**Instrumental assessment of halitosis for the general dental practitioner**

For figures, tables and references we refer the reader to the original paper.

Introduction

Halitosis is an unpleasant, offensive odour emanating from the oral cavity (Tonzetich and Ng [1976](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib43), Tonzetich [1977](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib42)). In the vast majority of patients (90%), the cause can be localized in the wet and warm oral cavity (Quirynen *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib25), Seemann *et al* [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib31)). In this case the term oral malodour or oral halitosis applies. It is the result of the microbial degradation by anaerobic bacteria of proteins present in saliva, food debris, gingival crevicular fluid, interdental plaque, shed epithelial cells, postnasal drip and blood. Thereby a range of volatiles are produced, of which the volatile sulphur compounds (VSCs) are the most studied (Tonzetich [1971](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib41), [1977](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib42), Yaegaki and Sanada [1992a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib53)). For a minority of the patients (10%), extra-oral causes can be identified, including ear-nose-throat pathologies, systemic diseases (e.g. diabetes or kidney diseases), metabolic or hormonal changes, hepatic or renal insufficiency, bronchial and pulmonary diseases (Quirynen *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib25), Seemann *et al* [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib31)). It is however important to realize that multiple causes may be present, and in the course of time the etiology may even shift.

A special situation arises when an obvious breath malodour cannot objectively be perceived by others, but the patient is convinced that he/she suffers from it. This 'imaginary halitosis' also called pseudo-halitosis, represents between 15% and 25% of the patients attending bad breath clinics (Quirynen *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib25), Seemann *et al* [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib31)). If after treatment of either genuine halitosis or diagnosis of pseudo-halitosis the patient still believes that bad breath is present, the term 'halitophobia' applies (Yaegaki and Coil [2000a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib51), [2000b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib52)).

At the moment, there are no fixed protocols for the diagnosis of halitosis. Experts agree that a bad breath consultation should include a thorough anamnesis about the breath malodour, eating habits, medical and dental history. Also the oropharyngeal area should be examined in detail with emphasis on the tonsils, pharynx, teeth, periodontium and the tongue, and the breath odour should be evaluated. However, there is no consensus about how to assess bad breath. An organoleptic evaluation that renders organoleptic scores (OLS) is still seen as the reference method (Greenman and Rosenberg [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib11)).

Today, several tools to detect compounds related to halitosis are on the market. Some are able to analyse compounds in breath (OralChroma™, Halimeter®, Breathtron®), others analyse compounds in saliva (BANA test, ninhydrin method, ...). For general dental practitioners who want to set up a halitosis consultation, there are so many devices on the market that they often cannot 'see the wood for the trees'.

This conference paper summarizes and compares the available information on most discussed tools used for the assessment of halitosis, to compare their respective advantages and disadvantages and provide guidance for the use by general dental practitioners.

1. Organoleptic scoring

1.1. Technique

Several techniques are described for an organoleptic assessment. On one hand, various sampling methods are used, e.g. smelling the breath at approximately 10 cm from the mouth of the patient, the additional use of a privacy screen and the use of a sampling bag. On the other hand, there are several scoring methods. The most widely used is the six-point '0–5' scale, also referred to as the 'Rosenberg scale' (Rosenberg and McCulloch [1992](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib28)).

1.2. Advantages and disadvantages

Organoleptic assessment is easy to perform and it resembles most closely the daily situation of the patient. In addition, the nose can distinguish 10,000 odours (Hatt [2004](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib14)), much more than any device on the market. Although the organoleptic assessment is easy and cheap, and a good reflection of the everyday situation (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)), this method has also some important disadvantages. Moreover, there is a quick habituation of the human nose. However, the most important disadvantage of the method is the reliability and reproducibility, both inter- and intra-examiner (see tables [1](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t1) and [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t2)). For both the correlations are relatively poor. Even with a panel of trained judges, the inter-examiner correlation remains low. Because of the subjectivity of this assessment (Rosenberg *et al* [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27), [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)), it is not always accepted by the patients, certainly the ones with imaginary halitosis.

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| Table 1. Inter-examiner correlation for organoleptic scoring (OLS) (only studies with more than 50 patients have been included),\* = probability <0.05. |  |  |  |  |  |  |

Table 2. Intra-examiner correlation for organoleptic scoring (OLS),§ = not mentioned if statistically significant.

2. Instrumental assessment

A wide variety of gases can contribute to bad breath, e.g. indole, skatole, putrescine and cadaverine. But most researchers suggest that mainly VSCs, such as hydrogen sulphide, methyl mercaptan and dimethylsulfide are crucial (because of volatility, odour power and odour threshold) and therefore highly associated with bad breath (Greenman and Rosenberg [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib11), Tonzetich [1971](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib41), [1977](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib42), Yaegaki and Sanada [1992a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib53)).

Gas chromatography, introduced by Tonzetich, is used in specialized centres for the identification of most compounds in expired air (Tonzetich [1971](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib41)). When this is coupled with a mass spectrometer, and the adequate columns and detectors are used, virtually any compound can be detected (Van den Velde *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib46), [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib47)). Moreover, it has a very high sensitivity and specificity. On the other hand gas chromatography is expensive, time consuming and requires trained staff (Furne *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib10), Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33), Tonzetich and Ng [1976](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib43), Tonzetich [1977](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib42)), which makes the technique not suitable for the general dental practitioner. To date, there are several more simple and portable devices on the market, which can objectively and quantitatively measure some gaseous components, especially the VSCs (table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3)).

Table 3. Advantages and disadvantages of chair-side devices for the detection of volatile sulphur compounds.

2.1. OralChroma™ (CHM-1)

2.1.1. Device

For chair-side use, a small, portable 'gas chromatograph', the OralChroma™ (figure [1](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f1)(*a*)), was introduced in 2003 (Hanada *et al* [2003](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib13)). This portable device can discriminate the three most important sulphur compounds (hydrogen sulphide, methyl mercaptan and dimethyl sulphide). It is equipped with an indium oxide semiconductor gas sensor and does not need a carrier gas, like standard gas chromatographs, but uses room air as carrier for the chromatographic column. Recently a new model is introduced: OralChroma™ (CHM-2), but since only the OralChroma™ (CHM-1) is available on the European market and there is still no literature about the new model, only the OralChroma™ (CHM-1) is discussed here.

Figure 1. (*a*) The OralChroma™ (CHM-1). (*b*) Sample collection occurs by use of a disposable syringe, which has to be inserted for two thirds in the oral cavity of the patient. Then, slowly pull the plunger, push it in and pull it again to take the sample. Next, take the syringe out of the mouth. If the top is wet, wipe it with a tissue. Put a needle on it and inject in the device. (*c*) Chromatogram: the first peak indicates the level of hydrogen sulphide, the second on those of methyl mercaptan and the third those of dimethyl sulphide. The threshold levels for bad breath are: 112 ppb for hydrogen sulphide, 26 for methyl mercaptan and 8 ppb for dimethyl sulphide.

2.1.2. Technique

As seen in figure [1](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f1)(*b*) sample collection occurs via a disposable 1 ml syringe. The syringe has to be inserted for two thirds in the oral cavity of the patient and then the patient has to close the mouth for 30 s. Afterwards the sample is taken and 0.5 ml is injected in the OralChroma™ (CHM-1). The measurement will start automatically.

After 8 min, the process is completed and the concentration of the three gases will be displayed in either ng/10 ml or ppb (nmol mol–1). A software packet is available, OralChroma™ Data Manager, which collects the data from the OralChroma™ and graphically displays the sensor responses on a computer screen, via a chromatogram (see figure [1](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f1)(*c*)).

2.1.3. Correlation with organoleptic scoring

A review of the literature only identified a small number of papers analysing the correlation between the OLS and the OralChroma™ (CHM-1) measurements (table [4](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t4)). This coefficient ranges from 0.66 to 0.77.

Table 4. Correlation of the OralChroma™ (CHM-1) measurements with organoleptic scoring (OLS) (only studies with more than 50 patients have been included), \* = *p* < 0.05.

2.1.4. Advantages and disadvantages

The most important advantages and disadvantages of this device are listed in table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3). The OralChroma™ (CHM-1) produces highly objective, reproducible and reliable measurements even when extremely low gas concentrations are present. It however cannot detect other than sulphur compounds and therefore some intra-oral and extra-oral causes can be overlooked. But, in contrast to the Halimeter® and Breathtron®, certain specific sulphur gases can be distinguished. This can be helpful for a differential diagnosis. But the OralChroma™ (CHM-1) also has some important disadvantages: it is an expensive device (although less expensive than a traditional GC) and it takes some time (8 min) before the breath sample is processed. The software is not always accurate and sometimes the graphics are not clear due to a wrong assignment of the VSCs in the chromatogram (Tangerman and Winkel [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib39)).

Since room air is used as a carrier, impurities and high humidity of the ambient air may influence the stability of the sensor, and sometimes problems arise on too warm days. The apparatus needs calibration and the sensor and column need replacement every two years.

2.2. Halimeter®

2.2.1. Device

The Halimeter® (Interscan, Chatsworth, CA) (figure [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f2)(*a*)) is a portable sulphur monitor developed by Rosenberg and co-workers in 1991 (Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). This device uses a voltametric sensor that generates a signal when exposed to sulphur-containing gases. Electrochemical reactions with the sulphur-containing compounds generate an electric current, which is directly proportional to the levels of VSCs (Kozlovsky *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib18), Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). It measures the global concentration of sulphur compounds, but without discriminating them. The Halimeter® has a high sensitivity for hydrogen sulphide, but a lower sensitivity for methyl mercaptan (Furne *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib10), Vandekerckhove *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50)).

Figure 2. (*a*) The Halimeter®. (*b*) Use of the Halimeter®: sample collection is done by inserting a drinking straw, fixed on the flexible tube of the device, into the subject's mouth above the posterior part of the tongue dorsum, not touching the oral mucosa nor the tongue. (*c*) Haligram, the black arrows indicate the two volatile sulphur compound peaks measured from two consecutive samples. The highest peak is 489 ppb.

[Study image](http://cdn.iopscience.com/images/1752-7163/8/1/017103/Full/jbr490252f2_online.jpg)

2.2.2. Technique

Measurements are performed by inserting a drinking straw (figure [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f2)(*b*)), fixed on the flexible tube of the device, into the subject's mouth above the posterior part of the tongue dorsum, not touching the oral mucosa nor the tongue (Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). To allow an increase in concentration of VSCs, the patients have to keep their mouth closed for 2 or 3 min prior to the first sample. During the sampling, the subjects have to keep the mouth slightly open and are not allowed to breathe via the mouth.

Using a recorder or specific software, a graphic of the response in function of the time, a 'haligram', can be obtained immediately (figure [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f2)(*c*)).

A wide range of threshold limits has been proposed as indicative of halitosis. Yaegaki and Sanada recommended a value of 75 ppb as the limit for social acceptance (Yaegaki and Sanada [1992b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib54)). The manufacturer proposes 150 ppb. Previous studies from our group showed that a reduction in this threshold to 107 ppb improves the sensitivity of the device without detriment of their specificity (Vandekerckhove *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50)).

2.2.3. Correlation with organoleptic scoring

A review of the literature identified several papers reporting the correlation between the OLS and the Halimeter® measurements (table [5](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t5)). This coefficient ranges from 0.37 to 0.82.

Table 5. Correlation of the Halimeter® measurement with organoleptic scoring (OLS) (only studies with more than 50 patients have been included),\* = probability <0.05.

2.2.4. Advantages and disadvantages

The most important advantages and disadvantages of the Halimeter® are listed in table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3). The Halimeter® is an easy-to-use chair-side test for which no trained personnel is needed. The results are immediately presented and the device is relatively inexpensive. Patients are usually less embarrassed for this examination than for the organoleptic assessment. Besides, the Halimeter® readings are more reproducible than organoleptic assessments, which make the follow-up of the patients easier. The most important drawback of the device is that it only detects sulphur compounds. Moreover, the absence of VSCs does not prove that breath odour is absent. The device also cannot discriminate among the different sulphur compounds. The sensitivity for methyl mercaptan is five times lower than for hydrogen sulphide, and the device is almost insensitive to dimethyl sulphide (Furne *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib10)). Ethanol and other compounds can disturb the measurements (Baharvand *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib3), Murata *et al* [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib22), Rosenberg *et al* [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27), van Steenberghe *et al* [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib48)). Finally the Halimeter® needs to be calibrated at a regular base and the sensor needs to be replaced at least every two years depending on how frequently the device is being used.

2.3. Breathtron®

2.3.1. Device

In 1996, another portable sulphide monitor, the Breathtron®, was introduced (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)). This sulphide monitor has a semiconductor sensor based on a thick zinc oxide membrane, which has a high specificity for VSCs (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33), Tanda *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib38)). Just as the Halimeter®, it can only detect the total amount of VSCs. An apparent difference with the Halimeter® is that the Breathtron® has an acidic silica-gel filter inside the disposable mouth piece (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33), Tanda *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib38)). This filter can trap other volatile organic compounds, such as ketones and alcohols which do lead to incorrect results with the Halimeter® (which are for example present in mouthwashes) (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)).

2.3.2. Technique

Measurements are done by inserting a disposable mouthpiece directly into the oral cavity. Then the subject has to close the mouth tightly and breathe through the nose while measuring.

The threshold proposed by the manufacture for having oral malodour is >250 ppb. However, Ueno and co-workers showed that this malodour threshold is too low, advising a threshold between 350 and 400 ppb (Ueno *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib45)).

2.3.3. Correlation with organoleptic scoring

A review of the literature only identified a small number of papers analysing the correlation between the OLS and the Breathtron® measurements (table [6](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t6)). This coefficient ranges from 0.61 to 0.82.

Table 6. Correlation of the Breathtron® measurement with organoleptic scoring (OLS) (only studies with more than 50 patients have been included), \* = probability <0.05.

2.3.4. Advantages and disadvantages

The most important advantages and disadvantages of the Breathtron® are listed in table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3). The Breathtron® is an easy-to-use chair-side test and produces highly objective, reproducible and reliable measurements. The results are immediately presented and the device is relatively inexpensive. Patients are usually less embarrassed for this examination than for the organoleptic assessment. Just as the OralChroma™ (CHM-1) and Halimeter®, this device measures only sulphur compounds, so some causes can be overlooked. Additionally no information could be found on an eventual relative sensitivity for different VSCs.

3. Salivary tests

Currently, several salivary tests, based on the detection of specific bacteria associated with bad breath or their metabolites, are available. The correlation between these tests and OLS is shown in table [7](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t7) and ranged from 0.02 to 0.60.

Table 7. Correlation of salivary tests and organoleptic scoring (OLS), (only studies with more than 50 patients have been included), \* = probability <0.05.

3.1. BANA test

The 'BANA test' is based on the ability of some bacterial species to hydrolyze a synthetic trypsin substrate (N-benzoyl-DL-arginine-2-naphthylamine) (Loesche *et al* [1990](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib20)). Especially *P. gingivalis*, *B. forsythus* and *T. denticola* possess this enzyme, whereas this is not found in over 60 other oral microorganisms. These organisms hydrolyze the synthetic peptide benzoyl-DL-arginine-naphtylamide (BANA), with witch the BANA strip is impregnated, turning this strip blue (Kozlovsky *et al* [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib19), Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35)). However, these microorganisms are mainly linked to periodontitis and not all people who have periodontal diseases suffer from bad breath and vice versa.

3.2. Amine detection tests

The gases which are responsible for bad breath are the result of the microbial degradation of primarily proteins. During this process, proteins are hydrolyzed into amino acids, which can be further metabolized to amines and polyamines. The ninhydrin test is a fast and cheap method that can be used for the detection of amino acids and low-molecular-weight amines (Iwanicka-Grzegorek *et al* [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib16)).

Recently, a new chair-side enzymatic test appeared to offer the possibility of assessing amines in saliva by means of a simple colour scale (Dadamio *et al* [2011](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib7)). In a first clinical study the test was capable of distinguishing between volunteers with and without malodour and with the organoleptic rating (Dadamio *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib8)).

3.3. Beta-galactosidase test

Oral malodour is the result of microbial degradation of proteins. An important source for this are glycoproteins whose carbohydrate side-chains must be removed to make them available for proteolytic degradation. β-galactosidase is one of the main responsible enzymes for the removal of these carbohydrate side-chains (Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35)). It has been demonstrated that β-galactosidase activity, which can be quantified by the use of chromogenic substrates, is correlated with malodor measurements (Petrini *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib24), Rosenberg *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib26), Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35), Yoneda *et al* [2010](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib55)). Recently it has been show that the use of spectrophotometric assessment of β-galactosidases increases the specificity, but not the sensitivity, of this test when compared with the colorimetric method (Petrini *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib24)).

4. Discussion

The OralChroma™ (CHM-1), Halimeter® and Breathron seem suitable devices for a halitosis consultation together with an organoleptic rating. These devices are easy to use, objective and their measurements are reproducible. A disadvantage of all three devices is that they can only detect sulphur gases and no other volatile components. Given the fact that besides volatile sulphide-containing compounds also other odorants can contribute to halitosis, it is possible that a high organoleptic rating is not always accompanied by a correspondingly high sulphide monitor measurement. The Halimeter® and Breathron have a faster turn-on and turn-around time and are cheaper than the OralChroma™ (CHM-1). The last, however, has the advantage that three different sulphur gases can be distinguished, which can be helpful for a differential diagnosis. A high concentration of methyl mercaptan compared to hydrogen sulphide could indicate for example periodontitis (Yaegaki and Sanada [1992a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib53)). If only hydrogen sulphide is increased, there might be a problem with oral hygiene. Dimethyl sulphide can be present in case of some extra-oral causes (Tangerman and Winkel [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib39)). A major drawback of the OralChroma™ (CHM-1), is that it always has to be used with the accompanying software since sometimes the concentrations given on the display are incorrect, due to a wrong assignment of the VSCs peaks (Tangerman and Winkel [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)). These incorrect assignments can only be evaluated on the chromatogram from the computer. Tangerman and Winkel ([2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)) proposed a method for manual recalculation of the peaks (Tangerman and Winkel [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)). However, in a private practice this is cumbersome and time consuming.

A review of the available literature shows that these machines have a medium correlation with the reference standard, the organoleptic scoring (see tables [4](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t4), [5](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t5) and [6](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t6)). However, when looking at inter-examiner agreement for organoleptic scoring, corresponding correlation coefficients are obtained (Amano *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib1), Baharvand *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib3), Hunter *et al* [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib15), Rosenberg *et al* [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27), [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29), Sterer and Rosenberg [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib36), Tanaka *et al* [2003](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib37)). An explanation can be that the samples used for organoleptic scoring are not exactly the same as the ones used for the sulphide monitors. Firstly, they are mostly taken at another time point and consecutive samples can differ in composition and intensity (Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32)). The sulphide monitors sample directly from the oral cavity, whereas the air rated by the malodour judges is expelled from the oral cavity and presumably mixed/diluted with lung and environmental air (Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). The highest correlations between the devices and organoleptic scoring were seen when specific sampling methods were used. Shimura and co-workers (1996, 1997) used a polytetrafluoroethylene bag into which the patient exhaled (Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32), [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)). This sample was used for both analysis with the Breathtron® and organoleptic assessment. Kim and co-workers also used a specific method of organoleptic assessment, the Kim method (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)). They sampled mouth air from the patient with a gastight syringe in underpressure and a small tube inserted in the mouth. Breath is collected into the syringe by opening the valve after closing the mouth for 3 min (see figure [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f3)(*a*)). During sampling, the subject is instructed to hold the breath to avoid lung air interruption. A disposable paper cup is used to perform the organoleptic test (see figure [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f3)(*b*)). The examiner places the cup over his nose and expels the sample through a plastic tube into the cup. The organoleptic value obtained by this method is higher because of a more concentrated sample.

Figure 3. (*a*) Collecting a sample for organoleptic assessment as described by Kim and co-workers (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)). (*b*) Smelling a pure sample (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)).

[Study image](http://cdn.iopscience.com/images/1752-7163/8/1/017103/Full/jbr490252f3_online.jpg)

Keeping all these remarks in mind, the OralChroma™ (CHM-1), Halimeter® and Breathtron® measurements show reasonable correlations with the OLS. In addition, because of the high specificity of sulphide monitors, they have an important role in proving the absence of halitosis in case of pseudo-halitosis and halitophobia (Vandekerckhove *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50)). In particular, patients who have doubts about their breath odour often see OLS 'as too subjective'. Also, for patient motivation, evaluation and follow-up, these devices proved their importance (Sanz *et al* [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib30), Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32)). For example, it is very informative and motivating for the patient when haligrams/chromatograms, before and after tongue scraping, are compared. Chair-side saliva tests are suggested as an alternative and cheap tool for the general dental practitioner to diagnose halitosis. The correlations with the organoleptic tests, are however lower than the ones obtained with the sulphide monitors. Moreover, the BANA test is made for detecting *P. gingivalis*, *B. forsythus* and *T. denticola.* These microorganisms are mainly linked to periodontitis and not all people who have periodontal diseases suffer from bad breath. The enzymatic test described by Dadamio and co-workers is not yet available on the market, and probably needs extra fine-tuning (Dadamio *et al* [2011](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib7), [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib8)).

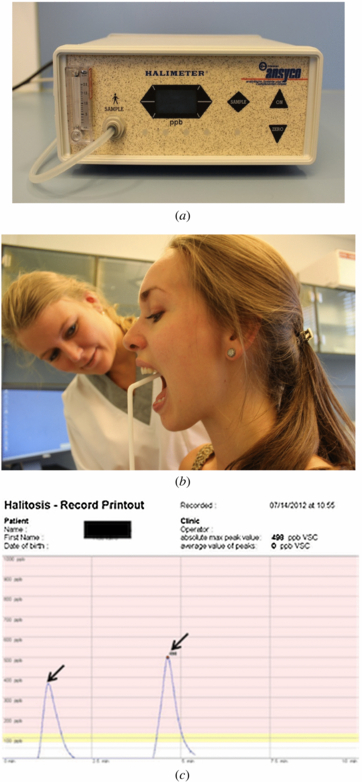
5. Conclusion

The Halimeter® and Breathtron® seem the most appropriate devices for the general dental practitioner who wants to set-up a halitosis consultation. On the other hand, the OralChroma™ (CHM-1), because of its capacity to distinguish between different sulphur compounds, appears more suitable in a research environment. A low-cost chair-side salivary test would of course be ideal for the diagnosis of halitosis. However, to date, the available products do not fulfil the basic requirements, or are only in a pre-commercial phase.

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The authors declare that they have no conflict of interest.



Reset

**Figure 2.** (*a*) The Halimeter®. (*b*) Use of the Halimeter®: sample collection is done by inserting a drinking straw, fixed on the flexible tube of the device, into the subject's mouth above the posterior part of the tongue dorsum, not touching the oral mucosa nor the tongue. (*c*) Haligram, the black arrows indicate the two volatile sulphur compound peaks measured from two consecutive samples. The highest peak is 489 ppb.

[Export PowerPoint slide](http://iopscience.iop.org/1752-7163/8/1/017103/powerpoint/figure/jbr490252f2)

Download figure: [Standard (233 KB)](http://iopscience.iop.org/1752-7163/8/1/017103/downloadFigure/figure/jbr490252f2)[High-resolution (418 KB)](http://iopscience.iop.org/1752-7163/8/1/017103/downloadHRFigure/figure/jbr490252f2)

[Study image](http://cdn.iopscience.com/images/1752-7163/8/1/017103/Full/jbr490252f2_online.jpg)

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-2-1)

**2.2.2. Technique**

Measurements are performed by inserting a drinking straw (figure [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f2)(*b*)), fixed on the flexible tube of the device, into the subject's mouth above the posterior part of the tongue dorsum, not touching the oral mucosa nor the tongue (Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). To allow an increase in concentration of VSCs, the patients have to keep their mouth closed for 2 or 3 min prior to the first sample. During the sampling, the subjects have to keep the mouth slightly open and are not allowed to breathe via the mouth.

Using a recorder or specific software, a graphic of the response in function of the time, a 'haligram', can be obtained immediately (figure [2](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f2)(*c*)).

A wide range of threshold limits has been proposed as indicative of halitosis. Yaegaki and Sanada recommended a value of 75 ppb as the limit for social acceptance (Yaegaki and Sanada [1992b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib54)). The manufacturer proposes 150 ppb. Previous studies from our group showed that a reduction in this threshold to 107 ppb improves the sensitivity of the device without detriment of their specificity (Vandekerckhove *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50)).

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-2-2)

**2.2.3. Correlation with organoleptic scoring**

A review of the literature identified several papers reporting the correlation between the OLS and the Halimeter® measurements (table [5](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t5)). This coefficient ranges from 0.37 to 0.82.

**Table 5.** Correlation of the Halimeter® measurement with organoleptic scoring (OLS) (only studies with more than 50 patients have been included),\* = probability <0.05.

| Reference | Year | Subjects | Judges *n* | OLS scale | Correlation coefficient |
| --- | --- | --- | --- | --- | --- |
| Rosenberg *et al* | [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27) | 75 | 7 | 0–5 | 0.60\* |
| Kozlovsky *et al* | [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib19) | 53 | 1 | 10 cm scale | 0.47\* |
| De Boever *et al* | [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib9) | 55 | 1 | 0–5 | 0.63\* |
| Bosy *et al* | [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib6) | 127 | 2 | 0–5 | 0.53\* |
| Oho *et al* | [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib23) | 155 | 3 | 0–3 | 0.66\* |
| Morita and Wang | [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib21) | 81 | 1 | 0–5 | 0.73\* |
| Sterer *et al* | [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35) | 64 | 2 | 0–5 | 0.37–0.46\* |
| Iwanicka-Grzegorek *et al* | [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib16) | 84 | 3 | 0–5 | 0.78\* |
| Tangerman & Winkel | [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib39) | 58 | 1 | 0–5 | 0.50\* |
| Baharvand *et al* | [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib3) | 77 | 3 | 0–3 | 0.49\* |
| Quirynen *et al* | [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib25) | 2000 | 1 | 0–5 | 0.51\* |
| Kim *et al* | [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17) | 52 | 1 | 0–4 | 0.82\* |
| Vandekerckhove *et al* | [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50) | 280 | 1 | 0–5 | 0.74\* |
| Bornstein *et al* | [2009a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib4) | 419 | 1 | 0–5 | 0.43\* |
| Van Tornout *et al* | [2013](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib49) | 96 | 1 | 0–5 | 0.62\* |
| Apatzidou *et al* | [2013](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib2) | 78 | 2 | 0–5 | 0.48\* |

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-2-3)

**2.2.4. Advantages and disadvantages**

The most important advantages and disadvantages of the Halimeter® are listed in table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3). The Halimeter® is an easy-to-use chair-side test for which no trained personnel is needed. The results are immediately presented and the device is relatively inexpensive. Patients are usually less embarrassed for this examination than for the organoleptic assessment. Besides, the Halimeter® readings are more reproducible than organoleptic assessments, which make the follow-up of the patients easier. The most important drawback of the device is that it only detects sulphur compounds. Moreover, the absence of VSCs does not prove that breath odour is absent. The device also cannot discriminate among the different sulphur compounds. The sensitivity for methyl mercaptan is five times lower than for hydrogen sulphide, and the device is almost insensitive to dimethyl sulphide (Furne *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib10)). Ethanol and other compounds can disturb the measurements (Baharvand *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib3), Murata *et al* [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib22), Rosenberg *et al* [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27), van Steenberghe *et al* [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib48)). Finally the Halimeter® needs to be calibrated at a regular base and the sensor needs to be replaced at least every two years depending on how frequently the device is being used.

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-2-4)

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-2)

**2.3. Breathtron®**

**2.3.1. Device**

In 1996, another portable sulphide monitor, the Breathtron®, was introduced (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)). This sulphide monitor has a semiconductor sensor based on a thick zinc oxide membrane, which has a high specificity for VSCs (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33), Tanda *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib38)). Just as the Halimeter®, it can only detect the total amount of VSCs. An apparent difference with the Halimeter® is that the Breathtron® has an acidic silica-gel filter inside the disposable mouth piece (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33), Tanda *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib38)). This filter can trap other volatile organic compounds, such as ketones and alcohols which do lead to incorrect results with the Halimeter® (which are for example present in mouthwashes) (Shimura *et al* [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)).

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-3-1)

**2.3.2. Technique**

Measurements are done by inserting a disposable mouthpiece directly into the oral cavity. Then the subject has to close the mouth tightly and breathe through the nose while measuring.

The threshold proposed by the manufacture for having oral malodour is >250 ppb. However, Ueno and co-workers showed that this malodour threshold is too low, advising a threshold between 350 and 400 ppb (Ueno *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib45)).

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-3-2)

**2.3.3. Correlation with organoleptic scoring**

A review of the literature only identified a small number of papers analysing the correlation between the OLS and the Breathtron® measurements (table [6](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t6)). This coefficient ranges from 0.61 to 0.82.

**Table 6.** Correlation of the Breathtron® measurement with organoleptic scoring (OLS) (only studies with more than 50 patients have been included), \* = probability <0.05.

| Reference | Year | Subjects *n* > 50 | Judges *n* | OLS scale | Correlation coefficient |
| --- | --- | --- | --- | --- | --- |
| Shimura *et al* | [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32) | 94 | 2 | 0–4 | 0.82\* |
| Sopapornamorn *et al* | [2006](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib34) | 260 | 2 | 0–5 | 0.64\* |
| Ueno *et al* | [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib45) | 475 | 2 | 0–5 | 0.61\* |

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-3-3)

**2.3.4. Advantages and disadvantages**

The most important advantages and disadvantages of the Breathtron® are listed in table [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t3). The Breathtron® is an easy-to-use chair-side test and produces highly objective, reproducible and reliable measurements. The results are immediately presented and the device is relatively inexpensive. Patients are usually less embarrassed for this examination than for the organoleptic assessment. Just as the OralChroma™ (CHM-1) and Halimeter®, this device measures only sulphur compounds, so some causes can be overlooked. Additionally no information could be found on an eventual relative sensitivity for different VSCs.

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-3-4)

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2-3)

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s2)

**3. Salivary tests**

Currently, several salivary tests, based on the detection of specific bacteria associated with bad breath or their metabolites, are available. The correlation between these tests and OLS is shown in table [7](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t7) and ranged from 0.02 to 0.60.

**Table 7.** Correlation of salivary tests and organoleptic scoring (OLS), (only studies with more than 50 patients have been included), \* = probability <0.05.

| Reference | Year | Test | Subjects *n* > 50 | Judges *n* | OLS scale | Correlation coefficient |
| --- | --- | --- | --- | --- | --- | --- |
| Kozlovsky *et al* | [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib19) | BANA method | 52 | 1 | 10 cm scale | 0.40\* |
| Morita and Wang | [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib21) | BANA method | 81 | 1 | 0–5 | 0.02–0.27\* |
| Sterer *et al* | [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35) | β-galactosidase | 64 | 2 | 0–5 | 0.38–0.47\* |
| Rosenberg *et al* | [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib26) | β-galactosidase | 88 | 1 | 0–5 | 0.59\* |
| Petrini *et al* | [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib24) | β-galactosidase | 94 | 2 | 0–5 | 0.73–0.78\* |
| Dadamio *et al* | [2011](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib7) | Enzymatic test for amines in saliva | 50 | 1 | 0–5 | 0.49\* |
| Dadamio *et al* | [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib8) | Enzymatic test for amines in saliva | 100 | 1 | 0–5 | 0.58\* |

**3.1. BANA test**

The 'BANA test' is based on the ability of some bacterial species to hydrolyze a synthetic trypsin substrate (N-benzoyl-DL-arginine-2-naphthylamine) (Loesche *et al* [1990](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib20)). Especially *P. gingivalis*, *B. forsythus* and *T. denticola* possess this enzyme, whereas this is not found in over 60 other oral microorganisms. These organisms hydrolyze the synthetic peptide benzoyl-DL-arginine-naphtylamide (BANA), with witch the BANA strip is impregnated, turning this strip blue (Kozlovsky *et al* [1994](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib19), Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35)). However, these microorganisms are mainly linked to periodontitis and not all people who have periodontal diseases suffer from bad breath and vice versa.

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s3-5)

**3.2. Amine detection tests**

The gases which are responsible for bad breath are the result of the microbial degradation of primarily proteins. During this process, proteins are hydrolyzed into amino acids, which can be further metabolized to amines and polyamines. The ninhydrin test is a fast and cheap method that can be used for the detection of amino acids and low-molecular-weight amines (Iwanicka-Grzegorek *et al* [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib16)).

Recently, a new chair-side enzymatic test appeared to offer the possibility of assessing amines in saliva by means of a simple colour scale (Dadamio *et al* [2011](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib7)). In a first clinical study the test was capable of distinguishing between volunteers with and without malodour and with the organoleptic rating (Dadamio *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib8)).

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s3-6)

**3.3. Beta-galactosidase test**

Oral malodour is the result of microbial degradation of proteins. An important source for this are glycoproteins whose carbohydrate side-chains must be removed to make them available for proteolytic degradation. β-galactosidase is one of the main responsible enzymes for the removal of these carbohydrate side-chains (Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35)). It has been demonstrated that β-galactosidase activity, which can be quantified by the use of chromogenic substrates, is correlated with malodor measurements (Petrini *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib24), Rosenberg *et al* [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib26), Sterer *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib35), Yoneda *et al* [2010](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib55)). Recently it has been show that the use of spectrophotometric assessment of β-galactosidases increases the specificity, but not the sensitivity, of this test when compared with the colorimetric method (Petrini *et al* [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib24)).

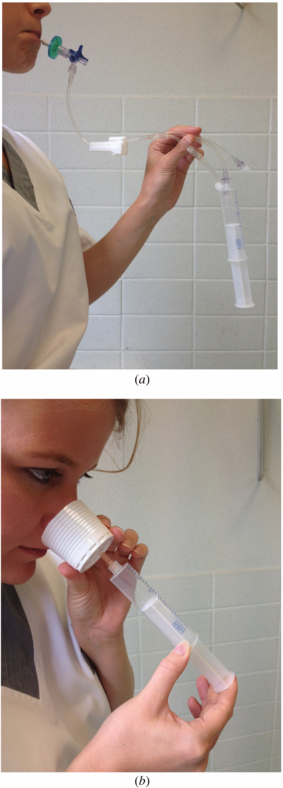
[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s3-7)

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s3)

**4. Discussion**

The OralChroma™ (CHM-1), Halimeter® and Breathron seem suitable devices for a halitosis consultation together with an organoleptic rating. These devices are easy to use, objective and their measurements are reproducible. A disadvantage of all three devices is that they can only detect sulphur gases and no other volatile components. Given the fact that besides volatile sulphide-containing compounds also other odorants can contribute to halitosis, it is possible that a high organoleptic rating is not always accompanied by a correspondingly high sulphide monitor measurement. The Halimeter® and Breathron have a faster turn-on and turn-around time and are cheaper than the OralChroma™ (CHM-1). The last, however, has the advantage that three different sulphur gases can be distinguished, which can be helpful for a differential diagnosis. A high concentration of methyl mercaptan compared to hydrogen sulphide could indicate for example periodontitis (Yaegaki and Sanada [1992a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib53)). If only hydrogen sulphide is increased, there might be a problem with oral hygiene. Dimethyl sulphide can be present in case of some extra-oral causes (Tangerman and Winkel [2007](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib39)). A major drawback of the OralChroma™ (CHM-1), is that it always has to be used with the accompanying software since sometimes the concentrations given on the display are incorrect, due to a wrong assignment of the VSCs peaks (Tangerman and Winkel [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)). These incorrect assignments can only be evaluated on the chromatogram from the computer. Tangerman and Winkel ([2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)) proposed a method for manual recalculation of the peaks (Tangerman and Winkel [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib40)). However, in a private practice this is cumbersome and time consuming.

A review of the available literature shows that these machines have a medium correlation with the reference standard, the organoleptic scoring (see tables [4](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t4), [5](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t5) and [6](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252t6)). However, when looking at inter-examiner agreement for organoleptic scoring, corresponding correlation coefficients are obtained (Amano *et al* [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib1), Baharvand *et al* [2008](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib3), Hunter *et al* [2005](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib15), Rosenberg *et al* [1991a](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib27), [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29), Sterer and Rosenberg [2002](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib36), Tanaka *et al* [2003](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib37)). An explanation can be that the samples used for organoleptic scoring are not exactly the same as the ones used for the sulphide monitors. Firstly, they are mostly taken at another time point and consecutive samples can differ in composition and intensity (Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32)). The sulphide monitors sample directly from the oral cavity, whereas the air rated by the malodour judges is expelled from the oral cavity and presumably mixed/diluted with lung and environmental air (Rosenberg *et al* [1991b](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib29)). The highest correlations between the devices and organoleptic scoring were seen when specific sampling methods were used. Shimura and co-workers (1996, 1997) used a polytetrafluoroethylene bag into which the patient exhaled (Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32), [1996](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib33)). This sample was used for both analysis with the Breathtron® and organoleptic assessment. Kim and co-workers also used a specific method of organoleptic assessment, the Kim method (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)). They sampled mouth air from the patient with a gastight syringe in underpressure and a small tube inserted in the mouth. Breath is collected into the syringe by opening the valve after closing the mouth for 3 min (see figure [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f3)(*a*)). During sampling, the subject is instructed to hold the breath to avoid lung air interruption. A disposable paper cup is used to perform the organoleptic test (see figure [3](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252f3)(*b*)). The examiner places the cup over his nose and expels the sample through a plastic tube into the cup. The organoleptic value obtained by this method is higher because of a more concentrated sample.



Reset

**Figure 3.** (*a*) Collecting a sample for organoleptic assessment as described by Kim and co-workers (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)). (*b*) Smelling a pure sample (Kim *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib17)).

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[Study image](http://cdn.iopscience.com/images/1752-7163/8/1/017103/Full/jbr490252f3_online.jpg)

Keeping all these remarks in mind, the OralChroma™ (CHM-1), Halimeter® and Breathtron® measurements show reasonable correlations with the OLS. In addition, because of the high specificity of sulphide monitors, they have an important role in proving the absence of halitosis in case of pseudo-halitosis and halitophobia (Vandekerckhove *et al* [2009](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib50)). In particular, patients who have doubts about their breath odour often see OLS 'as too subjective'. Also, for patient motivation, evaluation and follow-up, these devices proved their importance (Sanz *et al* [2001](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib30), Shimura *et al* [1997](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib32)). For example, it is very informative and motivating for the patient when haligrams/chromatograms, before and after tongue scraping, are compared. Chair-side saliva tests are suggested as an alternative and cheap tool for the general dental practitioner to diagnose halitosis. The correlations with the organoleptic tests, are however lower than the ones obtained with the sulphide monitors. Moreover, the BANA test is made for detecting *P. gingivalis*, *B. forsythus* and *T. denticola.* These microorganisms are mainly linked to periodontitis and not all people who have periodontal diseases suffer from bad breath. The enzymatic test described by Dadamio and co-workers is not yet available on the market, and probably needs extra fine-tuning (Dadamio *et al* [2011](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib7), [2012](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252bib8)).

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**5. Conclusion**

The Halimeter® and Breathtron® seem the most appropriate devices for the general dental practitioner who wants to set-up a halitosis consultation. On the other hand, the OralChroma™ (CHM-1), because of its capacity to distinguish between different sulphur compounds, appears more suitable in a research environment. A low-cost chair-side salivary test would of course be ideal for the diagnosis of halitosis. However, to date, the available products do not fulfil the basic requirements, or are only in a pre-commercial phase.

[↑ Close](http://iopscience.iop.org/1752-7163/8/1/017103/article#jbr490252s5)

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The authors declare that they have no conflict of interest.