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

Part 1:
Removal of nitric oxide

Reference number
ISO 17168-1:2018(E)

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Foreword

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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.

This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

A list of all parts in the ISO 17168 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Photocatalyst is a substance that performs decomposition and removal of contaminants, self-cleaning, antifogging, deodorization and antibacterial actions under photoirradiation. Its application has expanded considerably in recent years. The application of photocatalysts for indoor spaces has increasingly been sought as a solution to indoor environmental problems. Since conventional photocatalysts are responsive only to ultraviolet light, studies have been made to develop an indoor-light-active photocatalyst that makes effective use of indoor light, which room lights mainly emit, and thus demonstrates high photocatalytic performance indoors. The development has recently led to the commercialization of various indoor-light-active photocatalytic products, and there has been demand for the establishment of test methods to evaluate the performance of this type of photocatalyst.

This document is based on ISO 22197-1, a test method for air purification performance of photocatalytic materials under UV light, and is intended to provide a testing method to determine the performance of indoor-light-active photocatalytic materials with regards to the removal of nitric oxide, enabling swift distribution of photocatalytic products and thus contributing to a safe and clean environment.

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

Part 1:
Removal of nitric oxide

1 Scope

This document specifies a test method for the determination of the air purification performance, with regards to removal of nitric oxide, 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 from indoor light.

This document is intended for use with different kinds of materials, such as construction materials in flat sheet, board or plate shape, which are the basic forms of materials for various applications. This document also applies to materials in honeycomb form and to plastic or paper materials containing ceramic microcrystals and composites. This document does not apply to certain test pieces that contain a large amount of adsorbent, due to unattained adsorption equilibrium. 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.

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 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 14605, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Light source for testing semiconducting photocatalytic materials used under indoor lighting environment*

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

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

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:

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

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

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; a type of functional fine ceramics

3.2
indoor light
light from an artificial light source for general lighting service that does not include sunlight

3.3
indoor-light-active photocatalyst
photocatalyst (3.1) that performs under indoor light irradiation

3.4
photocatalytic material
material in which or on which the photocatalyst is added by, for example, coating, impregnation or mixing

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

3.5
zero-calibration gas
air in which common pollutants are below 0,01 µl/l

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

3.6
standard gas
diluted gas of known concentration supplied in cylinders and certified by an accredited laboratory

3.7
test gas
mixture of air and pollutant(s) of known concentration prepared from the *standard gas* (3.6) or the *zero-calibration gas* (3.5), or from the *standard gas* (3.6) only, to be used for the performance test of a *photocatalytic material* (3.4)

3.8
purified water
water with a specific conductivity lower than 1 µS/cm, prepared by the ion exchange method or distillation

3.9
dark conditions
test conditions of no light illumination by the light source for testing and room lighting

Note 1 to entry: Usually the test gas is supplied for comparison with the illuminated reaction.

4 Symbols

f	air-flow rate converted into that at the standard state (0 °C, 101,3 kPa) (l/min)
ϕ_{NO}	nitric oxide concentration at the reactor exit (µl/l)
ϕ_{NOi}	supply concentration of nitric oxide (µl/l)
ϕ_{NO2}	nitrogen dioxide concentration at the reactor exit (µl/l)
ϕ_{NO_x}	concentration of nitrogen oxides (ϕ_{NO} + ϕ_{NO2}) at the reactor exit (µl/l)
ρ_{NO2-}	nitrite ion concentration in the eluent from the test piece (mg/l)
ρ_{NO3-}	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_{NO2}	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 first and second elution, respectively]
V_w	volume of collected washings (ml) [w_1, w_2 are the first and second elution, respectively]
η_w	fractional recovery of nitrogen

5 Principle

This document deals with 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 indoor light[2]. Nitric oxide (NO) is chosen as a typical air pollutant that gives non-volatile products on the photocatalyst[2]. The test piece, placed in a flow-type photoreactor, is activated by indoor-light 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) is 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 gives information about the ease of regeneration and material balance of the pollutants.

The results of an interlaboratory test are given in Annex A.

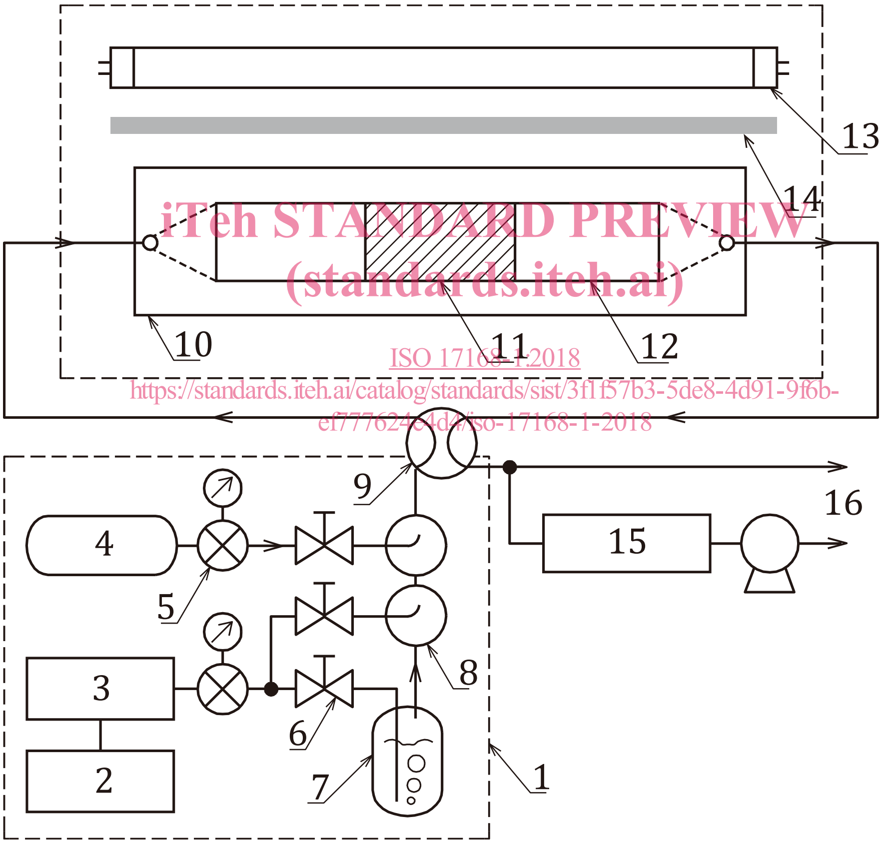
6 Apparatus

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, a UV sharp cut-off filter and pollutant measurement equipment. Since low concentrations of pollutants are to be tested, the system shall be constructed with materials of low adsorption, for example acrylic resin, stainless steel, glass and fluorocarbon polymers. An example of a testing 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 and so on. The flow rate of each gas should be within 5,0 % of the designated value, which is easily attained by using thermal mass-flow controllers with knowledge of calibrated gas flow rate and temperature (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 concentration of 30 – 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
2 air compressor
3 air-purification system
4 standard gas (pollutant)
5 pressure regulator with a gauge
6 mass-flow controller
7 humidifier
8 gas mixer
9 four-way valve
10 photoreactor
11 test piece
12 air-tight optical window
13 light source
14 sharp cut-off filter
15 analyser
16 vent

Figure 1 — A schematic of the test equipment

6.3 Photoreactor

The photoreactor holds a planar test piece within a 50 mm-wide trough, with its surface parallel to an air-tight optical window for photoirradiation. The reactor shall be fabricated from materials that adsorb minimal test gas and withstand irradiation of near-UV light. The test piece shall be separated from the window by a 5,0 mm ± 0,5 mm thick air layer. The test gas shall pass only through the space between the test piece and the window. This gap shall be accurately set up, for example by using height-adjusting plates with different thickness, as shown in Figure 2a). When a filter-type photocatalyst is tested, an alternative type of test piece holder shall be used, which holds the test piece while allowing the test gas to pass through the cells of the filter under illumination [Figure 2b)]. Quartz or borosilicate glass that absorbs minimal light at wavelengths longer than 300 nm shall be used for the window.

