New Products & Technologies

Reinforcing Microfiber "TIBREX"*

Hidefumi Kongnai** Yoshio Aso*** Yoshio Suzuki**** Yoshihito Tachi**

1 Introduction

Among industrial materials that offer a small size, light weight, and high performance, fiber-reinforced plastics (FRP) is well known.

Potassium titanate whiskers, having high crystalline perfection, possess a high strength and modulus, and permit microscopic reinforcement; hence they are attracting attention as a new material for reinforcing engineering plastics.

Kawatetsu Mining Co., Ltd. has developed potassium titanate whiskers under the commercial name of "TIBREX", which are described here with application examples.

2 Features of TIBREX

2.1 Shape

TIBREX is broadly differentiated in shape from such as glass fibers, and can be defined as microscopic fibers, or so-called "whiskers."

The shape of TIBREX is shown in **Photo 1**, indicating a high aspect ratio (fiber length/diameter) and high uniformity in shape. Its dispersibility is high, since there is no intertwining between fibers, and it is free of non-fiber material which could decrease the strength of the composite material. It has been difficult in the past to synthesize such a characteristic fiber shape by conventional industrial processes.

2.2 General Characteristics

Potassium titanate is an artificially synthesized multiple oxide of K_2O and TiO_2. Due to its chemical stability, TIBREX is acid and alkali resistant. Furthermore, it has a high melting point and is thermally stable, thereby providing outstanding thermal insulation characteristics. **Table 1** shows the general properties of TIBREX.

The material can attain a high strength as a composite with plastics, etc. due to its high aspect ratio, small microscopic size, and high mechanical strength. Since TIBREX has a Mohs hardness as low as 4, it offers the advantage of significantly low wear in the screw of the extruder and injection molds that are used to form products.

Photo 1 Scanning electron micrograph of TIBREX

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** Assistant Manager, Research Lab., Kawatetsu Mining Co., Ltd.

*** Manager, Production Control Dept., Chiba Works., Kawatetsu Mining Co., Ltd.

**** Manager, Research Lab., Kawatetsu Mining Co., Ltd.

Table 1 Typical properties of TIBREX

Substance name	Potassium titanate
Color	White
Shape	Needle-like crystal
Average length	20 μm (standard)
Diameter	Less than 1 μm
Specific gravity	3.5
Mohs hardness	4
Water content	Less than 0.3%
pH (dispersed in water)	7～9
Melting point	1 350°C
Tensile strength	More than 6 860 MPa
Elastic modulus	More than 274 GPa
Thermal conductivity	1.74 W/m·K (760°C)
Specific heat	920 J/kg·K

2.3 Surface Treatment

Surface-treated TIBREX offers high adhesion to matrix polymers. The standard coupling agents are amino-, epoxy-, and methacryloxy-silane, and other agents are also available.

Table 2 shows recommendations for surface-treating TIBREX to use as plastics reinforcement.

Table 2 Recommendations for surface-treated TIBREX as plastic reinforcement

Type of surface treatments \ Plastics	Thermo-plastics	Thermosets	Elastomers
Amino-silane	PA, PP PVC, PVAc PPO, POM	PF, MF EP, Furan PDAP, PUR	Silicone
Epoxy-silane	PBT, PS ABS, POM PVAc	PF, MF EP, Furan UP, PUR	PUR ACM, ANM Polysulphide
Methacryloxy-silane	PP, PE PS, ABS	UP, PDAP Vinyl, Polyacrylate	EPDM, EPM ACM, ANM
Mercapt-silane	PPS	EP, PUR	EPDM, EPM SBR, NBR, PUR Neoprene, IR
Vinyl-silane	PE, PP PS	UP, Vinyl PDAP Polyacrylate	ACM, ANM EPDM, Silicone
Titanate and others	Various plastics Improvement of dispersion, rheological behavior, etc.		

PA: polyamide PP: polypropylene PVC: polyvinylchloride PVAc: polyvinylacetate PPO: polyphenyleneoxide POM: polyacetal PBT: polybutyleneterephthalate PS: polystyrene ABS: acrylonitrile-butadien-styrene PE: polyethylene PPS: polyphenylenesulfide PF: phenol MF: melamine EP: epoxy PDAP: diallyl phthalate PUR: polyurethane UP: unsaturated polyester ACM, ANM: acrylic EPDM, EPM: ethylene propylene SBR: Styrene-butadiene NBR: acrylonitorile-butadiene IR: isoprene

2.4 Granules

TIBREX is available in two basic forms, one being powder type, and the other being the granule type. The production process for TIBREX is shown in **Fig. 1**. The granule type is specially granulated without using a binder, so that a fiber shape with a strong reinforcing effect would not be damaged. **Photo 2** shows a comparison of the appearance and bulk density between the granule type and the powder type when the same quantities are compared, while **Table 3** shows a comparison of the properties of TIBREX powder and granules.

The granule type offers high dispersibility into the

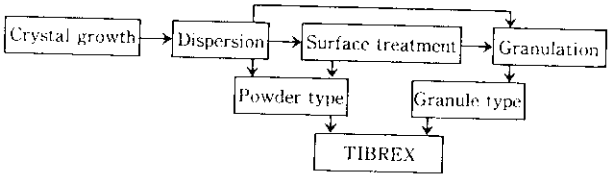
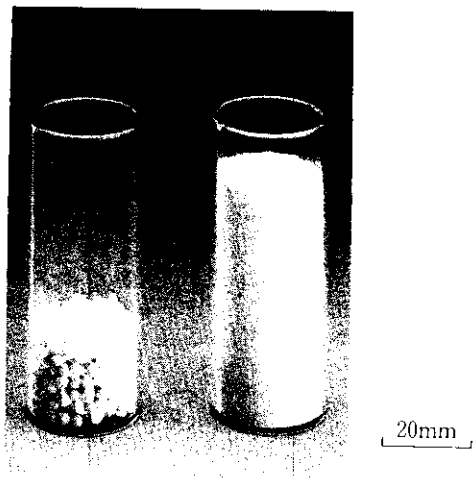


Fig. 1 Products and process flow of TIBREX



Granule type Powder type

Photo 2 Appearance of TIBREX and comparison of bulk density between granule and powder types

Table 3 Powder properties of TIBREX

Types \ Properties	Bulk density	Angle of repose (deg)	Flowability[a] (s)
Powder type	0.05～0.15	55～65	plugging
Granule type	0.3～0.5	38～42	1～2

[a] Time required for discharge of samples from cone chute (84 mmϕ × 35 mmϕ × 78 mmH)

plastics matrix as well as easy handling property and high flowability, thereby permitting an improvement in operating productivity during the compounding process.

The granulation techniques for fillers such as talc and calcium carbonate can also be applied to TIBREX.

3 TIBREX Applications

3.1 Application Examples

Properties and applications of TIBREX are shown in Fig. 2. It is expected that TIBREX will be applied not only to plastics but also to metals and ceramics. For example, reinforcements, friction materials, heat insulators, insulating materials, catalyst substrates, filter materials, filtration aids, lubricants, paints and other materials have been produced in TIBREX.

3.2 Plastic Reinforcement Examples

As shown by PA-6 (6-nylon) in **Fig. 3** and by PBT (polybutyleneterephthalate) in **Fig. 4**, TIBREX drastically enhances the tensile strength, flexural strength and

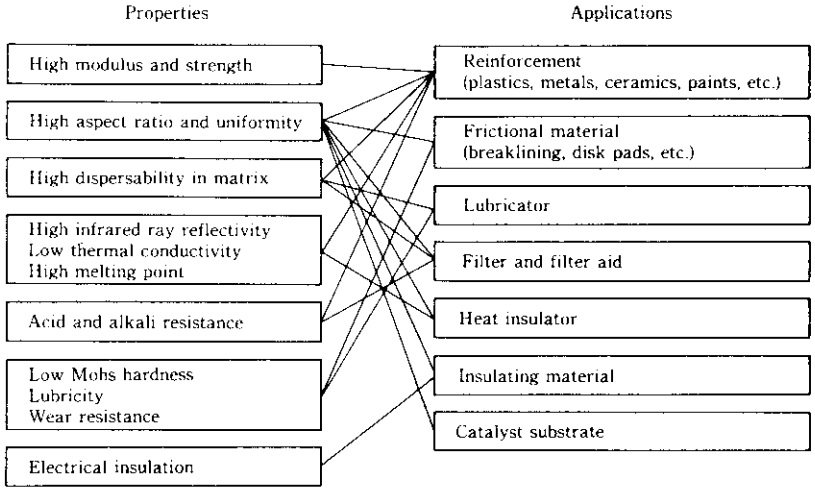


Fig. 2 Properties and applications of TIBREX

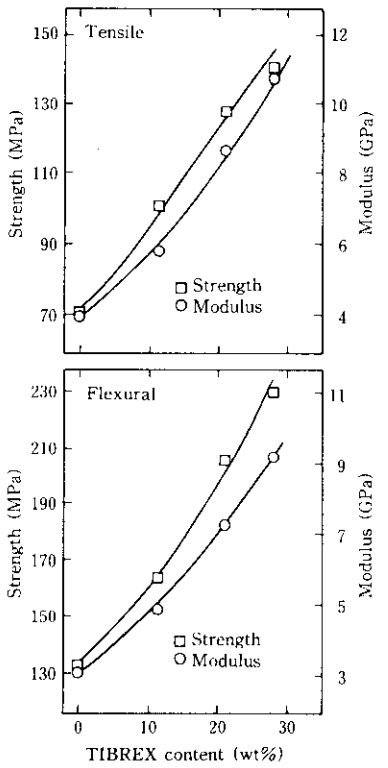


Fig. 3 Mechanical properties of TIBREX-reinforced PA-6

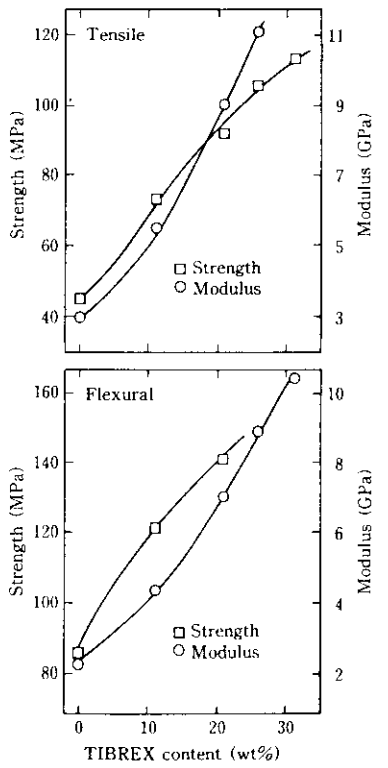


Fig. 4 Mechanical properties of TIBREX-reinfored PBT

modulus. It is also known that such properties as heat resistance and wear resistance are also enhanced, an example of heat resistance enhancement being shown in **Fig. 5**.

Photo 3 shows a precision gear reinforced by potassium titanate whiskers. As a reinforcing material for plastics, TIBREX is finer in size and lower in hardness than glass fibers, making it more suitable for fine, precise, and/or anti-abrasive molded plastic parts such as small gears.

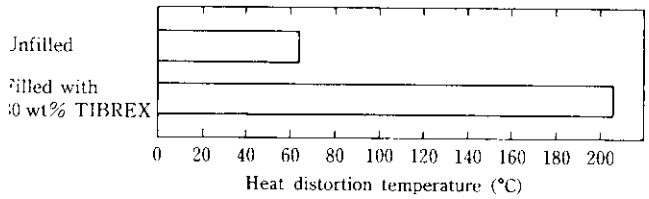


Fig. 5 Heat resistance of PBT

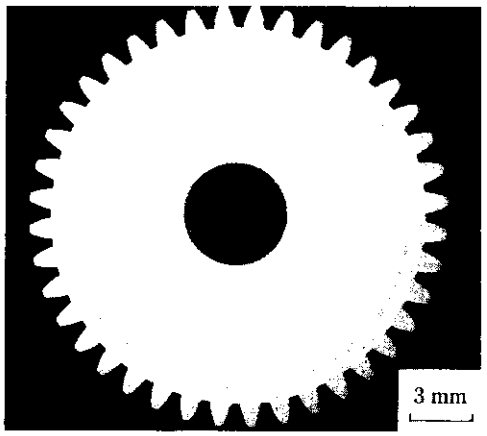


Photo 3 An example of plastic gear reinforced with potassium titanate whisker

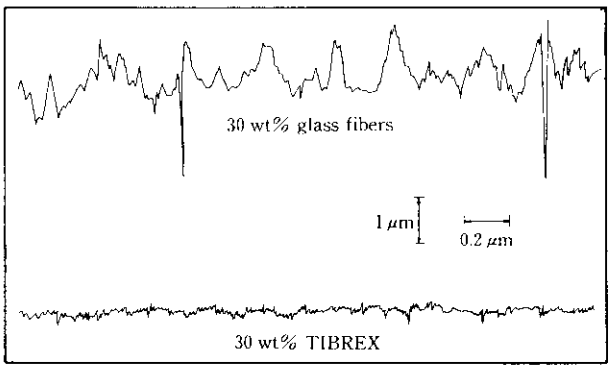


Fig. 6 Surface roughness profiles of fiber-reinforced PBT

In addition, the surface roughness results shown in **Fig. 6** indicate the outstanding surface smoothness of TIBREX-reinforced plastics.

4 Concluding Remarks

TIBREX is a new type of microscopic reinforcing fiber, and its granulated form can improve the working environment and enhance productivity. Its application to various materials including plastics is expected.

Kawatetsu Mining Co., Ltd. started the commercial manufacture of TIBREX in the spring of 1992 and plans to further enhance its quality and expand its applications in the future.

For Further Information, Please Contact:
Research Laboratory,
Kawatetsu Mining Co., Ltd.
1, Niihama-cho Chuo-ku, Chiba 260, Japan
Fax: 043 (262) 4259 Phone: 043 (262) 2176

New Materials Sales Dept.,
Kawatetsu Mining Co., Ltd.
Schuwa Shiba Park Bldg., 2-4-1, Shibakoen Minato-ku,
Tokyo 105, Japan
Fax: 03 (3578) 6349 Phone: 03 (3578) 6313