



BSI Standards Publication

Fine bubble technology — Agricultural applications

Part 3: Guidelines for the minimum viable number concentration of ultrafine bubbles for promoting the germination of barley seeds

National foreword

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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Fine bubble technology — Agricultural applications —

Part 3: Guidelines for the minimum viable number concentration of ultrafine bubbles for promoting the germination of barley seeds

Technologie des fines bulles — Applications agricoles —

*Partie 3: Lignes directrices relatives à la concentration minimale en
nombre viable de bulles ultrafines pour favoriser la germination des
graines d'orge*



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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).

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This document was prepared by Technical Committee ISO/TC 281 *Fine bubble technology*.

A list of all parts in the ISO 23016 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

The market for technologies using fine bubbles have been rapidly growing in many applications throughout the industrial, domestic and academic sectors. Most notably, the applications of ultrafine bubble (UFB) technology to the agricultural area are drawing very high interest as they are thought to be part of the key technologies improving the productivity and efficiency of agriculture. Consequently, this contributes to the promotion of the United Nations Sustainable Development Goals (SDGs) in terms of providing sufficient food and maintaining water resources on land, for example.

As part of the strategy for standardizing the agricultural applications of fine bubbles, ISO 23016-2 was published, describing the test method for promoting barley seed germination by application of a UFB water generation system. Although UFB number concentration is closely related to the promotion of barley seed germination, the effects of concentration were not specified in it.

For the practical application of UFB technology to seed germination, it is important to provide data specifying the minimum number concentration of UFB necessary for promoting seed germination. This data provides useful information to users in their selection of an appropriate UFB generation system.

This document describes the collected data indicating the experimental observations between various number concentrations of UFB and their promotion effects on barley seed germination.

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Fine bubble technology — Agricultural applications —

Part 3:

Guidelines for the minimum viable number concentration of ultrafine bubbles for promoting the germination of barley seeds

1 Scope

This document demonstrates guidelines for promoting the germination of barley seeds with a lower number concentration of ultrafine bubbles (UFB). This is achieved by taking the data concerning the germination ratio of barley seeds conforming to ISO 23016-2 as a starting point and then evaluating the minimum number concentration range of ultrafine bubble water necessary for promoting the effect on germination of barely seeds by changing germination time.

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 23016-2, *Fine bubble technology — Agricultural applications — Part 2: Test method for evaluating the promotion of the germination of barley seeds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23016-2 and the following 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

median germination period

T_{50}

time where the inferred germination ratio marks 50 % of the maximum germination ratio

Note 1 to entry: See Reference [1].

3.2

storage period

time length when barley seeds are stored under 20 °C

3.3

dormancy

failure of an intact viable seed to complete germination under favourable conditions

Note 1 to entry: The related term 'dormancy breaking' describes the breaking of dormancy. See Reference [2].

4 Test subjects

The items subject to the test are air containing UFB water stored in bottles or other containers for preservation and transport, and the UFB generating system used to generate the UFB water. UFB water is generated by supplying raw water to the UFB generating system. Distilled water with a quality of A2¹⁾ or greater is used as raw water according to ISO 23016-2.

The size, quantity and concentration of UFB in UFB water are measured and an example of measured data is given in [Annex A](#).

5 Judgement of significant difference in T_{50}

After determining the correlation curve shown in ISO 23016-2:2019, Formula (2), the sum squared of residual (SSR) and standard error (SE) around the time T_{50} are calculated. From this curve, the 95 % confidence interval of T_{50} is determined.

6 Seeds and measurement device

6.1 Seeds for germination test

Barley seeds stored longer than the period of dormancy breaking were used as the seeds for the germination test. Barley seeds are not obtained from a specific location, but can be obtained anywhere. It was not necessary for the seeds to be rinsed in water for use; the test was initiated using the dry seeds as supplied. The germination test was conducted at the constant temperature of 25 °C.

6.2 Measurement device for UFB size and concentration

The air containing UFB water was generated using the pressure dissolution system with the pressure just after the pressurizing pump at around 700 kPa and around 300 kPa at the saturator. These samples had their size and concentration measured using a particle tracking analysis instrument (see ISO 19430). The instrument used was a Nano Sight (Malvern Panalytical, UK)²⁾, allowing a measuring range from 50 to 1 000 nm. The wavelength of laser light source was 635 nm, the power was 40 mW, and a camera with black and white charge coupled device (CCD) was used in conjunction with analysis software of NTA 3.1 Build 3.1.46. Preset parameters are given in [Annex A](#). The measuring temperature was at a room temperature of around 22 °C.

6.3 Examination range of UFB number concentration

As the UFB generation system given in ISO 23016-2 stably generates UFB in the number concentration ranges from 10⁷/ml, 10⁸/ml and greater, the promotion effect in the lower region of number concentration of UFB was examined from between 10⁷/ml to 10⁸/ml. The air UFB number concentration in this range is known to be within the range able to be measured by the commercially available device mentioned in [6.2](#).

7 Measurement data

7.1 Necessary storage period of barley seeds longer than that of dormancy breaking

As barley plants grown under cool temperatures produce highly dormant seeds, extended periods of after-ripening are required to break dormancy. For example, storage for 3 to 4 months is required to allow dormancy to decay[[3](#)]. It is hoped that the barley seeds to be used are stored longer than the

1) Electrical conductivity 0,1 mS/S (25 °C), total organic carbon (TOC) 0,5 mg-C/l or less, zinc 0,5 µg-Zn/l or less, silica 50 µg-SiO₂/l or less, chloride ions µg-Cl⁻/l, sulphide ions µg-SO₄²⁻/l.

2) "Nano Sight" is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.