For Earth, For Life

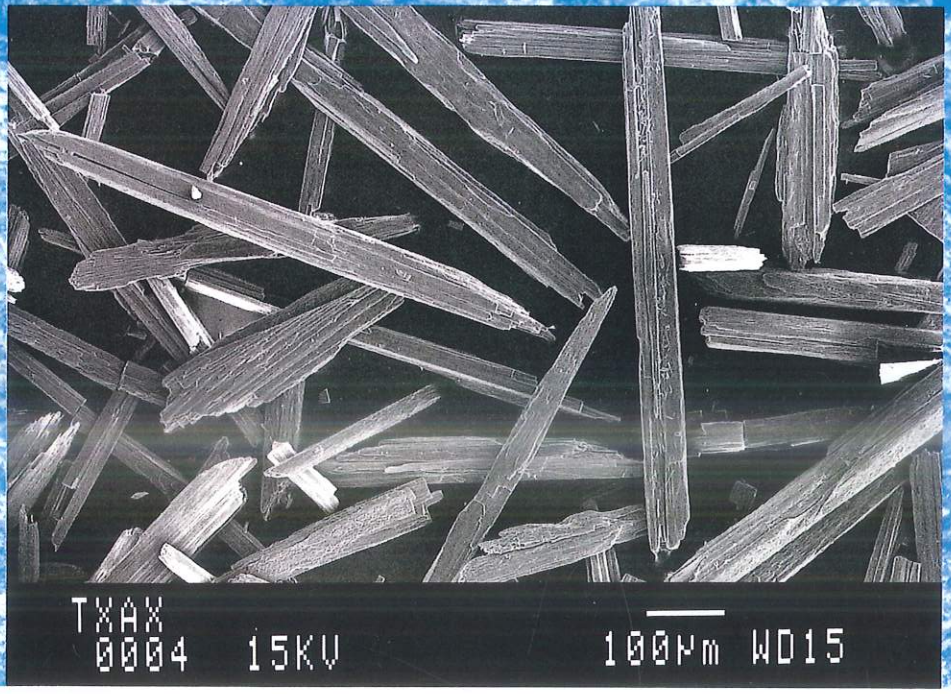
Kubota

Crystaline structure for chemical and physical stability

Large diameter and long-strand fiber enable a wide range of applications

KUBOTA TXAX-A

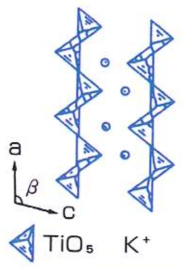
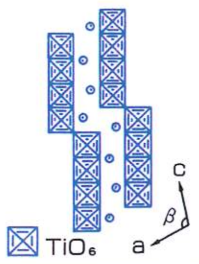
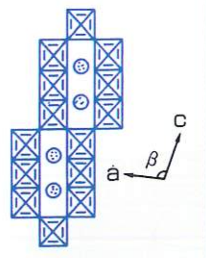
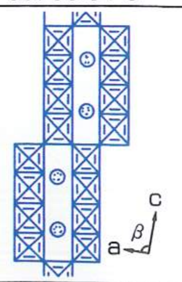
TXAX-A is a synthetic inorganic chemical compound that is not available naturally, and is a new material KUBOTA succeeded in developing and commercializing based on the research achievements of the National Institute for Research in Inorganic Materials at the Science and Technology Agency. In 1993 we received from the Research Development Corporation of Japan "The 18th Harushige Inoue Award" which is awarded to reserchers and companies who contribute to the progress of technology and improvement of economy and welfare.
TXAX-A is equipped with various high-level characteristics such as heat resistance, low thermal conductivity and wear-resistance at high temperatures. TXAX-A is chemically and physically stable by tunnel like crystal structure.
TXAX-A is produced by KUBOTA's original method of melting, in which control of forms is made by changing the speed of rapid cooling and crystallization leading to realization of the large diameter and length. TXAX-A is employed as friction material for brakes and clutches of automobiles and various machines.



A crystal structure of TXAX-A

TXAX-A is potassium hexatitanate which is shown by the chemical formula $K_2Ti_6O_{13}$. The crystal of $K_2Ti_6O_{13}$ is formed by the chain of TiO_6 octahedron shaped in a tunnel like structure, and is extremely stable both chemically and physically. Potassium titanate which is shown by the general formula $K_2O \bullet nTiO_2$ is a synthetic inorganic compound which does not exist in nature, and those with n=2, 4, 8 are well-known besides n=6. Those with n=2, 4 have layer structures and are chemically unstable and potassium ions are easily dissolved in water. Those with n=8 have the same tunnel structure as $K_2Ti_6O_{13}$, but are in a quasi-stability phase and resolve into $K_2Ti_6O_{13}$ and TiO_2 under a temperature of 700°C and above. Respective crystal structures are shown in the table below and each has a tendency to get longer towards the b-axis (perpendicular to the surface of this paper) and easily turns into fibrous shape. With $K_2Ti_6O_{13}$ and $K_2Ti_8O_{17}$ the tunnel axis and fiber axis (b-axis) are seen to go parallel.

Crystal structures of Potassium Titanate

Chemical formula / CAS No.		$K_2Ti_2O_5$ 12056-46-1	$K_2Ti_4O_9$ 12056-49-4	$K_2Ti_6O_{13}$ 12056-51-8	$K_2Ti_8O_{17}$ 59766-31-3
Crystal structure					
Crystal system		Monoclinic	Monoclinic	Monoclinic	Monoclinic
Space group		C2/m	C2/m	C2/m	C2/m
Type of structure		Layer	Layer	Tunnel	Tunnel
Lattice constant	a (nm)	1.137	1.825	1.558	1.568
	b (nm)	0.380	0.379	0.382	0.378
	c (nm)	0.662	1.201	0.911	1.195
	β (°)	100.1	106.4	99.76	95.67
Molecules per unit cell		2	4	2	2

Original method of melting made the large diameter and length of fiber possible.

TXAX-A is produced by KUBOTA's original method of melting, in which control of forms is made by changing the speed of cooling and crystallization leading to realization of the large diameter and length. With the conventional production method, nothing other than pure titanium oxide (TiO_2 content ≧99%) can be used. On the other hand with melting method, natural and impure materials of titanium oxide can be used (TiO_2 content is about 95%).

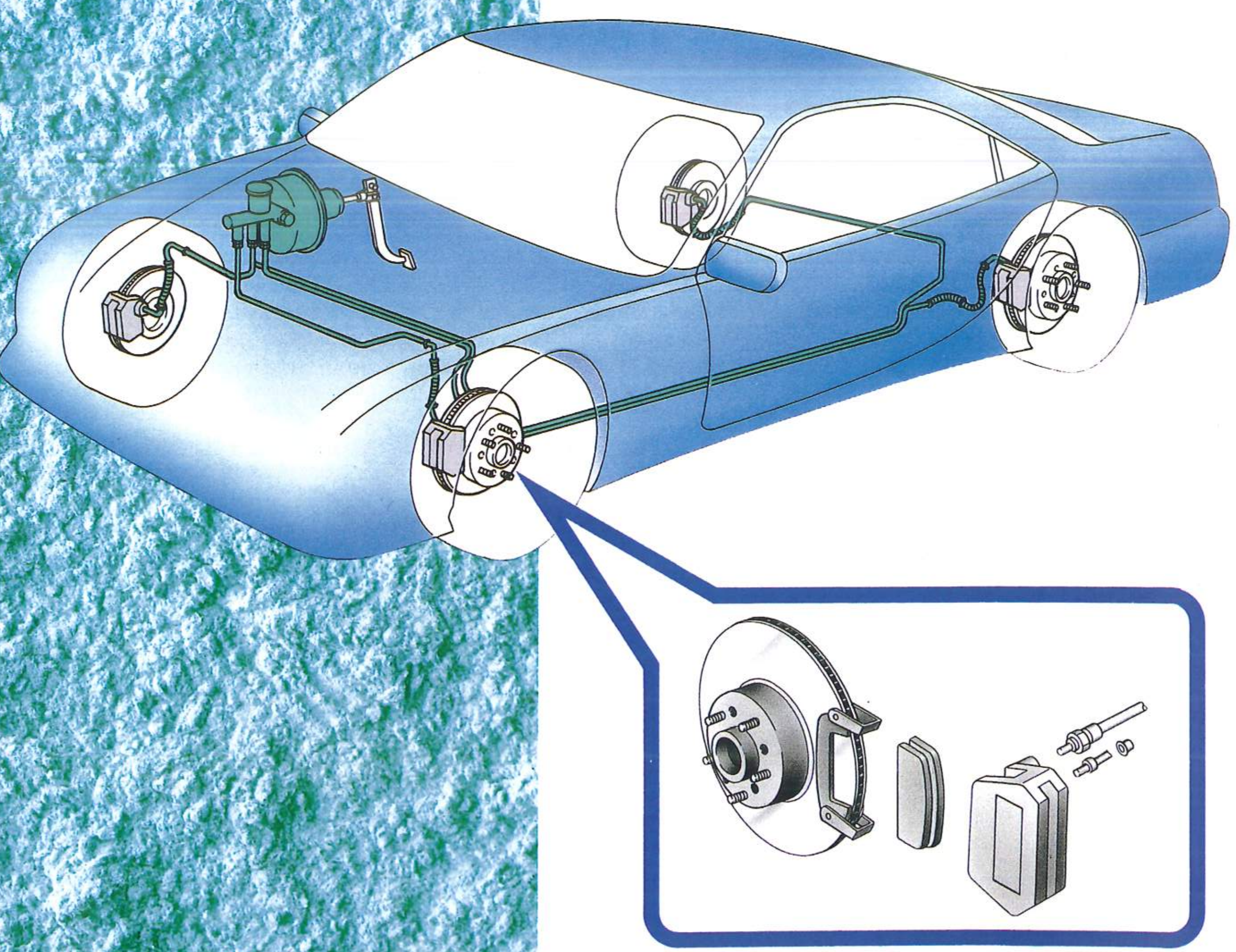
● Manufacturing sequence of TXAX-A Melting Method

Mixing of raw materials	Titanium oxide and potassium carbonate are used as raw materials.
Melting	Melting is made at the melting point (965°C) of $K_2Ti_2O_5$ or over.
Cooling & crystallization	Crystal of $K_2Ti_2O_5$ in a layer state is grown in one direction and a mass of fibers is made.
Mixing & extraction	The mass of fibers is loosened in water and potassium ions partly get liquefied.
Heat treatment	A layered form is turned into a tunnel structure of $K_2Ti_6O_{13}$ crystal.

EXHIBITS SUPERIOR PROPERTIES AS MATERIAL FOR COMPOSITE BRAKEPADS

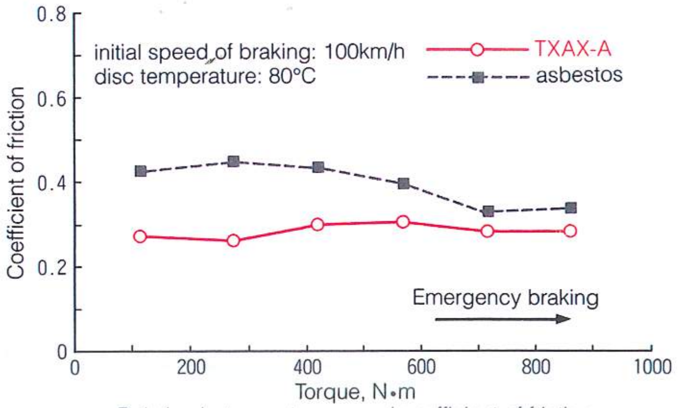
For superior high-speed braking...

As automobiles are more powerful and the maximum speed of such vehicles increases, the braking system plays an increasing central role in ensuring safety to passengers and even higher reliability is required. Various types of brake have been developed and put into practice based on new theories, but the point is the friction material which produces braking power. The material quality of the brake shoe and disc pad is the key to the braking performance. Most of the friction materials for brake are organic ones with a thermosetting resin used in the binders. They are composed of fibrous materials, frictional preparations (organic and inorganic filler, metal powders, solid lubricant) and binders. As TXAX-A is equipped with high-level characteristics such as heat resistance and relatively low hardness, TXAX-A is now drawing global attention. Under the technical guidance of the Mechanical Engineering Laboratory of Agency of Industrial Science & Technology, a comparison has been made on the frictional performance of TXAX-A composite friction materials and asbestos composited, the results of which are as follows:



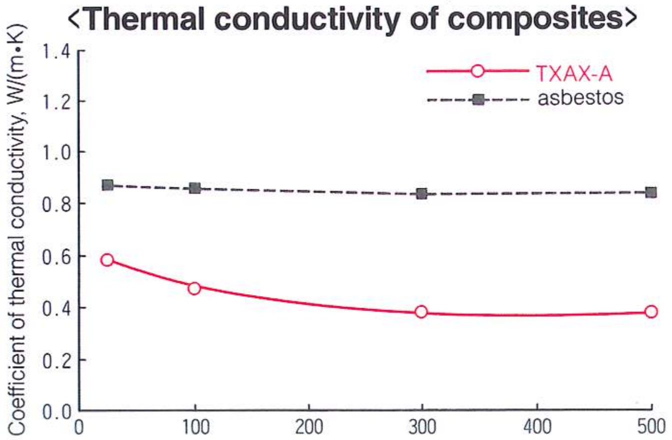
Composition (mass %)
Phenolic resin 20
Fiber 30
(TXAX-A or asbestos)
Barium sulfate 50

① Stable coefficient of friction



Relation between torque and coeffieicnt of friction
(JASO•C-406, the second effectiveness)

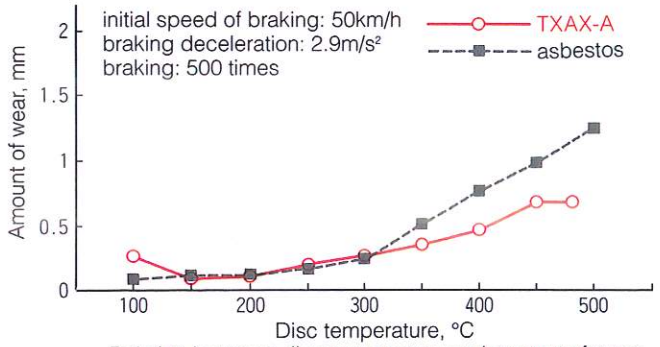
<Thermal conductivity of composites>



Coefficient of thermal conductivity of composites

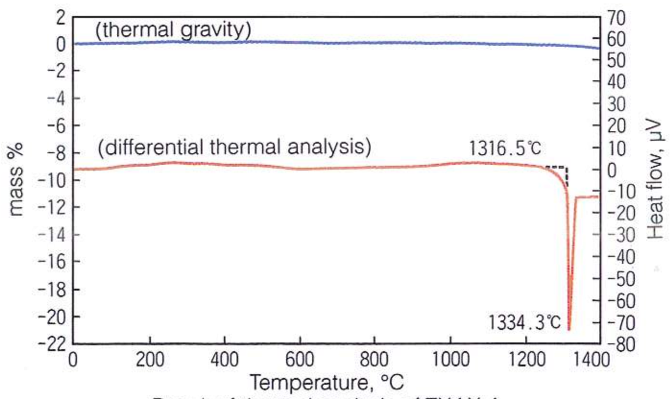
Friction coefficient of TXAX-A composite materials has shown slightly lower values than that of asbestos, but with almost no change at sudden braking. This is attributable to the superb heat resistance and low thermal conductivity of TXAX-A.

② Wear resistance



Relation between disc temperature and amount of wear
(JASO•C-427)

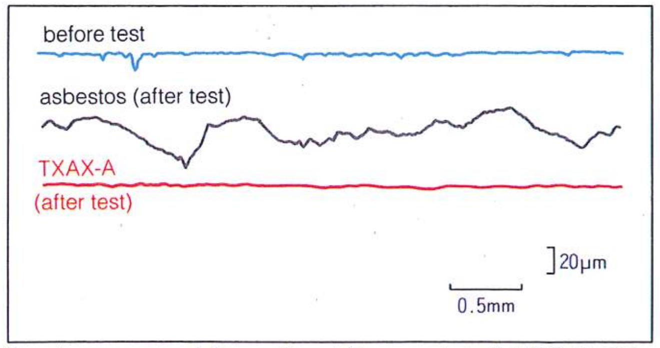
<Heat-resistance of TXAX-A>



Result of thermal analysis of TXAX-A

With asbestos composite materials, wear increases under higher temperatures, whereas with TXAX-A composite wear is found to be very little even under high temperatures. This is due to the fact that asbestos releases combined water at high temperatures and becomes brittle, whereas TXAX-A does not undergo any change under high temperatures.

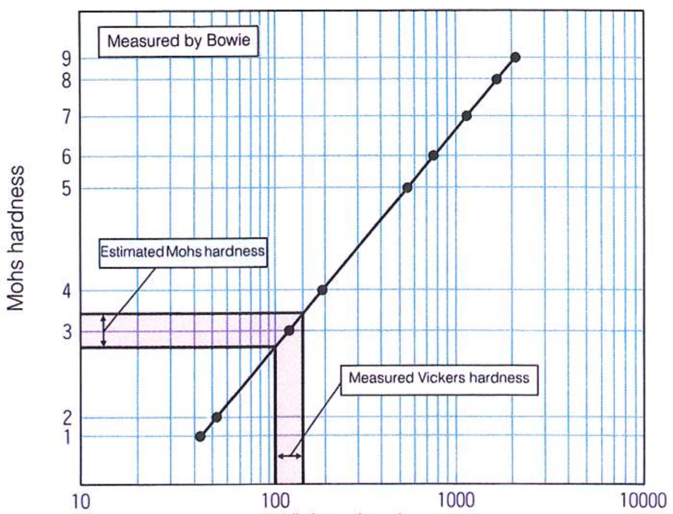
③ Low adjoining abrasion



Roughness curve of disc surface (after wear test of JASO•C-427)

The damaging property of TXAX-A composites to the disc is found to stay at a very low level. This owes to its Mohs hardness being low at about 3.

<Mohs hardness of TXAX-A>



Mohs hardness of TXAX-A

RAW MATERIAL FOR A VARIETY OF APPLICATIONS

A high level of physical and chemical features

TXAX-A is equipped with various high-level physical properties such as heat resistance, heat insulating properties under high temperature, water-resistance and electrical insulating properties. It's chemical characteristics are stable, too, due to its tunnel like state crystal structure. Chemical resistance is observed to be high and shows an excellent corrosion resistance to both acid and alkali.

● Chemical characteristics

Potassium insolubility	Put in boiling water for 18 weeks → No dissolution of potassium
Acid resistance	Stable in 10% H_2SO_4 (room temp.). Dissolution in thermal H_2SO_4, $NaHSO_4 \cdot H_2O$
Alkali resistance	Stable in 30% NaOH (115°C)

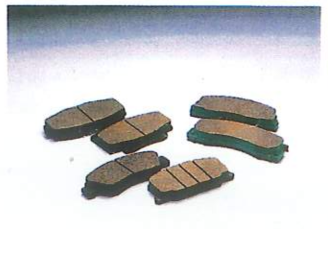
● Physical characteristics

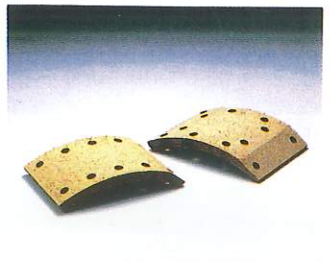
*Literature reference available

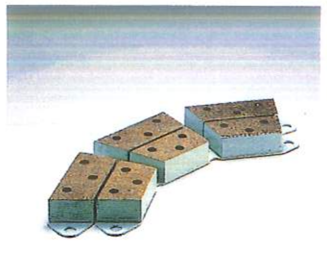
Category	Physical characteristics
Average of fiber length (μm)	150
Average of fiber diameter (μm)	30
Color	Light yellow
Chemical formula	$K_2Ti_6O_{13}$
Density (g/cm³)	3.53
Bulk density (g/cm³)	0.5
Mohs hardness	3
Melting point (°C)	1310~1350
Thermal conductivity (W/m•K)*	1.7 (at 760°C)
Specific heat (J/kg•K)*	920
Coefficient of linear thermal expansion (×10⁻⁶/K)*	6.8
Resistivity (Ω•cm)*	3.3×10^{15}
Dielectric constant (ε)*	3.5~3.7
Moisture (mass %)	0.5≧

As a wear-resistant material

TXAX-A is employed as friction material for brakes and clutches of various machines owing to its outstanding frictional properties, wear-resistance and heat resistance in the high temperature region.


Brake pads for passenger cars


Brake blocks for heavy duty cars


Brake shoes for trains

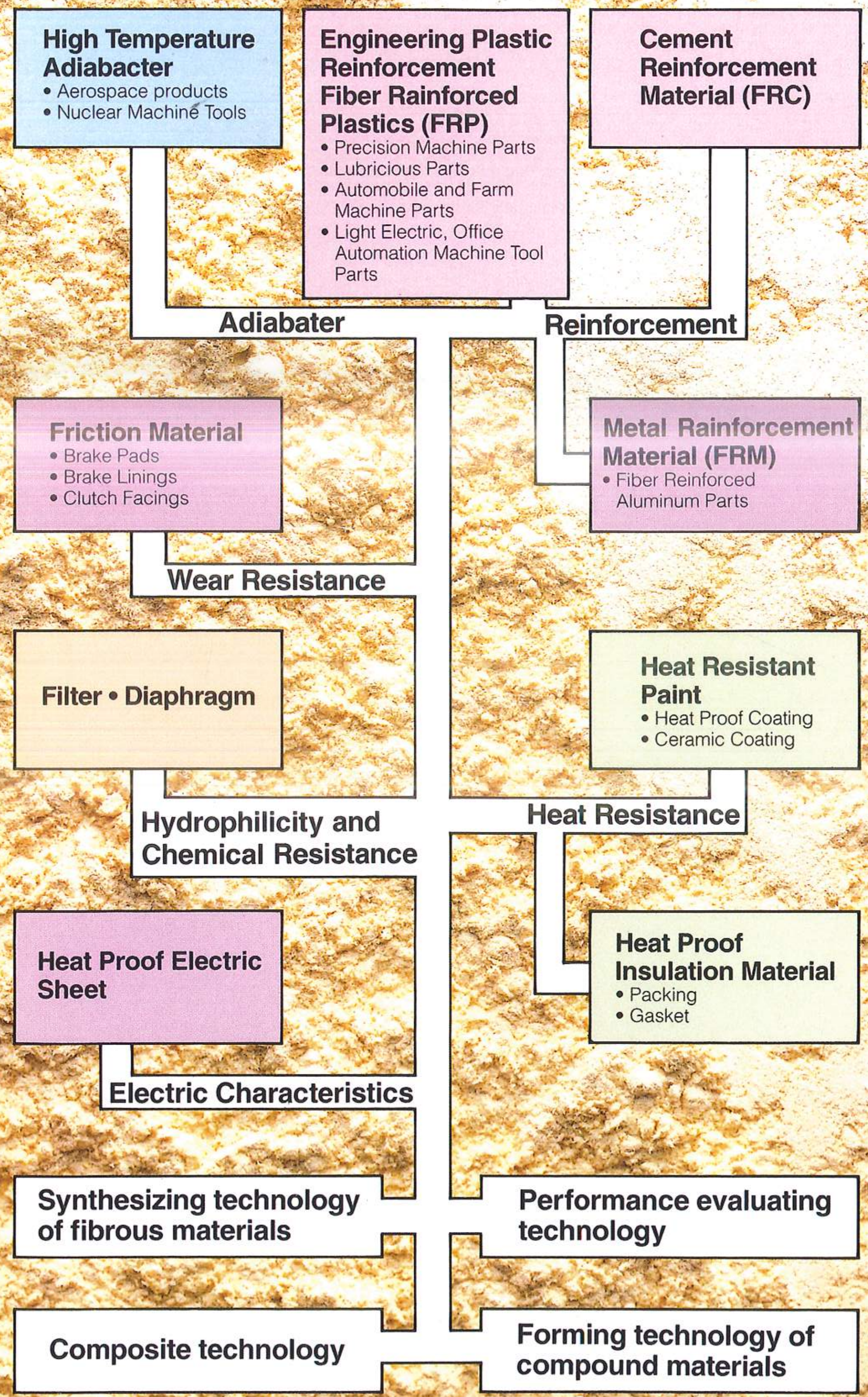

Clutch facing for tractors

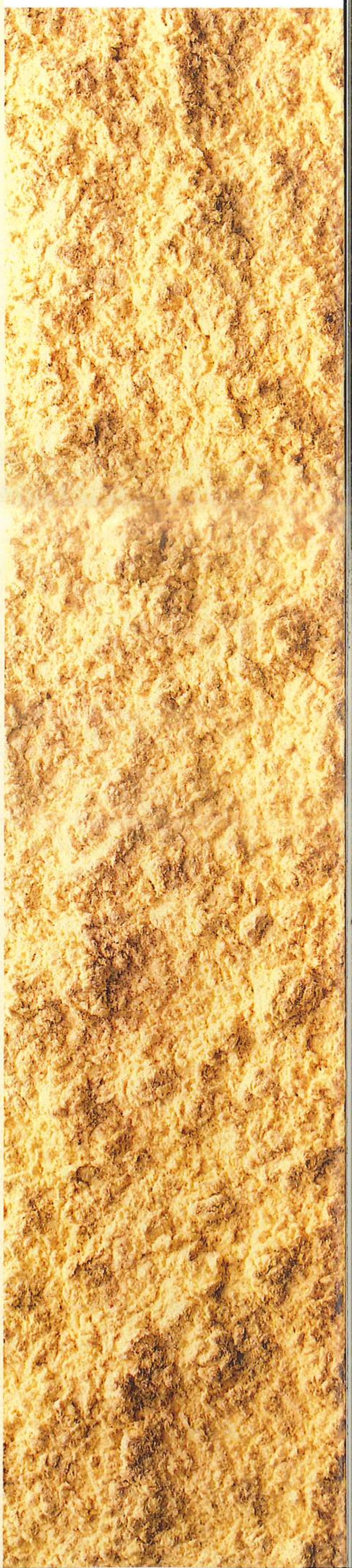
As a heat resistant and insulating material

TXAX-A shows high heat resistance and low thermal conductivity at high temperatures, so TXAX-A is employed as heat resistant paint and exhaust gas filters.

Caution	Read Material Safety Data Sheet for this product before using
	Processing and handling can produce airborne respirable fibrils. Use ventilation to minimize fibril inharation.

Possible Application of Kubota Potassium Titants Fiber





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