INTERNATIONAL STANDARD

ISO 23706

First edition
2020-08

Plastics — Determination of apparent activation energies of property changes in standard weathering test methods

Reference number
ISO 23706:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

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

Temperature is an important influencing factor on correlation and acceleration in lightfastness and weathering testing. This is acknowledged in international general weathering standards like ISO 4892-1 or ISO 16474-1.

The Arrhenius concept describes the influence of temperature on the reaction rate of chemical reaction. This model is also used (with limitations) to describe the reaction rate of photochemical/weathering reactions. Several assumptions and limitations should be taken into account; the Arrhenius concept might not be sufficient to describe complex degradation behaviours. However, this basic approach might help to better understand the influence of temperature on weathering degradation of polymeric materials.

An important material specific property to describe the temperature influence on degradation reactions is the activation energy E_a, which describes the required energy barrier for a chemical reaction to occur. E_a is only valid for a specific material and a specific degradation pathway. In weathering, this degradation pathway is usually attributed to a specific property change.

The Arrhenius principle is applied to determine the temperature dependency of the thermal degradation of polymers. The thermal activation energy can be calculated based on ISO 11358-2. There is no such standard to determine the activation barrier for weathering or photo-chemical degradation of polymers.

Limited information is available on the activation energies of photochemical degradation/weathering reactions. To determine activation energies, weathering experiments at least at two different temperatures are required. Due to this high effort, available activation energies are often calculated based on unsuitable weathering experiments (for example based on outdoor weathering and accelerated weathering).

There are some basic test requirements which help to increase the significance of the Arrhenius concept and the determination of the activation energy in accelerated weathering. These requirements are described in this document.

NOTE 1 Different property changes, for example yellowing and surface cracking of one material can have different activation energies.

NOTE 2 In this approach, the activation energy is considered as temperature independent for the selected temperature range.

The determination of activation energies of photo-chemical degradation processes allows including the temperature into the evaluation and correlation of different weathering experiments as quantitative factor. Knowing the activation energy improves the reliability and predictive value of artificial weathering.

NOTE 3 The use of the Arrhenius concept in artificial weathering simplifies complex chemical degradation processes and is therefore, in this context, a limited model to estimate the temperature dependency in weathering. However, by following some basic experimental preconditions, the relevance of the estimates can be increased.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent.

ISO takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured ISO that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from the patent database available at www.iso.org/patents.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those in the patent database. ISO shall not be held responsible for identifying any or all such patent rights.

Plastics — Determination of apparent activation energies of property changes in standard weathering test methods

1 Scope

This document describes a test method to determine the activation energy (E_a) of photochemical degradation reactions in accelerated weathering tests according to the Arrhenius model in the most comprehensive manner.

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 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to glass-filtered solar radiation, natural weathering or laboratory radiation sources*

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

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

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

ISO 10640, *Plastics — Methodology for assessing polymer photoageing by FTIR and UV/visible spectroscopy*

3 Terms, definitions and abbreviated terms

3.1 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/

3.1.1
activation energy
E_a
energy, above that of the ground state, which is be added to an atomic or a molecular system to allow a particular process to take place

Note 1 to entry: It is expressed in $J \cdot mol^{-1}$.

Note 2 to entry: The activation energy, E_a, is derived from the Arrhenius concept (see Annex A).

3.1.2
effective irradiance
E_{eff}
spectral irradiance triggering the relevant photo-degradation processes for the reactions under consideration

$$E_{eff} = \int E_\lambda \cdot s_x(\lambda)\, d\lambda$$