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Nanotechnologies — Air filter media containing polymeric nanofibres — Specification of characteristics and measurement methods

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Foreword

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This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

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

Air filter media play an important role in the performance and efficiency of different types of air filters. In this respect, most air filter media take advantage of nonwovens to separate solid or liquid particles. Air filter media have a wide range of applications such as gas turbine inlet air, industrial dust collectors, respiratory masks, personal protective equipment, heating, ventilation and air conditioning systems, cleanrooms, etc.

In recent years, air filter media containing nanofibres have been commercialized and widely used by different industries due to their high filtration efficiency along with a low pressure drop created by the slip flow effect[6]. Air filter media containing nanofibres are normally produced by depositing one or more types of polymer-based nanofibres directly on the surface of a suitable porous substrate during spinning.

Since the diameter of nanofibres is significantly smaller than that of conventional microfibres employed in filters, it offers a higher chance of inertial impaction and interception, i.e. a more optimum filtration efficiency. The slip flow also results in a reduced pressure drop and more contaminants passing near the surface of the nanofibres. Hence, the inertial impaction and interception efficiencies rise. As a result, the filtration capability of the nanofibres layer increases for the same pressure drop as compared with a conventional fibre layer. Additionally, the very high surface area of nanofibres facilitates the adsorption of contaminants from the air. All these desirable features have led to a wide range of air filter media containing nanofibres being used for air filtration applications[6][7][8].

Different techniques such as electrospinning, force spinning and other methods have been used to produce air filter media containing nanofibres. The deposited nanofibres form a web-like nonwoven layer on the surface of the substrate. Nanofibres can exhibit different crystalline structures, morphology and diameter. The surface area and crossed-fibres porosity of the formed nonwoven layer is mainly affected by the nanofibre diameter as well as the morphology. Polymeric nanofibres such as polyamide, polyvinylidene fluoride (PVDF), polyacrylonitrile (PAN) and polyurethane (PU) are normally used for air filter media. Nanofibres can be deposited on different kinds of woven and nonwoven substrates. Annex A shows a schematic of the cross-section of an air filter medium (see Figure A.1) and SEM images relating to the morphology of the nanofibres (see Figures A.2 and A.3).

This document facilitates the communication between sellers and buyers and supports the growing trade of this new class of air filter media.

Nanotechnologies — Air filter media containing polymeric nanofibres — Specification of characteristics and measurement methods

1 Scope

This document specifies the characteristics to be measured of air filter media containing polymeric nanofibres on the surfaces of a substrate. It also describes measurement methods for determining the individual characteristics.

This document does not cover characteristics specific for health and safety issues.

NOTE The properties/performances assessment of air filter media related to applications requires the use of relevant published standards. The physical properties and performances of filtration media, such as pressure drop, and the particle removal efficiency of air filter media are measured with test methods suitable for specific applications.

2 Normative references

There are no normative references in this document.

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
air filter
filter
device for separating solid or liquid *particles* (3.6) or gaseous contaminant from an air stream passing through the device

Note 1 to entry: The device is generally formed of a layer or layers of porous, fibrous or granular material.

Note 2 to entry: Air being cleaned by a filter must pass through the filter, whereas an air cleaner can reduce air contamination by any method.

[SOURCE: ISO 29464:2017, 3.1.16, modified — The preferred term has been changed to “air filter”.]

3.2
air filter medium
porous permeable material employed in *filtration* (3.3) within which the filtrate is trapped or deposited

Note 1 to entry: The filter medium is composed of a *nanofibre* (3.5) layer(s) and *substrate* (3.7).

[SOURCE: ISO 9912-1:2004, 2.27, modified — “air” has been added to the term and Note 1 to entry has been added.]

3.3
filtration
separation of contaminants from a fluid stream in which they are suspended through retention of the contaminants (by extension, also the whole of the activities involved in the construction and commissioning of a filter installation)

[SOURCE: ISO 29464:2011, 3.5.29]

3.4
nanoscale
length range approximately from 1 nm to 100 nm

Note 1 to entry: Properties that are not extrapolations from larger sizes are predominantly exhibited in this length range.

[SOURCE: ISO/TS 80004-1:2015, 2.1]

3.5
nanofibre
nano-object with two external dimensions in the *nanoscale* (3.4) and the third dimension significantly larger

Note 1 to entry: The largest external dimension is not necessarily in the nanoscale.

Note 2 to entry: The terms nanofibril and nanofilament can also be used.

Note 3 to entry: If the dimensions differ significantly (typically by more than 3 times), terms such as nanofibre or nanoplate may be preferred to the term nanoparticle.

[SOURCE: ISO/TS 80004-2:2015, 4.5]

3.6
particle
minute piece of matter with defined physical boundaries

Note 1 to entry: A physical boundary can also be described as an interface.

Note 2 to entry: A particle can move as a unit.

Note 3 to entry: This general particle definition applies to nano-objects.

[SOURCE: ISO/TS 80004-2:2015, 3.1]

3.7
substrate
base layer for depositing *nanofibres* (3.5) on the surface

4 Abbreviated terms

AFM	atomic force microscopy
FESEM	field emission scanning electron microscopy
FTIR	Fourier transform infrared
IR	infrared
SEM	scanning electron microscopy
STM	scanning tunnelling microscopy

TEM	transmission electron microscopy
TGA	thermo gravimetric analysis
UV-Vis	ultraviolet-visible
XRD	X-ray diffraction

5 Characteristics to be measured and their measurement methods

5.1 General

This clause provides both mandatory and optional characteristics to be measured of air filter media containing nanofibres and their measurement methods. The purpose, definition and measurement methods are described for each characteristic in the following individual subclauses.

For all measurements of the characteristics, pieces of the air filter media sample combining a nanofibre layer(s) and a substrate are used as test specimens.

5.2 Mandatory and optional characteristics and their measurement methods

The characteristics of air filter media containing nanofibres listed in Table 1 shall be measured. The relevant measurement methods listed in Table 1 should be taken for the determination of the individual characteristics. The other listed measurement methods can be also used. The characteristic measurements listed in Table 1 shall be done on a nanofibre layer deposited on the substrate and reported in the example report format shown in Annex B.

Table 1 — Mandatory characteristics to be measured and their measurement method(s)

Characteristics	Relevant measurement method(s)	Other measurement method(s)
Fibre diameter	SEM or FESEM	TEM
Morphology	SEM or FESEM	TEM, AFM or STM

The optional characteristics of air filter media containing nanofibres listed in Table 2 should be measured. The relevant measurement methods listed in Table 2 should be taken for determination of the individual characteristics. The other measurement methods listed in Table 2 can be also used. Measurement of the characteristics listed in Table 2 should be done for air filter media with nanofibres.

Table 2 — Optional characteristics to be measured and their measurement method(s)

Characteristics	Relevant measurement method(s)	Other measurement methods
Specific surface area	Gas adsorption method	—
Chemical composition content	FTIR spectroscopy and/or UV-Vis spectrophotometry	Raman spectroscopy, nuclear magnetic resonance, energy dispersive X-ray spectroscopy, gas chromatography, high performance liquid chromatography
Thermal stability	TGA	—
Crystalline structure	XRD	TEM or SAED
Crystallinity	XRD	DSC
Mean crystallite size	XRD	SEM or TEM