

# Manufacture of Platinum Fibre and Fabric

A TECHNICAL NOTE ON AN INTERESTING MATERIAL, SOME PROPERTIES AND USES

By Kenya Mori

Technical Administration Department, Tanaka Kikinzoku Kogyo K.K., Technical Center, 2-73 Shinmachi, Hiratsuka, Kanagawa 254-0076, Japan; E-mail: K-MORI@ml.tanaka.co.jp

*Since 1996, Tanaka Kikinzoku Kogyo K.K. has been producing flocculate platinum fibre and non-woven fabric made from this fibre. The background to the production of this material is briefly described. Flocculate platinum fibre and fabric are currently used as filtering materials in filtering applications that require both heat and chemical resistance. The platinum fibre and fabric are also finding application as electrically conductive fillers for porcelain enamel.*

Like gold, silver, and copper, platinum can be reshaped mechanically, without thermal treatment. Taking advantage of this characteristic, fine platinum fibre has been produced by repeated multi-core wire drawing processing using a combination of platinum wire with copper pipe. This has resulted in the formation of fibre – fine wire – having diameters of up to 0.1  $\mu\text{m}$  (1). Figure 1 shows platinum wire pieces from which the copper has been removed.

## Platinum Fabric Made from Platinum Fibre

A length of multi-core wire combining platinum and copper was cut into pieces 1 mm in length. The copper was then removed to produce short platinum fibres having a diameter of 0.1  $\mu\text{m}$ . These fibres were then dispersed in water and filtered to form a non-woven “fabric”. The non-woven platinum “fabric”, made from the 0.1  $\mu\text{m}$

fibre, was then heat-treated at 650°C to strengthen it – platinum begins to melt at 700°C. Figures 2 and 3 show heat-treated platinum fibres. Despite the classification of the filter components as heat-resistant materials, the micrographs suggest that the maximum working temperature for the filter is 600°C.

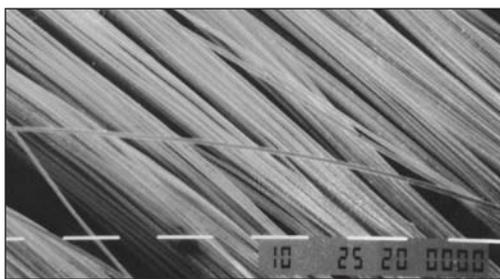
The separation characteristics of a non-woven fabric filter composed of platinum fibres 0.1  $\mu\text{m}$  in diameter was assessed at the Matsumoto Laboratory, Division of Materials Science and Chemical Engineering, Faculty of Engineering, Yokohama National University. Test samples had specifications: basis weight (weight per unit area of filter) of 210 to 830  $\text{g m}^{-2}$ ; thickness of 0.09 to 0.34 mm; and porosity of 88 to 90%. The Table gives specifications of the fibre in detail.

The following results were found:

[i] The effects of basis weight on the maximum fine pore diameter, and the results of measuring the maximum fine pore diameter by the bubble point method, indicated that the maximum fine pore diameter was  $\sim 1 \mu\text{m}$ . The maximum fine pore diameter varied between 1 and 2  $\mu\text{m}$  with low basis weights.

[ii] The effects of the basis weight on the mean fine pore diameter, and the results of measuring the mean fine pore diameter by the transmission method, indicated that the mean fine pore diameter was  $\sim 0.35 \mu\text{m}$ , regardless of the basis weight.

[iii] The variations in filtration pressure and the percentage of particles rejected over time: the filtration experiment involved using ultrapure water



*Fig. 1 Multi-core drawn platinum wire approximately 1  $\mu\text{m}$  in diameter. As an indication of the scale, one of the dashes that make up the dotted white line at the bottom of the micrograph is 10  $\mu\text{m}$  long*

Parameters of Platinum Fabric Made from Platinum Fibre			
Sample number	Thickness, $\mu\text{m}$	Porosity, %	Basis weight, $\text{g m}^{-2}$
1	0.1	90.2	210
2	0.1	90.2	210
3	0.35	88.8	837
4	0.35	88.9	832
5	0.17	88.5	418
6	0.17	88.4	423
7	0.16	87.8	418
8	0.17	88.5	420
9	0.15	89.1	348
10	0.18	89.0	423

with suspended particle contaminants from the environment. In the dispersion media, particles having diameters of 0.1, 0.15, 0.2, 0.3 and 0.5  $\mu\text{m}$  were counted with a particle counter. Over time, more than 95% of particles having a diameter greater than 0.1  $\mu\text{m}$  were filtered and removed from the water. Nevertheless, the filtration pressure remained virtually constant, and no significant increase in filtration pressure (considered to indicate a transition from depth-type filtration to cake filtration) was observed. This may be due to the high porosity (88 to 90%) of the filter and thick depth-type filtration material.

These results were compared with those of other material filters. The porosity of materials that have a mean fine pore diameter of less than 1  $\mu\text{m}$  and which are widely used, was 30% or less, while the porosity of the 0.1  $\mu\text{m}$  diameter platinum fibre filters reached 90%, as described above. Such high porosity for the platinum fibre filter may be due to a combination of factors: low filtration pressure loss, less-pronounced pressure increase, and superior filter characteristics. In addition, despite a maximum working temperature of 600°C, the filter is significantly resistant to heat and exhibits the corrosion resistance that is expected of platinum materials. However, due to high cost, this filter is currently used only in special analyses, and in minute quantities.

The potential application as electrically conductive fillers for porcelain enamel was suggested by a porcelain enamel manufacturer (2). In this application, platinum fibre is described as being used in

glass-lining materials, which are utilised as insulating material for glass-lined devices used by the chemical, pharmaceutical and food industries.

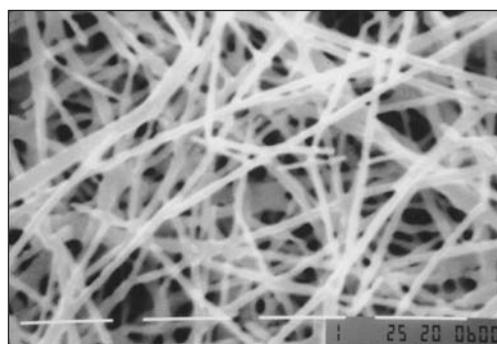


Fig. 2 Heat-treated platinum fibre of diameter 0.087  $\mu\text{m}$ . The fibre has been heated at 650°C for 30 minutes in air; melting only occurred at places where the fibres touched. Scale: one of the dashes that make up the dotted white line at the bottom of the micrograph is 1  $\mu\text{m}$  long

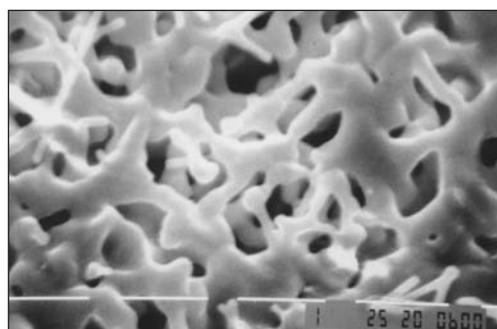


Fig. 3 Heat-treated platinum fibre of diameter 0.087  $\mu\text{m}$ . The fibre was heated for 30 minutes at 700°C in air; melting occurred. Scale: one of the dashes that make up the dotted white line at the bottom of the micrograph is 1  $\mu\text{m}$  long

These materials have volume resistivity of  $1 \times 10^{13}$  to  $1 \times 10^{14} \Omega \text{ cm}$ . Thus, agitation in nonaqueous solutions containing organic substances results in a significant buildup of excess electric charge over leak charge. This can result in static charges of several tens of thousand or hundreds of thousand volts that could lead eventually to damage or explosion of the glass-lining materials, even if the glass-lined devices are electrically earthed. It is standard practice to embed or wind platinum or tantalum wires in or around the glass lining materials, but such treatment primarily has a local effect and is inadequate.

An example in (2) describes how the addition of 0.5 wt.% of platinum fibre of diameter 0.5  $\mu\text{m}$  and length 2 mm to porcelain enamel reduced the volume resistivity to  $1.3 \times 10^3 \Omega \text{ cm}$ . This can effectively prevent electrostatic buildup. If, howev-

er, platinum powder is used, 20 wt.% of platinum powder must be added to achieve a volume resistivity of  $4.7 \times 10^3 \Omega \text{ cm}$ .

A container that had to be glass-lined every three months to repair damage caused by static discharge was replaced with a container made of electrically conductive enamel, using the said method. After five years, the container remains serviceable and exhibits no problems.

## References

- 1 S. Shimizu, K. Mori and E. Sakuma, *Japanese Appl.* 11-226,627; 1999
- 2 Y. Iizawa and M. Akazawa, *Japanese Appl.* 10-081,544; 1998

## The Author

Kenya Mori is a Chief Researcher at TKK's Technical Center in Kanagawa. His main professional interests are in developing precious metals for industrial materials.

# Iridium Oxide Sensors for Industrial Lubricants

Engine oil lubricates and protects engines against wear. Engine oils comprise a base oil and additives (1) to improve the performance and long term stability of the oil, such as antioxidants, antiwear and corrosion inhibitors, detergents (surfactants), dispersants and viscosity modifiers. The working life of any engine oil or industrial lubricant may depend on its base oil formulation and the additives, and the engine size and its operating conditions.

In use, engine oils change chemically due to oxidation and contamination by ethylene glycol, fuel, soot, water, worn metal, etc. Industrial lubricant is degraded by exposure to high temperature, air, alcohols, glycol, NOx and water. The additives interact with both the oil contaminants and oxidative by-products of oil degradation to render them harmless.

However, continuous monitoring of the chemical condition and degradation of the oils, by an online sensor to indicate the necessary oil changes, could make engines more efficient and safer. Engine oil breakdown is closely related to the level of acidity: increase in total acid number (TAN) (oxidative degradation), and level of basicity: decrease in total base number (TBN) (degradation of antioxidants, dispersants and detergents), in the oil.

Acidity/basicity measurements by potentiometric testing is standard practice and iridium oxide ( $\text{IrO}_2$ ) shows promise for measuring pH range and sensitivity, ion and redox interference, and hysteresis effects. Now, a team from Case Western Reserve University and the Lubrizol Corp., U.S.A., have run

tests with chronopotentiometric (CP) sensors having  $\text{IrO}_2$  as working electrode, and have detected TAN and TBN in a diesel oil (2). The sensors were both conventional (a macro-scale) and miniaturised (microelectromechanical system (MEMS)) devices.

In diesel oil drains the sensors showed good correlation between the TBN and TAN numbers and their individual voltage outputs. Conventional  $\text{IrO}_x$  sensors displayed greater sensitivity to changes in TAN and TBN than the MEMS sensors.

A CP sensor (a "melt Ir oxide sensor") consisting of an Ir wire electrode, oxidised in a  $\text{Li}_2\text{CO}_3$  melt to form a  $\text{Li}_x\text{IrO}_y$  film on its surface, had a large increase in sensitivity due to the  $\text{Li}_x\text{IrO}_y$ , responding to carboxylic acids, and also to esters through a second surface reaction catalysed by Li.

The sputter-formed CP sensor gave a better response to oxidative degradation of oil due to its higher sensitivity to ketones and carboxylic acids. The differences in reaction mechanisms between the Ir oxide and the components of the solution gave opposite responses to changes in basicity in aqueous and non-aqueous systems. However, as long term stability and durability is a problem it is concluded that work is needed to improve design and fabrication.

## References

- 1 A. J. J. Wilkins, *Platinum Metals Rev.*, 2003, 47, (3), 140
- 2 M. F. Smiechowski and V. F. Lvovich, *Sens. Actuators B: Chem.*, 2003, 96, (1-2), 261