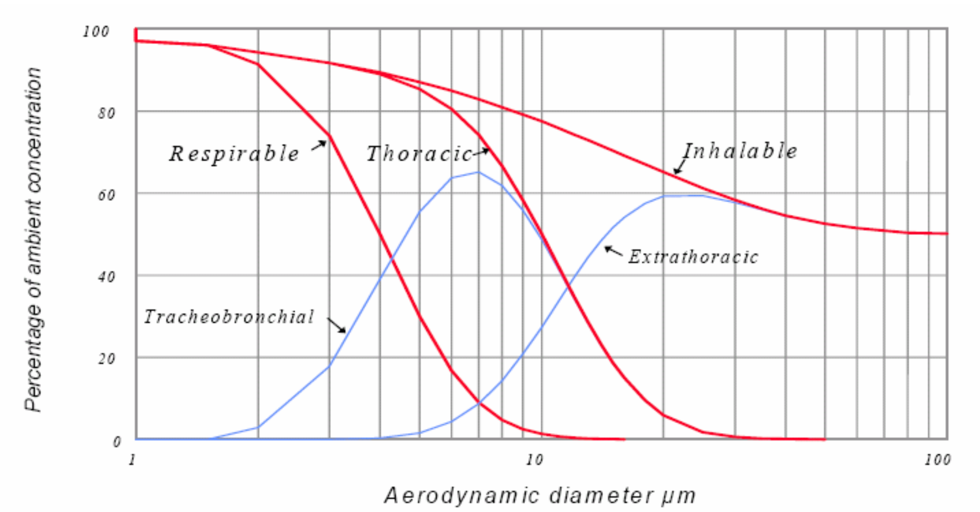
Machine Made Fibres

HSE Research Report RR503. 2006
An inventory of fibres to classify their potential hazard and risk

The report provides summaries of toxicological and risk information on synthetic, some semi-synthetic fibres (e.g. cellulosic fibres) which are sometimes referred to as machine-made (or man-made) organic fibres (MMOFs) and also a range of other non-organic fibres and whiskers and specialist technical fibres including various types of carbon fibres and nanofibres. The report does not include information on asbestos or man made vitreous fibres (MMVF) as these have been extensively reported already. [some have also been assessed by IARC for cancer risk]

Experimental data on the dimensions, durability/solubility, dose and dustiness, are thought to be useful predictors of lung related health hazards and risks. Fibres with an aerodynamic diameter of less than 10 µm can enter the smallest air sacks in the lung and if insoluble can be a cause of persistent inflammation leading to lung damage [and possibly cancer]. Some fibres are susceptible to mechanical degradation and thereby act as an unexpected source of respirable fibres. The probability of deposition and location of deposition of fibres depends on aerodynamic diameter as follows:



The graph shows that submicron fibres have a high probability of deposition in the deepest parts of the lung. Particles of 7 µm aerodynamic diameter most likely deposit in smaller airways at the point where the airways divide. The graph is taken from an ISO sampling convention. Effective aerodynamic diameters are subject to particle density; heavier materials will have smaller effective diameters. [Aerodynamic diameter is not directly related to particle dimensions or density; it must be established by experimentation.]

Novel production techniques may change some of the above properties without any change in chemical composition. Regulation would not automatically require a new risk assessment of such fibres.

The processes of fibre carcinogenicity are still not well-defined and the hazard and risk may also be modified by the surface chemistry, surface structure and chemical composition. It is unclear which parameters should be measured for the purposes of risk assessment. Fibres which are less than 10 µm in diameter but longer than 20 µm are thought to present particular risk of cancer, but only because this is accepted wisdom for asbestos.

Hazard assessment

- Fibre samples were viewed under a microscope. Presence of fibres less than 6 µm diameter was noted. Length-weighted geometric mean diameter was established by standard counting methods.
- Mechanical challenge (1 minute of wet grinding) to the fibre followed by microscopic examination. Tendency to produce fibrils was noted.
- Dustiness was measured if small fibres were found. Fibres were agitated in a sealed drum and fibres per ml of air were counted per gramme of fibre.
- If dusty, analysis of solubility rate of fine dusts.

The principle factor is the presence of respirable fibres in the product or the ability to create finer fibres by abrasion. Samples that contained or would produce fine fibres when abraded would be tested for their solubility in simulated lung fluid.

<u>Fibre samples which contained respirable particles:</u>
Para-aramid [low proportion]
Liquid crystal polyester [low proportion]
PIPD [low proportion]
Polybenzobisoxazole (PBO) fibres [low proportion]
PTFE fibres [low proportion]
Polyester fibres [low proportion]
Polyphenylene sulphide (PPS) fibres [low proportion]
Polypropylene fibres [low proportion]
Hemp fibres [low proportion]
Carbon nanofibres [high proportion but tendency to agglomerate, see figure]

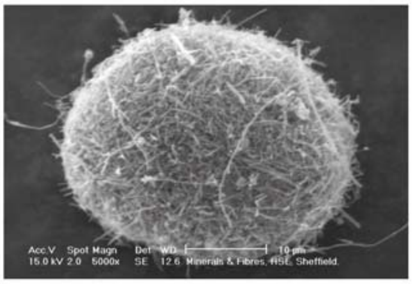


Figure 24: Vapour grown Carbon nanofibres, showing their typical tendency to form agglomerates.

Nanofibres [high proportion]
Stainless steel [high proportion]
Polyethylene tetra phthalate [high proportion]

<u>Fibrillation results</u>:
Acrylic
Para-aramid
Liquid crystal polymer
PIPD
PBO
Solubilized cellulose derivative fibres
Cotton fibres
Flax
Hemp
Jute
Preoxidised / Oxidised PAN fibres
Preoxidised fibres
Flame retardant paper (40% melamine fibres + other fibres)
Bi component fibres?

<u>Dustiness</u>
Dustiness was recorded by reference to blank samples. For the purposes of the risk assessment values of 0.1 – 1.0 f/ml/g are regarded as low, 1 –10 f/ml/g as medium and 10 – 100 f/ml/g as high release of respirable fibres.

Those fibres which released fibres with counts significantly above background levels were:
Polyacrylonitrile flock [medium]
Kevlar Pulp [low]
Metal fibres [low]

<u>Solubility</u>

Table 10: Weight changes in 500 mg test samples					
		Percentage weight change of a ~500 mg sample after			
		7 days	14 days	21 days	28 days
Carbon X	08720/04 2	6.06	5.47	5.09	5.34
L.C.	08350/03 2	1.34	0.72	0.72	0.62
Para aramid	08334/03 2	2.67	1.32	0.70	1.07
Lyocell	08460/04 2	1.86	1.01	-0.10	0.02
Zylon	08266/04 2	1.01	0.24	0.08	1.04
Nylon flock	08260/04 2	0.44	0.16	0.59	-0.54
Metal fibres	08456/04 2	0.09	0.15	0.23	0.31
Pan flock	08262/04 2		0.15	-0.68	-0.09

Weight changes of below 1% over this time scale were probably not significant. Low solubility indicates a potential for long term retention in the lung, unless the fibre is cleared by some other mechanism e.g. phagocytosis.

Comment
The database of results is intended for HSE use only. There may be some scope to negotiate on this point.

The present report employs inconsistent nomenclature and does not follow the hierarchy of decision-making that was promised. However, the proposed methodology is logical and should help identify risks from fibrous materials.

The present report suggests, on the basis of solubility, concern about respirable particles of L.C. [acrylic], Para-aramid, Lyocell, Zylon, Nylon flock, Metal fibres and Pan flock. Of these, and without mechanical abrasion, metal fibres were of low dustiness the rest were of negligible dustiness or were not reported. With mechanical abrasion: acrylic and para-aramid generated respirable particles.

The report is of limited scope but suggests concern about metal fibres under normal handling conditions and, acrylic fibres and para-aramid fibres if subject to mechanical abrasion. In vivo solubility tests on these would confirm whether or not a risk remains in live animals; clearance mechanisms in vivo are more powerful than the test tube solubility test may indicate.

Metal fibres are produced on an industrial scale to between 1 µm and 100 µm diameter. Applications were not specified in this report but include sound insulation, thermal insulation, concrete reinforcement and chemical filration.

Acrylic and para-aramid (e.g. Kevlar) fibres typically have diameters between 15 µm and 20 µm. Major applications include fabrics and reinforcement. Kevlar has been studied and is not usually regarded as carcinogenic; fibres are not very bio-persistent in vivo.

Manufacturers of fibres could commission HSL to assess their fibre products and compare with the database.