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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for air-purification performance of semiconducting photocatalytic materials —

Part 1: Removal of nitric oxide

Céramiques techniques — Méthodes d'essai relatives à la performance des matériaux photocatalytiques semi-conducteurs pour la purification de l'air —

Partie 1: Élimination de l'oxyde nitrique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 206, *Fine ceramics*.

This second edition cancels and replaces the first edition (ISO 22197-1:2007), which has been technically revised with the following changes:

— deletion of reference to ISO 4677-1 (withdrawn) from Clause 2 and 8.2.2;

— addition of a definition of "dark condition" (3.7);

— change of air-flow rate measurement to a wet gas basis (6.2);

— change of tolerance on dimensions of test piece in Clause 7;

— update of procedure in Clause 8 to reflect the latest knowledge;

— addition of a test method for test pieces with lower performance (new Clause 10).

A list of all parts in the ISO 22197 series can be found on the ISO website.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for air-purification performance of semiconducting photocatalytic materials —

Part 1: Removal of nitric oxide

1 Scope

This document specifies a test method for the determination of the air-purification performance of materials that contain a photocatalyst or have photocatalytic films on the surface, usually made from semiconducting metal oxides, such as titanium dioxide or other ceramic materials, by continuous exposure of a test piece to the model air pollutant under illumination with ultraviolet light. This document is intended for use with different kinds of materials, such as construction materials in flat sheet, board or plate shape, that are the basic forms of materials for various applications. This document also applies to materials in honeycomb-form and to plastic or paper materials if they contain ceramic microcrystals and composites. This document does not apply to powder or granular photocatalytic materials.

This test method is usually applicable to photocatalytic materials produced for air purification. This method is not suitable for the determination of other performance attributes of photocatalytic materials, i.e. decomposition of water contaminants, self-cleaning, antifogging and antibacterial actions. It concerns the removal of nitric oxide.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

ISO 4892-3, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 6145-7, *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods — Part 7: Thermal mass-flow controllers*

ISO 7996, *Ambient air — Determination of the mass concentration of nitrogen oxides — Chemiluminescence method*

ISO 10304-1, *Water quality — Determination of dissolved anions by liquid chromatography of ions — Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate*

ISO 10523, *Water quality — Determination of pH*

ISO 80000-1, *Quantities and units — Part 1: General*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
photocatalyst
substance that performs one or more functions based on oxidation and reduction reactions under photoirradiation, including decomposition and removal of air and water contaminants, deodorization, and antibacterial, self-cleaning and antifogging actions

3.2
photocatalytic materials
materials in which or on which the photocatalyst is added by coating, impregnation, mixing, etc.

Note 1 to entry: Such photocatalytic materials are intended primarily for use as building and road construction materials to obtain the above-mentioned functions.

3.3
zero-calibration gas
air that does not contain pollutants (i.e. in which common pollutants are below 0,01 µl/l)

Note 1 to entry: The zero-calibration gas is prepared from indoor air using a laboratory air-purification system, or supplied as synthetic air in a gas cylinder.

3.4
standard gas

diluted gases of known concentrations supplied in cylinders and certified by an accredited laboratory

3.5
test gas
mixture of air and pollutant(s) of known concentration prepared from a standard gas or a zero-calibration gas, to be used for the performance test of a photocatalytic material

3.6
purified water
water to be used for elution, etc., with a specific conductivity lower than 1 µS/cm, prepared by the ion exchange method or distillation

3.7
dark condition
test condition with no light illumination by the light source for testing and room lightings

4 Symbols

f	air-flow rate converted into that at the standard state (0 °C, 101,3 kPa) (l/min)
ϕ_{NO}	nitric oxide volume fraction at the reactor exit (µl/l)
ϕ_{NOi}	supply volume fraction of nitric oxide (µl/l)
ϕ_{NO2}	nitrogen dioxide volume fraction at the reactor exit (µl/l)
ϕ_{NOx}	volume fraction of nitrogen oxides ($\phi_{NO} + \phi_{NO2}$) at the reactor exit (µl/l)

$\rho_{NO_2^-}$ nitrite ion concentration in the eluent from the test piece (mg/l)

$\rho_{NO_3^-}$ nitrate ion concentration in the eluent from the test piece (mg/l)

t time of adsorption, removal or desorption operation (min)

n_{ads} amount of NO_x adsorbed by the test piece (µmol)

n_{des} amount of NO_x desorbed from the test piece (µmol)

n_{NO} amount of NO removed by the test piece (µmol)

n_{NO_2} amount of NO_2 formed by the test piece (µmol)

n_{NO_x} amount of NO_x removed by the test piece (µmol)

n_w amount of nitrogen eluted from the test piece (µmol); w_1, w_2 are the 1st and 2nd elutions, respectively

V_w volume of collected washings (ml); w_1, w_2 are the 1st and 2nd elutions, respectively

η_w fractional recovery of nitrogen

5 Principle

This document concerns the development, comparison, quality assurance, characterization, reliability, and design data generation of photocatalytic materials.[1] The method described is intended to obtain the air-purification performance of photocatalytic materials by exposing a test piece to model polluted air under illumination by ultraviolet (UV) light.[2] Nitric oxide (NO) is chosen as a typical air pollutant that gives nonvolatile products on the photocatalyst. The test piece, placed in a flow-type photoreactor, is activated by UV illumination, and adsorbs and oxidizes gas-phase NO to form nitric acid (or nitrate) on its surface.[3] A part of the NO is converted to nitrogen dioxide (NO_2) on the test piece. The air-purification performance is determined from the amount of the net removal of nitrogen oxides (NO_x) (= NO removed – NO_2 formed). The simple adsorption and desorption of NO by the test piece (not due to photocatalysis) are evaluated by tests in the dark. Although the photocatalytic activity is reduced by the accumulation of reaction products, it is usually restored by washing with water.[4] The elution test provided here gives information about the ease of regeneration and material balance of the pollutants.

6 Apparatus

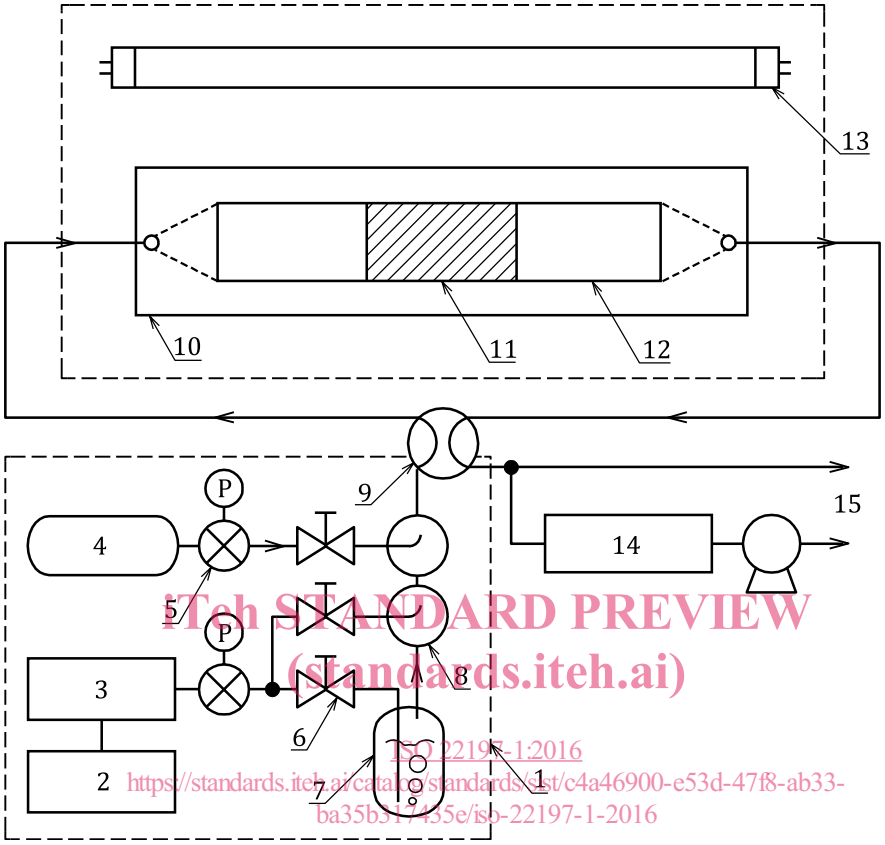
6.1 Test equipment

The test equipment enables a photocatalytic material to be examined for its pollutant-removal capability by supplying the test gas continuously, while providing photoirradiation to activate the photocatalyst. It consists of a test gas supply, a photoreactor, a light source, and pollutant measurement equipment. Since low concentrations of pollutants are to be tested, the system shall be constructed with materials of low adsorption and resistant to ultraviolet (UV) radiation, for example, acrylic resin, stainless steel, glass and fluorocarbon polymers. An example of a test system is shown in Figure 1.

6.2 Test gas supply

The test gas supply provides air polluted with the model contaminant at a predetermined concentration, temperature and humidity, and supplies it continuously to the photoreactor. It consists of flow regulators, a humidifier, gas mixers, etc. The flow rate of each gas should be within 5 % of the designated value, which is easily attained by using thermal mass-flow controllers, with the knowledge of calibrated gas flow rate and temperature in accordance with ISO 6145-7. Typical capacities of the flow controller

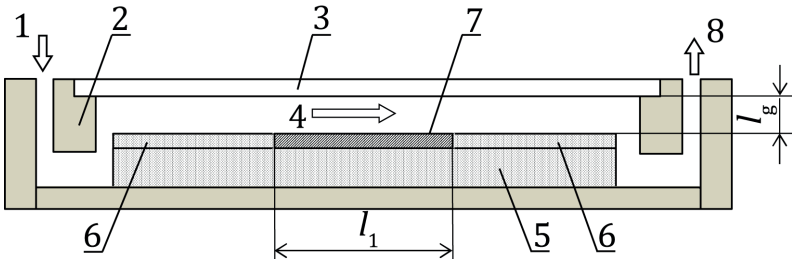
for pollutant gas, dry air and wet air are 0,1 l/min, 2,0 l/min and 2,0 l/min, respectively. The expression of gas flow rate in this document is that converted to the standard state (0 °C, 101,3 kPa). The standard NO gas, normally balanced with nitrogen in a cylinder, shall have a volume fraction of 30 µl/l to 100 µl/l, because the oxidation of NO to NO_2 upon mixing with purified air becomes prominent with a higher concentration of NO.



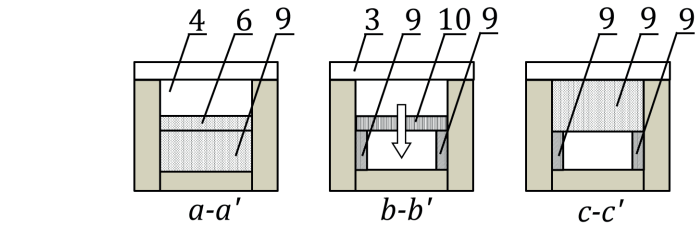
Key

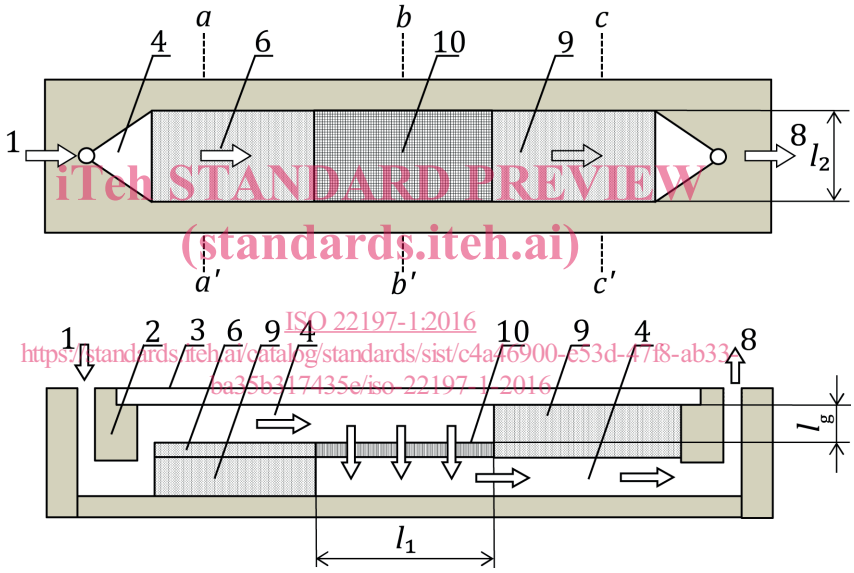
1 test gas supply	6 mass-flow controller	11 test piece
2 air compressor	7 humidifier	12 air-tight optical window
3 air-purification system	8 gas mixer	13 light source
4 standard gas (pollutant)	9 4-way valve	14 analyser
5 pressure regulator	10 photoreactor	15 vent

Figure 1 — Schematic of the test equipment



a) For flat test pieces





b) For filter-type test pieces

Test piece length l_1	Test piece width l_2	Air layer thickness l_g
99,0 mm ± 1,0 mm	49,0 mm ± 1,0 mm	5,0 mm ± 0,5 mm

Key

1 test gas inlet
2 baffle
3 air-tight optical window
4 flow channel
5 height-adjusting plate
6 auxiliary plate
7 test piece (flat-type)
8 test gas outlet
9 test piece holder
10 test piece (filter-type)

Figure 2 — Cross-sectional view of photoreactor