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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 2: Removal of acetaldehyde

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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).

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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, with ISO 17168-1 as the basis, is intended to provide a testing method to determine the performance of indoor-light-active photocatalytic materials with regards to the removal of acetaldehyde, a representative lower aliphatic volatile organic compound (VOC), 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 2: Removal of acetaldehyde

1 Scope

This document specifies a test method for the determination of the air-purification performance, with regards to removal of acetaldehyde, 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 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 4224, *Ambient air — Determination of carbon monoxide — Non-dispersive infrared spectrometric method*

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

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

ISO 16000-3, *Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — Active sampling method*

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

ISO 17168-1, *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*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17168-1 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/

4 Symbols

f	air-flow rate converted into that at the standard state (0 °C and 101,3 kPa) (l/min)
ϕ_{A}	acetaldehyde volume fraction at the reactor exit (µl/l)
ϕ_{AD}	acetaldehyde volume fraction at the reactor exit under dark conditions (µl/l)
ϕ_{A0}	volume fraction of acetaldehyde in the test gas (µl/l)
ϕ_{CO2}	CO_2 volume fraction generated by indoor-light irradiation (µl/l)
$\phi_{CO2,L}$	CO_2 volume fraction at the reactor exit under indoor-light irradiation (µl/l)
$\phi_{CO2,D}$	CO_2 volume fraction at the reactor exit under dark conditions (µl/l)
$\phi_{CO2,Dpost}$	CO_2 volume fraction in the dark before indoor-light irradiation (µl/l)
$\phi_{CO2,Dpre}$	CO_2 volume fraction in the dark after indoor-light irradiation (µl/l)
n_{A}	quantity of acetaldehyde removed by the test piece (µmol)
n_{CO2}	quantity of CO_2 converted from acetaldehyde per hour (µmol/h)
R_{A}	removal percentage, by test piece, of acetaldehyde (%)
R_{CO2}	conversion from acetaldehyde to CO_2 (%)

5 Principle

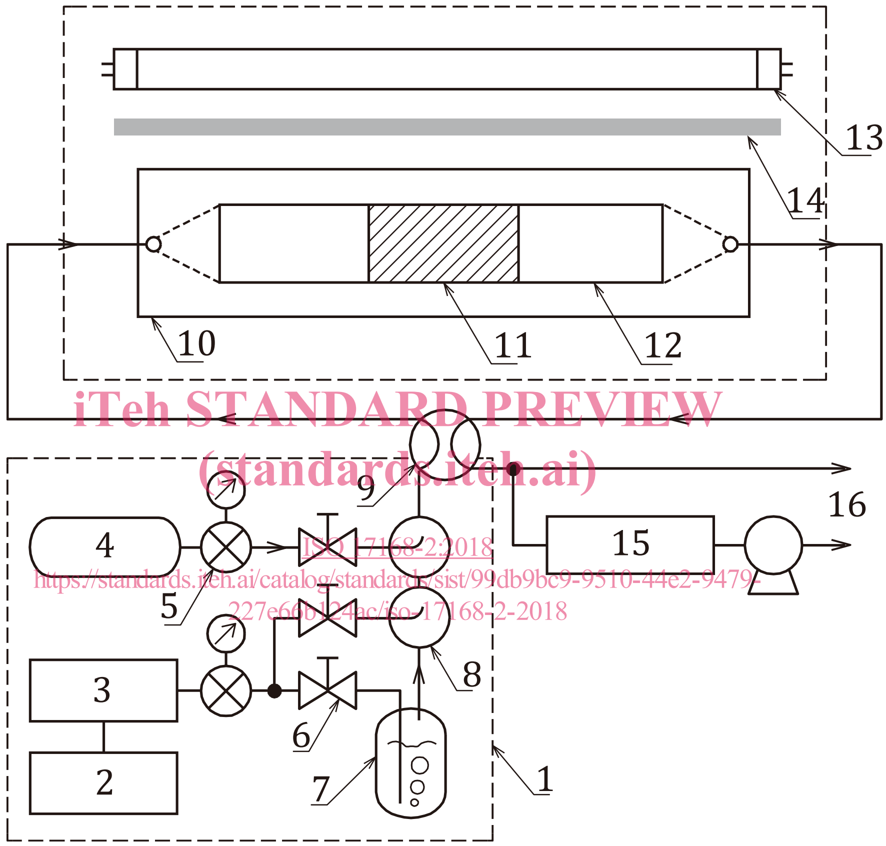
This document deals with the development, comparison, quality assurance, characterization, reliability and design data generation of photocatalytic materials[1]. The method described is intended to obtain the air-purification performance of photocatalytic materials by exposing a test piece to model polluted air under illumination by indoor-light. Acetaldehyde (CH_3CHO) is chosen as a typical volatile organic compound (VOC) with lower molecular mass and offensive odour[2]. The test piece, placed in a flow-type photoreactor, is activated by indoor-light illumination, and adsorbs and oxidizes gas-phase acetaldehyde to form carbon dioxide (CO_2) and other oxidation products[3]. The air-purification performance is determined from the amount of acetaldehyde removed by the test piece (µmol). The simple adsorption by the test piece (not due to photocatalysis) is evaluated by the tests in the dark. However, some test pieces are very absorbent, and a stable volume fraction of acetaldehyde may not be attained in the designated test time. The photocatalytic activity may depend on the physical and chemical properties of pollutants, mainly due to the adsorption process involved. For a better evaluation of the air purification performance of photocatalytic materials, it is recommended that one or more suitable test methods are combined, as provided in other parts of the ISO 17168 series.

The results of an interlaboratory test are given in Annex A to demonstrate the validity of this test method.

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 is the same as that used in a test method for the removal of nitric oxide (see ISO 17168-1) and consists of a test gas supply, a photoreactor, a light source, a UV sharp cut-off filter and pollutant measurement equipment. Since low-volume fractions of pollutants are to be tested, the system shall be constructed with materials of low adsorption and resistant to ultraviolet (UV) radiation. An example of a testing system is shown in Figure 1.



Key

1	test gas supply	9	four-way valve
2	air compressor	10	photoreactor
3	air-purification system	11	test piece
4	standard gas (pollutant)	12	airtight optical window
5	pressure regulator with a gauge	13	light source
6	mass-flow controller	14	sharp cut-off filter
7	humidifier	15	analyser
8	gas mixer	16	vent

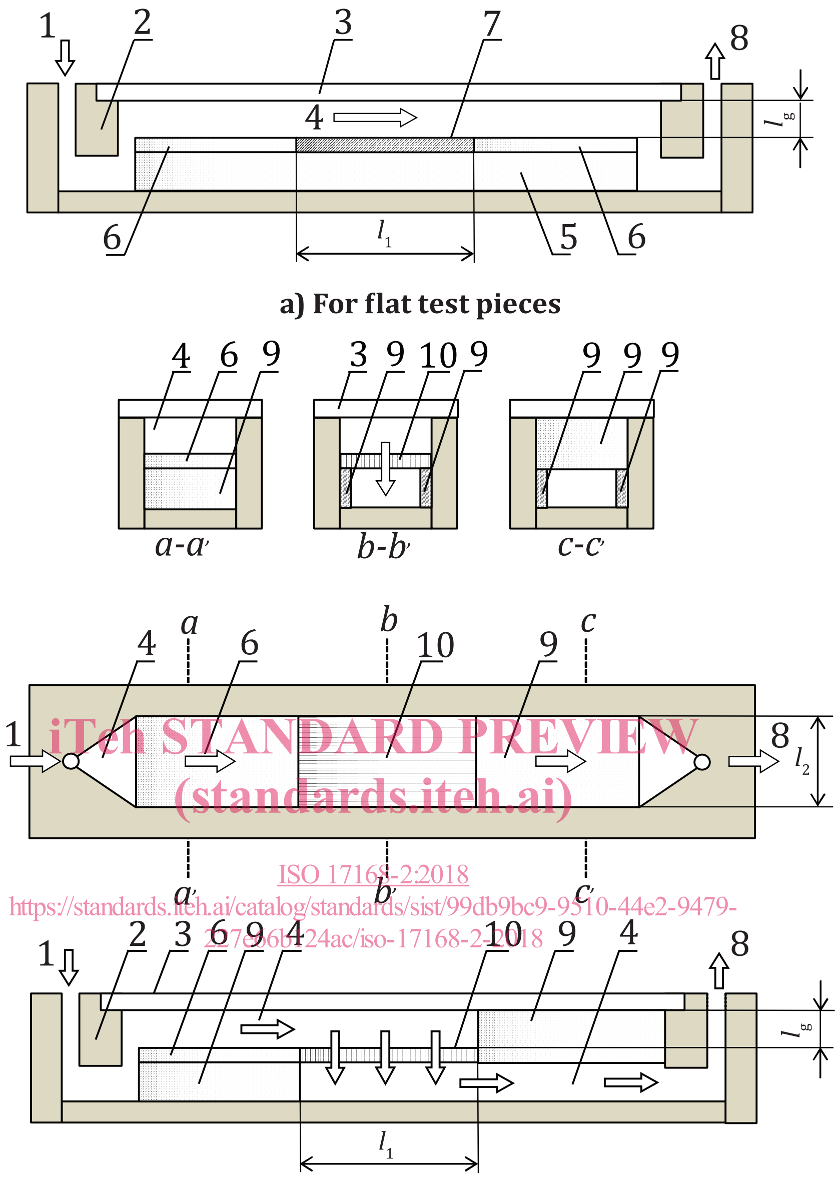
Figure 1 — A schematic of the testing equipment

6.2 Test gas supply

The test gas supply provides air polluted with 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 % of the designated value, which is easily attained by using thermal mass-flow controllers with knowledge of temperature and gas type at calibration in accordance with ISO 6145-7. The expression of gas flow rate in this document is that converted to the standard state (0 °C, 101,3 kPa). Typical capacities of flow controller for pollutant gas, dry air and wet air are 100, 1 000 and 1 000 ml/min, respectively. The standard acetaldehyde gas before dilution, normally balanced with nitrogen in a cylinder, shall have a volume fraction of 50 µl/l to 250 µl/l. Synthetic air (N_2 + O_2, such as supplied in cylinders) shall be used for dilution when the CO_2 from acetaldehyde is also measured.

6.3 Photoreactor

The photoreactor holds a planar test piece within a 50 mm-wide trough, with its surface parallel to an airtight optical window for photoirradiation. The reactor shall be fabricated from materials that adsorb little 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 according to the thickness of the test piece, for example by using height-adjusting plates with different thicknesses, as shown in Figure 2 a). When a filter-type material 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 2 b)]. Quartz or borosilicate glass that absorbs minimal light at wavelengths longer than 300 nm should be used for the window.



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 ± 1,0 mm	49,0 ± 1,0 mm	5,0 ± 0,5 mm

Key

1 test gas inlet
2 baffle
3 airtight 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 views of photoreactor

