Title: CERAMIC FILTER AND ITS PRODUCING METHOD

Abstract: The present invention relates to a process for preparing a ceramic filter comprising the steps of preparing a slurry by mixing ceramic powder selected from the group consisting of silicon carbide, alumina, sillimanite, kaolin, silica, titania and siliceous earth, clay, supplementing agent, a binder and a dispersion, supporting the slurry on a support to mold; drying and sintering the molded product, and a ceramic filter prepared by the process. According to the present invention, production cost decreases, preparation is easy, shape can be easily modified and large sized filter can be easily prepared, abrasion resistance and heat resistance of ceramic filter can be remarkably improved, porosity control range can be relatively improved.
CERAMIC FILTER AND ITS PRODUCING METHOD

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a ceramic filter and a method for preparing the same. More particularly, according to the method of the present invention, production cost can be reduced, preparation is easy, modification of a shape and preparation of a large-sized filter are easy, abrasion resistance and heat resistance are remarkably improved, porosity control range is comparatively improved.

(b) Description of the Related Art

With the development of industries, damages from hazardous material such as dust, smoke, waste gas, fume, volatile organic chemicals (VOC's), etc. have increased. Therefore, in order to prevent release of such pollutants, a polymer filter is used. However, the polymer filter has problems of inferior heat resistance, chemical resistance, abrasion resistance and flame retardation. Specifically, polyester shrinks at 150°C, and even PTFE (Teflon) has maximum heat resistance of approximately 250°C. Since various waste gases and moisture are simultaneously generated under conditions for process using an industrial filter, if the surface of a non-woven fabric filter made of polymers such as polyester, polypropylene, acryl, polyamide, polyimide, glass fiber, etc. is dust off, dust falls down to seriously abrade a filter surface, thereby damaging a filter and shortening life cycle of a filter. In addition, sparks generated during firing process may be attached to a filter to cause fire or make a hole in the filter, which may expose waste gas in the air in case filters are used for a waste incinerator, a boiler, a coal steam power plant, a coal gasification complex plant, and this is against
recent environmental regulation.

Therefore, in order to solve these problems, a ceramic filter has been developed, which has superior heat resistance, chemical resistance, abrasion resistance to a polymer filter, and does not require a separate cooling apparatus in an exhauster due to superior heat resistance to reduce installation and maintenance costs.

However, the existing ceramic filters are generally prepared by vacuum molding or extrusion molding of ceramic fiber into a tube shape. Although such ceramic filters have relatively superior filtering efficiency and pressure property, the production cost is high, durability of a filter decreases due to deterioration of ceramic fiber thereby decreasing filtering efficiency if used for a long time, compressed air is reverse-sprayed during regeneration of a filter and thus ceramic fiber is damaged when dusting off the external wall, the damaged ceramic fiber is included in and discharged as exhaust gas to cause secondary pollution.

In addition, in a vacuum molding, a lot of cost is required for preparing vacuum chambers and vacuum pumps, the size of ceramic filter that can be manufactured is limited according to the size limitation of a vacuum chamber and thus a large-sized filter cannot be manufactured because of the limitation of ceramic filter size manufactured by a vacuum molding, and a mold should be replaced at an interval of certain productions due to serious abrasion of ceramic material and thus production cost is high.

In addition to the vacuum molding, an extrusion molding, a press molding, a hydrostatic pressure molding, etc. are employed. However, since these also require preparation of moldings and pressurizing apparatus, production cost increases, preparation is not easy and shape modification is
not easy due to the fixed molding, a large-sized filter cannot be prepared. And, since these molding methods employ pressurization, porosity is low and ventilation decreases, and pressure loss increases during passage of the filter.

**SUMMARY OF THE INVENTION**

In order to solve the problems of the prior art, it is an object of the present invention to provide a ceramic filter having light weight, which has superior abrasion resistance and heat resistance, comparatively broad porosity control range.

It is another object of the present invention to provide a method for preparing a ceramic filter, wherein production cost is low, preparation is easy, and modification of shape and production of a large-sized filter are easy.

It is another object of the present invention to provide a ceramic filter that can maximize filtering area by shape modification in a certain space to maximize dusting efficiency.

In order to achieve these objects, the present invention provides a method for preparing a multi-layered ceramic filter, which comprises the steps of:

a) mixing

i) 25 to 60 parts by weight of ceramic powder selected from the group consisting of silicon carbide, alumina, sillimanite, kaolin, silica, titania, and siliceous earth;

ii) 10 to 40 parts by weight of clay;

iii) 5 to 40 parts by weight of pore-forming material;

iv) 1 to 20 parts by weight of a binder; and

v) 20 to 60 parts by weight of a dispersion
to prepare a slurry;

b) supporting the slurry prepared in step a) on a support to prepare a molded article;

c) drying the molded article prepared in step b); and

d) sintering the molded article dried in step c).

The present invention also provides the ceramic filter prepared by the above method.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 shows a cross-sectional view of one embodiment of a mold used in the preparation method of a ceramic filter of the present invention.

Fig. 2 is a photograph of a circular tube shaped ceramic filter prepared by the preparation method of the present invention.

Fig. 3 is a photograph of a radial curbed tube shaped ceramic filter prepared by the preparation method of the present invention.

Fig. 4 is a photograph of various kinds of ceramic filters prepared by the preparation method of the present invention.

Fig. 5 is a photograph of a ceramic filter in which the upper and the lower caps are assembled, prepared by the preparation method of the present invention.

Fig. 6 is a Scanning Electron Microscope picture of the ceramic filter prepared by the preparation method of the present invention.

Fig. 7 is a photograph of an extended ceramic filter prepared by the preparation method of the present invention.

Fig. 8 is a photograph of a ceramic filter installed in a dusting apparatus, prepared by the preparation method of the present invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**
The present invention will now be explained in more detail.

The ceramic filter of the present invention is prepared by a method comprising the steps of mixing ceramic powder selected from the group consisting of silicon carbide, alumina, sillimanite, kaolin, titania and siliceous earth, clay, pore-forming material, a binder and a dispersion to prepare a slurry; supporting the slurry on a support to prepare a molded article; drying the molded article; drying; and sintering.

The method will be explained in detail.

a) Preparation of a slurry

This step is to mix i) 25 to 60 parts by weight of ceramic powder selected from the group consisting of silicon carbide, alumina, sillimanite, kaolin, silica, titania and siliceous earth, ii) 10 to 40 parts by weight of clay, iii) 5 to 40 parts by weight of a pore-forming material, iv) 1 to 20 parts by weight of a binder, and v) 20 to 60 parts by weight of a dispersion.

The i) ceramic powder, which constitutes a basic structure of the ceramic filter after sintering, functions as a support of a ceramic filter.

Ceramic powder of various kinds commonly used in the art can be used. Preferably, silicon carbide, alumina, sillimanite group (Al₂O₃·SiO₂), kaolin group (Al₂O₃·2SiO₂·2H₂O), silica (SiO₂), titania or siliceous earth can be used, and more preferably, alumina, silicon carbide or a mixture thereof is used.

As the ceramic powder, various kinds of material having various particle sizes, specific kinds of material having the same particle diameter, or one kinds of material having different particle sizes can be used. The particle size is preferably 0.001 μm to 1 mm. If the particle size of the ceramic powder falls within the above range, pore formation and mechanical
strength of a ceramic filter can be improved.

The ceramic powder preferably is comprised in the slurry composition in an amount of 25 to 60 parts by weight, more preferably in an amount of 30 to 50 parts by weight. If the content falls within the above range, physical strength, shape of a ceramic filter can be maintained, filtering efficiency can be remarkably improved, twisting and cracks can be prevented during sintering, and abrasion resistance of a ceramic filter can increase.

The ii) clay, which constitutes a basic structure of a ceramic filter after sintering, facilitates bonding between ceramic particles during sintering.

As the clay, various kinds of material having various particle sizes, specific kinds of material having the same particle size, or one kind of material having different particle sizes can be used. The particle size is preferably 0.001 \( \mu \text{m} \) to 1 mm. If the particle size of the clay falls within the above range, pore formation and mechanical strength of a ceramic filter can be improved.

The clay is preferably comprised in the slurry composition in an amount of 10 to 40 parts by weight, more preferably in an amount of 15 to 25 parts by weight. If the content falls within the above range, physical strength and shape of a ceramic filter can be maintained, filtering efficiency can be remarkably improved, twisting and cracks can be prevented during sintering, and abrasion resistance of a ceramic filter can increase.

The iii) pore forming material forms pores in a ceramic filter after sintering.

As the pore forming material, carbon, active carbon, wood-based powder, sawdust, salt, naphthalene or talc can be used.

As the pore forming material, those having various particle sizes can
be used. The particle size is preferably 0.001 \( \mu m \) to 1 mm. If the particle size of the pore forming material falls within the above range, pores with appropriate size can form and mechanical strength of a ceramic filter can be improved.

The pore forming material burns to disappear during sintering process thereby forming pores in a ceramic filter. The pore forming material is preferably comprised in the slurry composition in an amount of 5 to 40 parts by weight, and more preferably 10 to 25 parts by weight. If the content falls within the above range, the pore forming material completely burns during sintering to efficiently form pores in a ceramic filter.

The iv) binder functions for binding the slurry with the support.

As the binder, an organic binder, an inorganic binder, or a mixture thereof can be used, preferably a mixture of an inorganic binder and an organic binder is used.

Specifically, the binder includes an inorganic binder such as frit or barium carbonate (\( \text{BaCO}_3 \)), and an organic binder such as MAP (monoaluminum phosphate), water binder, polyvinylbutyral, polyvinylalcohol or polyvinyl acetate, etc., and preferably a mixture of frit and a water binder is used.

The binder is preferably composed in the slurry composition in an amount of 1 to 20 parts by weight, preferably in an amount of 5 to 10 parts by weight. If the content falls within the above range, the slurry and the support can be efficiently bound.

The v) dispersion may be varied according to the kinds of the binder, and preferably water or alcohol is used.

The dispersion is preferably composed in the slurry composition in an
amount of 20 to 60 parts by weight, preferably in an amount of 20 to 30 parts by weight. If the content falls within the above range, each component can be efficiently mixed, and the slurry can maintain appropriate viscosity to efficiently bind to the support.

The ceramic powder, clay, pore-forming material and a binder can be simultaneously introduced into the dispersion, or sequentially separately introduced at a specific interval. It is preferable to mix ceramic powder, clay, pore forming material and an inorganic binder (mixed in case an inorganic binder is used) with the dispersion and then mix an organic binder with the mixture in order for convenience of mixing.

The mixing is preferably conducted for 1 to 10 hours.

The mixed slurry is preferably aged for 1 hour or more.

b) Supporting

This step is to support the slurry prepared in step a) on a support to prepare a molded article.

The size of the support may be varied according to the size of a ceramic filter to be prepared.

The support may include those having porous structure capable of supporting a slurry, and preferably non-woven fabric, woven-fabric or sponge, etc. is used in terms of facility of application.

The non-woven fabric is prepared by binding short staple to a web or sheet type fiber aggregate using an adhesive, adhering fibers using thermoplastic fiber, or entangling fibers by needle punching, sewing, etc. Preferably, polyester, aramide, polyphenylenesulfide, home-acrylic, polyimide, polytetrafluoroethylene (PTFE), viscose, natural fiber, glass fiber, ceramic fiber or metal fiber, etc. is used.
The woven-fabric is prepared by spinning, weaving, cotton weaving, etc. Preferably, it is loosely woven to contain sufficient pores for supporting the slurry.

This step is conducted by coating the slurry on the support, immersing the support in the slurry, or spraying the slurry on the support. And, before supporting the slurry, the support may be made into a shape of a ceramic filter to be prepared by adhesion, fusion, sewing, bonding or molding with a mold.

Preferably, a process of immersing the support in a slurry solution and squeezing is repeated 2~3 times so that sufficient amount of a ceramic mixture can be safely arrived on the support. And, it is more preferable to repeat a process of coating or spraying the slurry on the support and squeezing 2~3 times so that sufficient amount of the slurry solution can be supported on the support.

In case the slurry is supported on the support after cutting or molding the support to a specific size, drying may be immediately conducted. And, in case the support is not cut or molded to a specific size, a step of molding to a suitable shape can be further conducted to prepare a molded article with a specific shape.

The support on which the slurry is supported can be molded into various shapes according to its purposes. Specifically, the support is closely adhered and bound to a mold of circular tube shape, radial curved tube shape, or rectangular tube shape, and they are fixed with a clamp, etc. to mold into circular tube, radial tube or rectangular tube shape. In case a ceramic filter of radial curved tube shape is prepared using a mold of radial curved tube shape as shown in Fig. 1, it can be applied to those that a
circular tube is applied to, while maximizing filtering area to increase filtering efficiency.

In addition, in case a support is closely adhered to a mold, a release film can be added between the support and the mold in order to facilitate separation of the mold and the support. As the release film, resin film made of rubber, urethane resin, or epoxy resin, or a paper film such as kraft paper can be used.

c) Drying

This step is to dry the molded article prepared in step b). It allows safe sintering and prevents modification of a shape of the molded article during sintering preparation process and sintering process.

It can be conducted by natural drying, hot wind, sunlight, or shade. Preferably, drying is conducted by infrared rays so as to reduce drying time and prevent modification of a molded article and cracks.

d) Sintering

This step is to sinter the molded article dried in step c).

The sintering is conducted by removing a mold from the dried molded article and introducing it into a sintering furnace and then elevating the temperature of the furnace to a sintering temperature.

And, the sintering may be conducted after further conducting a processing step for cutting the molded article into a size of a ceramic filter to prepare body of the filter; and an assembling step of manufacturing a lower cap fitted to an outer diameter of the body and an upper cap having wings by supporting a slurry on a support and drying, and assembling the upper and lower caps using a ceramic bond so that lower part is closed and an upper part is opened as shown in Fig. 5.
The sintering temperature may be set according to components and compositional ratio of the slurry. In order to prevent modification, shrinkage and damage of the molded article during temperature elevation, it is preferable to elevate temperature at a speed of 0.5~3 °C/min from room temperature to 500°C. And, it is more preferable to elevate at a speed of 0.5~1 °C/min between 150~450°C, and to finally elevate to 900~1300°C according to composition of a ceramic powder and maintain the temperature for 2~48 hours to complete sintering.

The finally prepared ceramic filter can be made into various shapes as shown in Figs. 2 to 5, and it can be manufactured into a structure having high porosity as shown in Figs. 6. And, as shown in Fig. 7, two or more ceramic filters can be adhered using an adhesive to use extended ceramic filter, wherein a pipe with a size smaller than inner diameter of a ceramic filter can be introduced between the ceramic filters.

The adhesive can be commonly used adhesive, and ceramic adhesive is preferable.

In addition, the method of the present invention, in order to improve functionality of a ceramic filter, may further comprise the steps of further coating functional material insider or outside of a ceramic filter dried in step c), one sintered in step d); and then drying. The coating of the functional material can be conducted by known methods capable of appropriately bonding ceramic filter with functional material. And, after coating the functional material and drying, sintering step can be further conducted.

As the functional material such as zeolite, platinum, palladium, silver, TiO₂, or ZnO can be used alone or in combination.

The inside and outside of the ceramic filter can be coated with the
same or different material.

According to the method of the present invention, production cost is low, preparation is easy, modification of a shape and production of a large-sized filter are easy, abrasion resistance and heat resistance are superior, and porosity control range broadens.

The present invention also provides a ceramic filter prepared by the above method. The ceramic filter of the present invention can be used for a post treating apparatus in various industries, a dusting filter of various dusting equipment as shown in Fig. 8, an incinerator, a dusting apparatus for a crematory, a dusting apparatus for engine exhaust gas, an air purifier for automobile exhaust gas, or an apparatus for removing volatile organic compounds by photo-catalytic activity in an air purifier. In addition, the ceramic filter can be in the shape of circular tube, rectangular tube or radial curbed tube according to its application fields.

The present invention will be explained in more detail with reference to the following Examples. However, these are to illustrate the present invention and the present invention is not limited to them.

**EXAMPLES**

**Example 1**

To 50 parts by weight of water, 40 parts by weight of alumina (Al₂O₃), 25 parts by weight of clay, 25 parts by weight of active carbon and 5 parts by weigh of an inorganic binder of frit (VA950, Duklim material) were added and mixed in a mixer. And, 5 parts by weight of an organic binder of water binder was added to the mixture and then they were mixed for 2 hours in a mixer to prepare a slurry solution.

The slurry solution was coated on non-woven fabric with size of
1000mm x 1500mm x 2 mm so as to be sufficiently supported thereon.

Then, a mold with a circular tube shape was manufactured from PVC, a release film is bound to the mold surface, and then the non-woven fabric immersed in the slurry solution was wound along with the shape of the mold to prepare a molded article, which was dried by hot wind at 30~90 °C for 1 hour.

The mold and the release film were removed from the dried molded article, and then the molded article was put in an electric furnace, which was elevated at a speed of 3°C/min from room temperature to 150°C, slowly elevated at a speed of 0.5~1°C/min from 150 to 450°C, and maintained at 900~1300°C for 2 hours to complete sintering thereby preparing a ceramic filter having 2 layers with different pore sizes.

The weight of the ceramic filter prepared by the method above is reduced by 10~30% after sintering. The ceramic filter is shrunken by 5~25%.

Fig. 2 is the picture of a circular tube ceramic filter prepared by Example 1. Fig. 6 is Scan Electronic Microscope (SEM) picture of a ceramic filter prepared by Example 1.

Example 2

A ceramic filter was prepared by the same method as in Example 1, except that silicon carbide was used instead of alumina in the slurry solution.

Example 3

A ceramic filter was prepared by the same method as in Example 1, except that 25 parts by weight of alumina and 25 parts by weight of silicon carbide were used together instead of alumina in the slurry solution.

Example 4

A ceramic filter was prepared by the same method as in Example 1,
except that a radial curved tube shaped mold (Fig. 1) was used instead of the circular tube shaped mold to mold a non-woven fabric supporting the slurry solution as shown in Fig. 3.

**Example 5**

A ceramic filter was prepared by the same method as in Example 1, except that a rectangular tube shaped mold was used instead of the circular tube shaped mold to mold a non-woven fabric supporting the slurry solution.

**Example 6**

A non-woven fabric immersed in a slurry solution was molded and dried by hot wind by the same method as in Example 1, except using a mold of radial curved tube shape.

Then, the dried mold was cut to manufacture a body of a filter, and a lower cap fitted to an outer diameter of the body and an upper cap having wings were manufactured by immersing or coating the non-woven fabric with the slurry solution and drying. The body and the upper and lower caps were assembled so that the lower part is closed and the upper part is opened as the wing shape.

Then, the same process as in Example 1 was conducted to manufacture a ceramic filter.

**Example 7**

Two ceramic filters were prepared by the same method as in Example 1, then an extended ceramic filter was prepared by joint the ceramic filters with binder. Fig. 7 is a photograph of an extended ceramic filter prepared by Example 7.

A large-sized ceramic filters having diameter of 100mm or more and length of 1m or more can be manufactured by Examples 1 to 7, which has
high porosity of 40% or more and superior heat resistance up to 1000°C.

According to the method of the present invention, a separate preparation of an expensive mold is not required, a pressurizing device or vacuum device is not required, and thus production cost of a ceramic filter is low, preparation is easy, modification of a shape is easy, and a large-sized filter can be produced as long as the size of a sintering furnace allows. And, porosity control range can be comparatively broad because pressurization or vacuum process is not needed, pore size can be selected within the range of 0.001~5 mm according to the density of a support, the size and content of pore forming material to control pore size with small variation, high porosity of 40% or more can be achieved, and a light-weighted porous filter can be prepared.

In addition, the present invention can prepare a ceramic filter that can maximize filtering area within a specific space because modification of a shape and production of a complicated shape are easy. In addition, the ceramic filter of the present invention can be applicable in high temperature and pressure condition because of its superior heat resistance and abrasion resistance.

In addition, the ceramic filter of the present invention does not require a heat-exchange device for cooling liquid at high temperature, is very light because of porous structure with pores of 40% or more, dusting efficiency is 99.8% or more, dusting can be conducted with more rapid filtering speed than the existing dusting filter, deterioration or damage of a filter does not occur even at high temperature, high pressure, and it can be easily applied for a waste incinerator, a crematory, a boiler, a cement preparation process, a coal steam power plant, a coal gasification complex power equipment.
because there is no concern about a fire due to sparks.
WHAT IS CLAIMED IS:

1. A method for preparing a ceramic filter, which comprises the steps of:
   a) mixing
      i) 25 to 60 parts by weight of ceramic powder selected from the group consisting of silicon carbide, alumina, sillimanite, kaolin, silica, titania, and siliceous earth;
      ii) 10 to 40 parts by weight of clay;
      iii) 5 to 40 parts by weight of pore-forming material;
      iv) 1 to 20 parts by weight of a binder; and
   v) 20 to 60 parts by weight of a dispersion to prepare a slurry;
   b) supporting the slurry prepared in step a) on a support to prepare a molded article;
   c) drying the molded article prepared in step b); and
   d) sintering the molded article dried in step c).

2. The method for preparing a ceramic filter according to claim 1, further comprising the step of molding the support on which the slurry is supported into a determined shape, before or after the step of b) supporting.

3. The method for preparing a ceramic filter according to claim 1, wherein the a) i) ceramic powder is alumina, silicon carbide or a mixture thereof.

4. The method for preparing a ceramic filter according to claim 1, wherein the a) iii) a pore-forming material is selected from the group consisting of carbon, active carbon, wood-based powder, salt, naphthalene, and talc.

5. The method for preparing a ceramic filter according to claim 1, wherein the a) iv) binder is an inorganic binder selected from the group consisting of frit, barium carbonate (BaCO₃), or an organic binder selected from the group...
consisting of MAP (mono aluminum phosphate), water binder, polyvinyl butyral, polyvinyl alcohol and polyvinyl acetate.

6. The method for preparing a ceramic filter according to claim 1, wherein the b) support is non-woven fabric, woven-fabric or sponge having pores on which the slurry of a) is supported.

7. The method for preparing a ceramic filter according to claim 6, wherein the non-woven fabric is selected from the group consisting of polyester, aramide, polyphenylene sulfide, home-acryl, polyimide, PTFE, viscose, natural fiber, glass fiber, ceramic fiber and metal fiber having pores.

8. The method for preparing a ceramic filter according to claim 1, wherein the b) molded article is of circular tube, radial curved tube, or rectangular tube shape.

9. The method for preparing a ceramic filter according to claim 1, wherein the step b) comprises bonding a release film on a molding and then bonding the molded article with the support.

10. The method for preparing a ceramic filter according to claim 1, wherein the step c) drying is conducted with infrared ray.

11. The method for preparing a ceramic filter according to claim 1, wherein the sintering step comprises elevating temperature at a rate of 0.5 to 1 °C/min from 150~450 °C.

12. A ceramic filter prepared by the method of anyone of claims 1 to 11.

13. The ceramic filter according to claim 12, wherein the ceramic filter is of circular, rectangular or radial curved tube shape.

14. The ceramic filter according to claim 12, wherein the ceramic filter is used for a dusting apparatus for an incinerator or crematory, an apparatus for dusting engine exhaust gas, a support of automobile exhaust gas, or an
apparatus for removing volatile organic compounds.
FIG. 1
**INTERNATIONAL SEARCH REPORT**

A. **CLASSIFICATION OF SUBJECT MATTER**

   **IPC7 B01D 39/00**

   According to International Patent Classification (IPC) or to both national classification and IPC

B. **FIELDS SEARCHED**

   Minimum documentation searched (classification system followed by classification symbols)
   
   IPC7 B01D, C04B

   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
   
   Korean Patents and applications for inventions since 1975
   Korean Utility models and applications for Utility models since 1975
   Japanese Utility models and applications for Utility models since 1975

   Electronic database consulted during the international search (name of database and, where practical, search terms used)
   
   eKIPASS

C. **DOCUMENTS CONSIDERED TO BE RELEVANT**

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<tr>
<td>Y</td>
<td>JP 11-333226 A (TAKASAGO THERMAL ENG CO LTD) 7 DECEMBER 1999 See the whole document</td>
<td>1-8, 12</td>
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<tr>
<td>P, Y</td>
<td>KR 2003-0007302 A (KIM GI HO) 23 JANUARY 2003 See the whole document</td>
<td>1-8, 12</td>
</tr>
<tr>
<td>A</td>
<td>JP 2002-219919 A (NGK INSULATORS, LTD.) 6 AUGUST 2002 See the whole document</td>
<td>1-2, 12</td>
</tr>
<tr>
<td>A</td>
<td>JP 9-206524 A (BRIDGESTONE CORP, NARITA SEitoushiyo:KK) 12 AUGUST 1997 See the whole document</td>
<td>1-2, 12</td>
</tr>
<tr>
<td>A</td>
<td>US 6080219 A (MOTT METALLURGICAL CORPORATION) 27 JUNE 2000 See the whole document</td>
<td>1-2, 12</td>
</tr>
</tbody>
</table>

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   *A* document defining the general state of the art which is not considered to be of particular relevance
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Further documents are listed in the continuation of Box C.

See patent family annex.

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Name and mailing address of the ISA/KR

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Form PCT/ISA/210 (second sheet) (January 2004)
**INTERNATIONAL SEARCH REPORT**

Information on patent family members

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<th>Publication date</th>
<th>Patent family member(s)</th>
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<tr>
<td></td>
<td></td>
<td>US 6352578 A</td>
<td>05.03.2002</td>
</tr>
<tr>
<td>KR 2003-0007302 A</td>
<td>23.01.2003</td>
<td>None</td>
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</tr>
<tr>
<td>JP 2002-219319 A</td>
<td>06.08.2002</td>
<td>US 2003041574 A1</td>
<td>06.08.2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 200241972 A1</td>
<td>30.05.2002</td>
</tr>
<tr>
<td>JP 9-200524 A</td>
<td>12.08.1997</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>US 6080219 A</td>
<td>27.06.2000</td>
<td>WO 9958223 A1</td>
<td>18.11.1999</td>
</tr>
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</table>

Form PCT/ISA/210 (patent family annex) (January 2004)