compounds with the selective removal of a targeted compound.

Although work is still ongoing to extend the range of these enhanced carbons, the first filter product of this type was launched last year, the HCNR™ filter. This material allows for the targeted reduction of hydrogen cyanide and could be used in any type of carbon filter. The hydrogen cyanide yield of an unventilated cigarette is often between 150-400µg/cigarette, depending on the tobacco blend used.

This selective reduction is achieved by using a special impregnated carbon. The selective carbon also increases the overall vapour phase reduction given by filters incorporating standard carbon. Naturally this also includes a higher reduction of semi-volatile compounds. The reduction of hydrogen cyanide can be increased to over 90% if sufficient carbon is used. The mechanism of this reduction is a chemical reaction rather than physical adsorption, so the removal efficiency of hydrogen cyanide does not change with time (i.e. when cigarettes are aged).

This HCNR™ carbon also reduces higher amounts of volatile aldehydes, ketones and hydrocarbons alongwith semi-volatile compounds like pyridine and styrene . As the boiling point of compounds increase the carbons have less vapour to remove and hence the retention is nearer to that of acetate for the phenols and cresols. For non-volatile compounds such as tobacco specific nitrosamines and Benzo [a] Pyrene the retention of all of these filters are very similar to the tar retention. When used with moderate ventilation and filters incorporating about 100 mg of this selective carbon it may be possible to produce cigarettes that are essentially free of compounds like hydrogen cyanide, pyridine and styrene which can only help the designer of potentially lower risk products.

One major component of cigarette smoke is carbon monoxide. The toxic effects of carbon monoxide are relatively well known. This toxic effect, coupled with the relatively high levels in cigarette smoke, makes the reduction of carbon monoxide of prime concern for the development of potentially lower risk products. At this point in time the only practical way of reducing carbon monoxide in smoke is by the use of filter ventilation. In general ventilation will reduce the cigarette draw resistance and the yields of all smoke components including tar and nicotine. To achieve a highly ventilated cigarette with an acceptable draw resistance, a filter with a high-pressure drop is required. But if, for example, a cigarette with a high level of ventilation is combined with a high-pressure drop/high retention filter the result will be a very low tar yield and low taste cigarette.

Ventilating toxins

Studies demonstrate that ventilation is the only current practical method of reducing carbon monoxide. Ventilation also reduces other gas/vapour phase compounds much more effectively than cellulose acetate filters. To utilise the effect of ventilation to reduce carbon monoxide whilst producing a cigarette with an acceptable draw resistance and tar yield, a filter with a high-pressure drop but low tar and nicotine retention is required.

The methods of reducing the retention for a filter of a particular pressure drop include reducing filter length, increasing filament denier, reducing filter circumference and/or the use of novel materials or constructions with high-pressure drop and low retention

characteristics. A new novel filter construction that meets this high-pressure drop, low retention criteria is now available - the COR™ filter. This is designed as a triple filter construction with an acetate segment at both ends of the filter. The tobacco-end segment is low-pressure drop, low retention, whilst the mouth-end segment is high-pressure drop, low retention. The filter will allow the reduction of carbon monoxide relative to tar whilst offering acceptable draw resistance when combined with high ventilation levels. The COR™ filter also reduces the deliveries of organic volatiles and other gas phase compounds such as nitric oxide.

A considerable number of options already exist for the reduction of toxic compounds in cigarette smoke. However, much work is also being carried out to reduce them further. A cigarette brand has already been in the market place using an ion exchange resin in combination with carbon to give reductions of toxic compounds in smoke. This may be the first of many products using a more complex filter construction and multiple removal reagents to reduce the levels of toxic materials in smoke.

Multifunctional filter

The filter of the future will probably be a multifunctional device, manufactured at very high speed, containing carbon and a number of selective filtration media. Such devices will give the cigarette designer a great deal of help in producing products that may be considered as reduced risk.

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