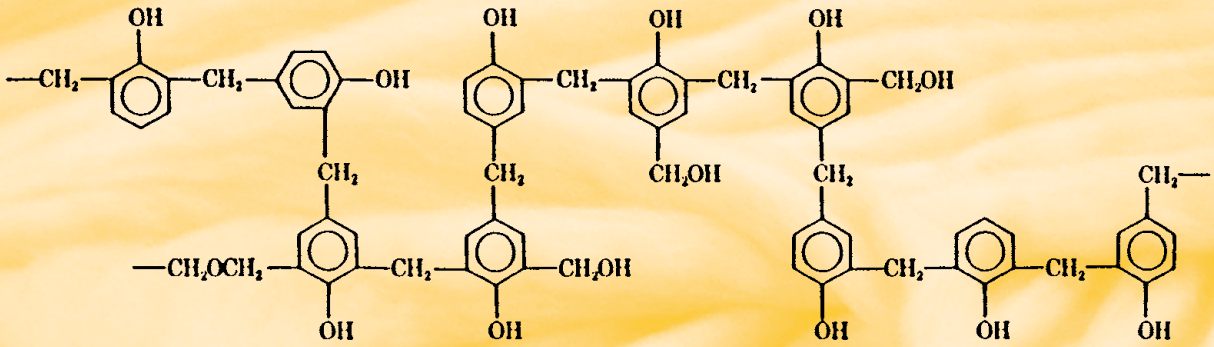
Kynol®

Novoloid Fibers

Introduction

Kynol novoloid fibers are cured phenol-aldehyde fibers made by acid-catalyzed cross-linking of melt-spun novolak resin to form a fully cross-linked, three-dimensional, amorphous „network“ polymer structure similar to that of thermo-setting phenolic resins (see sketch). Chemically, the fibers contain approx. 76% carbon, 18% oxygen and 6% hydrogen.
Because of their basic chemical structure Kynol fibers are infusible (non-melting) and insoluble, and possess physical and chemical properties that clearly distinguishes them from all other man-made and natural fibers. The uniqueness of this fiber structure is implicit in the generic term “novoloid”, officially recognized by the United States Federal Trade commission, designating a manufactured fiber containing at least 85% of a crosslinked novolak. Kynol® is a registered trademark and the only commercial available novoloid fibers.



Fiber Properties

The typical properties of Kynol novoloid fibers are listed in the table below. These properties vary slightly with the fiber diameter (dtex).
The individual fibers are generally elliptical in cross-section, with a ratio of diameters of approx. 5:4. The virgin fiber is light gold in colour, and darkens gradually to deeper shades with age and exposure to heat and light; this change in colour does not result from or imply any significant change in the other fiber properties.
Kynol fibers have a very soft touch or “hand”, and the comparatively high moisture regain is an important comfort factor in processing and use.

Properties:

Colour	gold
Diameter	15, 18, 23, 33 µm (2,2; 3,3; 5,5 and 11 dtex)
Fiber length	standard: 51, 70, 100 mm, crimped and un-crimped but also others, e.g. short cut
Specific gravity	1.27
Tensile strength	12 – 16 cN/tex (1.3 – 1.8 g/d)
Elongation	10 – 50 %
Modulus	260 – 350 cN/tex (350 – 450 kg/mm^2)
Loop strength	19 – 27 cN/tex (2.2 – 3.1 g/d)
Knot strength	10 – 13 cN/tex (1.1 – 1.5 g/d)
Elastic recovery	92 – 96 %
Moisture regain at 20°C, 65% rh	6 %
LOI	30 – 34

Chemical Resistance

Kynol fibers display excellent resistance to most chemicals and solvents. They are virtually unaffected by non-oxidizing acids, including hydrofluoric and phosphoric acids, dilute bases and organic solvents.

Chemicals	Concen. %	Temper. °C	Exposure Time h	Effect on Breaking Strength*				
				None	Slight	Moderate	Appreciable	Degraded
Strong Mineral Acids								
Hydrochloric	20	98	1000	●				
Hydrochloric	35	98	1000	●				
Hydrochloric	50	60	1000	●				
Nitric	10	20	100	●				
Nitric	70	20	100					●
Sulfuric	10	98	1000	●				
Sulfuric	60	60	100		●			
Sulfuric	98	150	100				●	
Phosphoric	85	135	1000	●				
Fluoric	15	50	40	●				
Organic Acids								
Acetic	100	98	100	●				
Formic	91	93	100	●				
Oxalic	10	98	100	●				
Strong Alkalis								
Ammonium Hydroxide	28	20	100	●				
Sodium Hydroxide	10	20	100	●				
Sodium Hydroxide	40	20	100		●			
Organic Chemicals								
Acetone	100	56	1000	●				
Benzene	100	80	1000	●				
Carbon Disulfide	100	20	1000	●				
Carbon Tetrachloride	100	20	1000	●				
Cresol(meta)	100	98	1000	●				
Dimethylformamide	100	98	1000	●				
Dimethyl Sulfoxide	100	98	1000	●				
Ethyl Alcohol	100	75	1000	●				
Ethylene Glycol	100	0	1000	●				
Formaldehyde	37	20	1000	●				
Freon 113	100	20	1000	●				
Gasoline	100	20	1000	●				
Jet Fuel	100	70	1000	●				
Perchloroethylene	100	98	1000	●				
Xylene	100	98	1000	●				
Gases								
Ammonia	100	200	100	●				
Hydrogen Chloride	100	98	100	●				
Hydrogen Fluoride	100	98	100	●				
Steam		155	100	●				

Flame Resistance

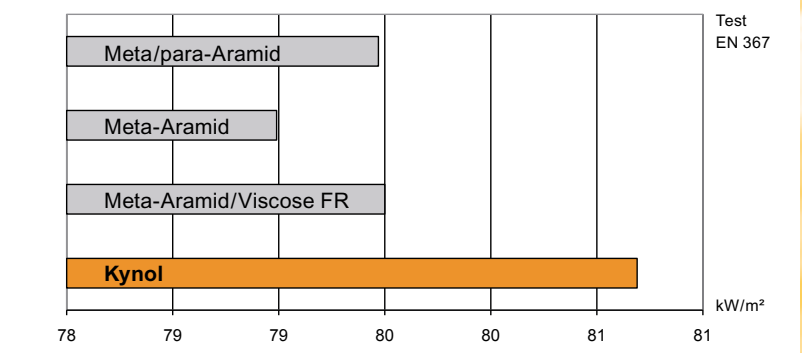
One measuring unit of the flame resistance of a given material is its "limited oxygen index" or LOI, which gives in essence the concentration of oxygen required in the local atmosphere for continuous self-supporting combustion. The LOI of Kynol materials varies with the particular textile structure (fiber, felt, fabric) under test and the test method and apparatus, but is generally in the range of 30 to 34.

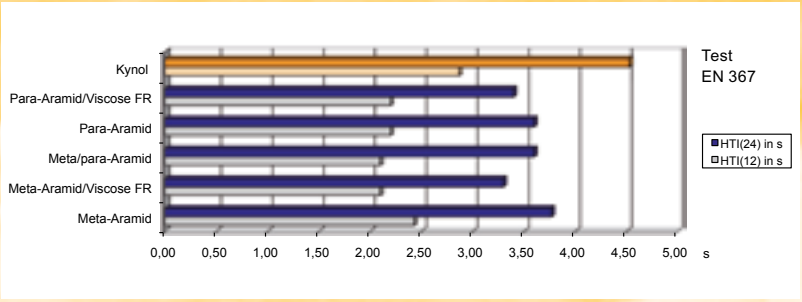
All of the foregoing factors are believed to contribute to the high flame resistance of Kynol materials. When actually exposed to flames Kynol materials do not melt but gradually char until completely carbonized, without losing their original fiber structure. The limited production of combustible volatiles results in minimal additional contribution to combustion. The stable surface char radiates heat away from the material, presents a minimum reactive surface to the flame, and retards further production of volatiles.

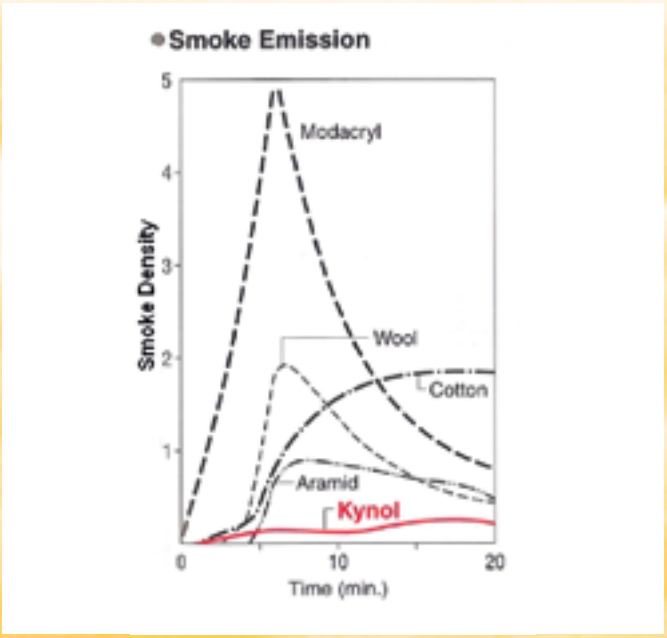
The low shrinkage and absence of melting allows the charred material to retain its integrity as a barrier to keep heat and oxygen away from the interior of the fiber structure, and the low thermal conductivity of the uncharred interior material further limits penetration of the heat. Finally, the water vapour and CO_2 evolved as products of decomposition and combustion serve to carry heat away from the material and provide an ablative type of cooling effect.

Heat Resistance

Kynol fibers and materials are highly flame resistant; in addition, they are excellent thermal insulators. However, they are not high temperature materials in the usual sense of the term. While a 290 g/m² woven fabric will withstand an oxyacetylene flame at 2500°C for 12 seconds or more without breakthrough, the practical temperature limits for long-term applications are 150°C in air and 200 – 250°C in the absence of oxygen. At higher temperatures the materials will undergo gradual loss of weight and strength over time.



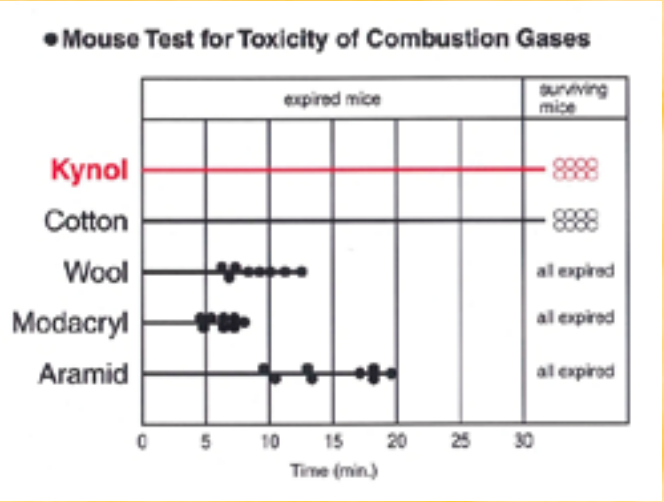




Smoke Emission and Toxicity

The chemical structure of Kynol fibers includes only carbon, oxygen and hydrogen; therefore, when Kynol products are exposed to flame the products of combustion are principally water vapour, carbon dioxide and carbon char. Moderate amounts of carbon monoxide may be produced if the supply of oxygen is limited; but the HCN, HCl, bromine- and phosphorous-containing compounds and other toxic by-products of combustion of many other inherently flame-resistant and FR-treated organic fibers are not produced.
Moreover, since the fiber chars without melting and produces few volatiles, smoke emission is also minimal, less than that of virtually any other organic fiber.

The attached figures show comparative smoke emission curves, as well as the results of a series of tests in which the products of combustion of various fiber materials were passed through a chamber containing live mice to obtain a comparative indication of acute toxicity of combustion gases.



Main applications of Kynol products:

Flame resistant safety products:
Fire blankets, flame barriers, drapes, smoke barriers, seat linings, protective curtains and special carpets in: aircrafts, motorcars, ships, ferries, submarines, hotels, discos, theatres, hospitals, etc.
Cover (fire blocking layer) for mattresses and as filling in sleeping bags for navy, army and civilian use.
Fire extinguishing blankets.
Apparel:
For welders, as linings in gloves, racing car drivers' and pilots' jackets, in firemen's and other rescue coats or suits; escape hoods for aircrafts and hotel visitors etc.

Thermal insulation, also against radiant heat:
For air condition, ventilation ducts, in shoe soles and for military vehicles,
insulation of roofs and walls, also in a blend with rock wool.

Laser, spark and metal splash protection:
Protective curtains, also for welding.

Chemical resistant products:
Gland packings, gaskets, composites, garments, gloves, reinforcement for phenolic resin in walls, flexible tanks; waste water applications.

Electrical applications:
Flame-proof coatings, filler yarns and wrapping tapes in high performance communication and power cables in energy plants, highway tunnels, high-rise buildings, underground concourses and subways.

Other industrial uses:
Brake bands, joints, clutch facings, disc brake pads, brake linings and as reinforcement in other composites.

Kynol fibers and textiles are excellent precursors for activated carbon materials.
These can be used for example for the following applications:

Kynol activated carbon products:
Air filtration, solvent recovery, radioactive iodine filtration, ozone elimination, medical and military (NBC) applications, industrial safety, water treatment, ceramics and electrical and electronic applications.

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