

SN

中华人民共和国出入境检验检疫行业标准

SN/T 4675.25—2016

出口葡萄酒颜色的测定 CIE 1976 ($L^* a^* b^*$)色空间法

Determination of chromatic characteristics of wine for export based on CIELAB
color space system

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前 言

SN/T 4675《出口葡萄酒品质质量安全分析方法》共分为 30 个部分：

- SN/T 4675.1 出口葡萄酒中甘油的测定 酶法；
- SN/T 4675.2 出口葡萄酒中 2,3-丁二醇的测定 气相色谱法；
- SN/T 4675.3 出口葡萄酒中乙醇稳定碳同位素比值的测定；
- SN/T 4675.4 出口葡萄酒中乳酸的测定 酶法；
- SN/T 4675.5 出口葡萄酒中有机酸的测定 离子色谱法；
- SN/T 4675.6 出口葡萄酒中葡萄糖、果糖和蔗糖的测定；
- SN/T 4675.7 出口葡萄酒中乙醛的测定 气相色谱-质谱法；
- SN/T 4675.8 出口葡萄酒中 5-羟甲基糠醛的测定 液相色谱法；
- SN/T 4675.9 出口葡萄酒中二甘醇的测定 气相色谱-质谱法；
- SN/T 4675.10 出口葡萄酒中赭曲霉毒素 A 的测定 液相色谱-质谱/质谱法；
- SN/T 4675.11 出口葡萄酒中 7 种花色苷的测定 超高效液相色谱法；
- SN/T 4675.12 出口葡萄酒中溶菌酶的测定 液相色谱法；
- SN/T 4675.13 出口葡萄酒中 2,4,6-三氯甲苯醚残留量的测定 液相色谱-质谱/质谱；
- SN/T 4675.14 出口葡萄酒中纳他霉素的测定 液相色谱-质谱/质谱法；
- SN/T 4675.15 出口葡萄酒中水杨酸、脱氢乙酸和对氯苯甲酸的测定 液相色谱法；
- SN/T 4675.16 出口葡萄酒中富马酸的测定 液相色谱-质谱/质谱法；
- SN/T 4675.17 出口葡萄酒中丁基锡含量的测定 气相色谱-质谱/质谱法；
- SN/T 4675.18 出口葡萄酒中二硫代氨基甲酸酯 残留量的测定 顶空气相色谱法；
- SN/T 4675.19 出口葡萄酒中钠、镁、钾、钙、铬、锰、铁、铜、锌、砷、硒、银、镉、铅的测定；
- SN/T 4675.20 出口葡萄酒中稀土元素的测定 电感耦合等离子体质谱法；
- SN/T 4675.21 出口葡萄酒中可溶性无机盐的测定 离子色谱法；
- SN/T 4675.22 出口葡萄酒中总二氧化硫的测定 比色法；
- SN/T 4675.23 出口葡萄酒及葡萄汁中氨氮的测定 连续流动分析法；
- SN/T 4675.24 出口葡萄酒福林-肖卡指数的测定 分光光度计法；
- SN/T 4675.25 出口葡萄酒颜色的测定 CIE 1976($L^*a^*b^*$)色空间法；
- SN/T 4675.26 出口葡萄酒浊度的测定 散射光法；
- SN/T 4675.27 出口葡萄酒碱性灰分的测定；
- SN/T 4675.28 出口葡萄酒细菌、霉菌及酵母的计数；
- SN/T 4675.29 出口葡萄酒中酒香酵母检验 实时荧光 PCR 法；
- SN/T 4675.30 出口葡萄酒中拜氏接合酵母检验 实时荧光 PCR 法。

本部分为 SN/T 4675 的第 25 部分。

本部分按照 GB/T 1.1—2009 给出的规则起草。

本部分修改采用国际葡萄与葡萄酒组织(OIV)的方法 OIV-MA-AS2-11 II 颜色特征的检测 CIELab。本部分在技术内容上与方法一致,但考虑到我国标准本身的特点及汉语表达习惯,对 OIV 的方法 OIV-MA-AS2-11 II 的个别内容作了编辑性修改和验证。修改的主要内容为:

- 增加了定义；
- 增加了 CIE 1976($L^*a^*b^*$)色空间各参数的计算公式；

- 增加了 CIE 1976($L^*a^*b^*$)色空间色差计算公式;
- 增加了 CIE 照明体在 CIE 1964 标准色度观察者下的三刺激值;
- 增加了 CIE 1964 标准色度观察者(色匹配函数);
- 增加了 CIE 标准光源相对光谱功率分布;
- 增加了不同光程比色皿的色度值参数表示方法。

请注意本文件的某些内容可能涉及专利。本文件的发布机构不承担识别这些专利的责任。

本部分由国家认证认可监督管理委员会提出并归口。

本部分起草单位:中华人民共和国秦皇岛出入境检验检疫局、中华人民共和国北京出入境检验检疫局、中华人民共和国广东出入境检验检疫局、济南海能仪器股份有限公司。

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出口葡萄酒颜色的测定 CIE 1976 ($L^* a^* b^*$)色空间法

1 范围

SN/T 4675 的本部分规定了葡萄酒颜色测定的 CIE 1976($L^* a^* b^*$)色空间的测定方法。
本部分适用于葡萄酒颜色的检测。

2 规范性引用文件

下列文件对于本文件的应用是必不可少的。凡是注日期的引用文件,仅注日期的版本适用于本文件。凡是不注日期的引用文件,其最新版本(包括所有的修改单)适用于本文件。

GB/T 3978 标准照明体和几何条件

GB/T 3979 物体色的测量方法

GB/T 6682 分析实验室用水规格和试验方法

3 术语和定义

下列术语和定义适用于本文件。

3.1

色空间 color space

表示颜色的三维空间。

3.2

均匀色空间 uniform color space

能以相同距离表示相同知觉色差的色空间。

3.3

CIE1976($L^* a^* b^*$)色空间 color space (CIE LAB color space)

1976 年 CIE 推荐的均匀色空间。该空间是三维直角坐标系统。

3.4

色差 color difference

定量表示的色知觉差别。用 ΔE 表示。

3.5

明度 lightness

表示物体表面颜色明亮程度的视知觉特性值,以绝对白色和绝对黑色为基准给予分度。颜色的三属性之一。

3.6

彩度 curoma

用距离等明度无彩色的视知觉特性来表示物体表面颜色的浓淡,并给予分度。颜色的三属性之一。

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3.7

色调(色相) Hue

表示红、黄、绿、蓝、紫等颜色的特性。颜色的三属性之一。

3.8

心理明度 psychometric lightness在均匀色空间中,相当于明度的坐标。在 $L^*a^*b^*$ 色空间中的 L^* 定义为 CIE 1976 心理明度。

3.9

心理彩度坐标 psychometric chroma coordinates在均匀色空间中,表示等明度面内的两个坐标。例如在 $L^*a^*b^*$ 色空间中的两个坐标 a^* 和 b^* 。

3.10

三刺激值 tristimulus values在三色系统中,与待测色刺激达到色匹配所需的三种参照色刺激的量。在 CIE 1964 标准色度系统中,用 X_{10} 、 Y_{10} 、 Z_{10} 表示三刺激值。

3.11

色匹配函数 color matching function匹配等能光谱各波长所需要的参考色刺激 X_{10} 、 Y_{10} 、 Z_{10} 的一组归一化单色辐射三刺激值。

3.12

CIE 标准照明体 CIE standard illuminants由 CIE 规定的入射在物体上的一个特定的相对光谱功率分布,包括标准照明体 D_{65} ,相关色温约为 6 504 K 的平均昼光。

3.13

CIE 1964 标准色度观察者 CIE 1964 standard color imetric observerCIE 1964 标准色度观察者色度特性与 CIE 1964 标准色度系统中的色匹配函数 $\bar{x}_{10}(\lambda)$ 、 $\bar{y}_{10}(\lambda)$ 、 $\bar{z}_{10}(\lambda)$ 一致,适用于大于 4° 的视场范围。

3.14

色刺激函数 color stimulus function

色刺激以辐射亮度或辐射功率一类辐射度量作为波长函数的光谱密集度的表达式。

3.15

相对色刺激函数 relative color stimulus function

色刺激函数的相对光谱功率分布。

3.16

光谱透射比 spectral transmittance物体透射的波长 λ 的辐通量或光通量,与入射到物体表面的波长 λ 的辐通量或光通量之比,光谱透射比以 $\tau(\lambda)$ 表示。

3.17

色刺激值 psychophysical color specification

用三刺激值表示色刺激性质的量。

4 方法提要

样品净化后,测定样品在 380 nm~780 nm 波长范围内的吸光度,对吸光度进行相对色刺激函数、色匹配函数进行积分,再与标准三刺激值比较,计算出样品的 L^* 值、 a^* 值、 b^* 值、彩度 C_{ab} 值和色调角 h_{ab} 值。

5 试剂材料

5.1 水:GB/T 6682 规定的一级水。

5.2 甲醇:分析纯。

6 仪器和设备

6.1 所有接触待测样品的器材,用水(5.1)清洗后,用甲醇(5.2)去除残留的油脂、色素等杂质,阴干备用。

6.2 分光光度计或颜色测量仪:光谱范围 380 nm~780 nm,间隔 5 nm,狭缝 2.0,中速或低速,积分时间 2.0。

6.3 比色皿:1.0 mm,2.0 mm,5.0 mm,10 mm,20 mm 光程的光学玻璃比色皿。

6.4 滤膜:0.45 μm ,水性滤膜。

7 试样制备与保存

7.1 试样的制备

起泡酒需预先脱气。将 100 mL 试样倒入带排气塞的瓶中,在室温下使用水平振荡器或超声波水浴脱气,直至无气泡逸出。

7.2 净化

将样品在 8 000 r/min 离心 10 min,吸取上清液约 10 mL,经滤膜(6.4)过滤,待测。

7.3 仪器条件

根据需要,选择颜色测量仪或者分光光度计:

a) 分光光度计测量方法

按照说明书要求设置仪器,用水(5.1)作参比进行分光光度计(6.2)的空白校正。

把测定样液注入比色皿中,读取样品在 380 nm~780 nm、间隔 5 nm 的吸光度值。

b) 颜色测量仪测量方法

按照说明书要求设置仪器参数,用水(5.1)作参比进行颜色测量仪(6.2)的空白校正。

把测定样液注入比色皿中进行测定,利用仪器自带的软件处理系统读取 CIE 1976($L^*a^*b^*$)色空间的色度值参数。

8 结果计算和表述

8.1 试样的 CIE 1976($L^*a^*b^*$)色度值,由颜色测量仪(5.1)的数据处理软件直接读取相关色度值参数,或由分光光度计(5.1)测量的吸光度值后,按式(2)、式(3)、式(4)、式(5)、式(1)计算出样品在 CIE 1964 标准色度系统的三刺激值 X 、 Y 、 Z ,再按照式(6)、式(7)、式(8)式(9)和式(10)计算 CIE 1976($L^*a^*b^*$)色空间的心理明度 L^* 、心理彩度坐标 a^* 和心理彩度坐标 b^* 。

8.2 色刺激函数计算公式,见式(1):

$$\varphi(\lambda) = \tau(\lambda)S(\lambda) \dots\dots\dots (1)$$

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式中:

 $\varphi(\lambda)$ ——样品的三刺激值计算中的色刺激函数; $\tau(\lambda)$ ——样品的光谱透射比,按照 GB/T 3979 规定的方法,由吸光度值的反对数计算得出; $S(\lambda)$ ——CIE 标准照明体的相对光谱功率分布因数,按照 GB/T 3978 规定的 D65 取值(参见表 A.1)。

8.3 色刺激值计算公式,见式(2)~式(5):

$$X = \kappa_{10} \sum_{380}^{780} \varphi(\lambda) \bar{x}_{10}(\lambda) \Delta\lambda \quad \dots\dots\dots (2)$$

$$Y = \kappa_{10} \sum_{380}^{780} \varphi(\lambda) \bar{y}_{10}(\lambda) \Delta\lambda \quad \dots\dots\dots (3)$$

$$Z = \kappa_{10} \sum_{380}^{780} \varphi(\lambda) \bar{z}_{10}(\lambda) \Delta\lambda \quad \dots\dots\dots (4)$$

$$\kappa_{10} = \frac{100}{\sum S(\lambda) \bar{y}_{10}(\lambda) \Delta\lambda} \quad \dots\dots\dots (5)$$

式中:

 X ——样品的色刺激值 X ; Y ——样品的色刺激值 Y ; Z ——样品的色刺激值 Z ; $\bar{x}_{10}(\lambda)$ ——CIE 1964 标准色度观察者的色匹配函数(参见表 A.1); $\bar{y}_{10}(\lambda)$ ——CIE 1964 标准色度观察者的色匹配函数(参见表 A.1); $\bar{z}_{10}(\lambda)$ ——为 CIE 1964 标准色度观察者的色匹配函数(参见表 A.1); κ_{10} ——归一化系数; $\Delta\lambda$ ——为样品测量时的波长间隔,5 nm。

8.4 色度值计算公式,见式(6)~式(10):

$$L^* = 116f\left(\frac{Y}{Y_{10}}\right) - 16 \quad \dots\dots\dots (6)$$

$$a^* = 500 \left[f\left(\frac{X}{X_{10}}\right) - f\left(\frac{Y}{Y_{10}}\right) \right] \quad \dots\dots\dots (7)$$

$$b^* = 200 \left[f\left(\frac{Y}{Y_{10}}\right) - f\left(\frac{Z}{Z_{10}}\right) \right] \quad \dots\dots\dots (8)$$

$$C_{ab}^* = [(a^*)^2 + (b^*)^2]^{\frac{1}{2}} \quad \dots\dots\dots (9)$$

$$h_{ab} = \arctan\left(\frac{b^*}{a^*}\right) \quad \dots\dots\dots (10)$$

式中:

 L^* ——样品在 CIE 1976($L^* a^* b^*$)色空间中的心理明度坐标值(也称明度值); a^* ——样品在 CIE 1976($L^* a^* b^*$)色空间中的心理彩度坐标值(也称红-绿色品指数值); b^* ——样品在 CIE 1976($L^* a^* b^*$)色空间中的心理彩度坐标值(也称黄-蓝色品指数值); C_{ab}^* ——样品在 CIE 1976($L^* a^* b^*$)色空间的彩度值; h_{ab} ——样品在 CIE 1976($L^* a^* b^*$)色空间的色调角值,单位°; X_{10} ——CIE 1964 标准色度观察者中的色刺激值 X (参见表 B.1); Y_{10} ——CIE 1964 标准色度观察者中的色刺激值 Y (参见表 B.1); Z_{10} ——CIE 1964 标准色度观察者中的色刺激值 Z (参见表 B.1)。测定时的明度值 L^* 应不低于 20。如果低于此值,应更换短光程比色皿重新测定。

在用式(6)、式(7)、式(8)、式(9)和式(10)进行计算时,要参照式(C.1)、式(C.2)、式(C.3)、式(C.4)、

式(C.5)和式(C.6)规定的条件进行选择(参见附录 C)。

本标准以 10 mm 光程比色皿的测定结果为标准表示方法。使用其他光程比色皿的测定结果,均要换算成标准表示方法的测定值,并在测定参数右下角注明使用的比色皿光程数值(参见附录 D)。

计算实例(参见附录 E)。

结果以重复性条件下获得的两次独立测定结果的算术平均值表示, L^* 保留小数点后 1 位位数, a^* 、 b^* 、 C_{ab}^* 和 h_{ab}^* 保留小数点后 2 位位数。

9 精密度

在重复性条件下获得的两次独立测定结果的色差 ΔE_{ab} 不得超过 1.5(色差计算方法参见附录 F)。

附 录 A
(资料性附录)

CIE 1964 标准色度观察者(色匹配函数)与 CIE 标准光源相对光谱功率分布

在 CIE 1976($L^* a^* b^*$)色空间中,CIE 1964 标准色度观察者(色匹配函数)的值和 CIE 标准光源相对光谱功率分布的值见表 A.1。

表 A.1 CIE 1964 标准色度观察者(色匹配函数)与 CIE 标准光源相对光谱功率分布表

序号	波长 λ nm	CIE 1964 标准色度观察者(色匹配函数)			CIE 标准光源相对光谱功率分布 (标准照明体 D65)
		$\overline{X}_{10(\lambda)}$	$\overline{Y}_{10(\lambda)}$	$\overline{Z}_{10(\lambda)}$	
1	380	0.000 160	0.000 017	0.000 705	49.975 5
2	385	0.000 662	0.000 072	0.002 928	52.311 8
3	390	0.002 362	0.000 253	0.010 482	54.648 2
4	395	0.007 242	0.000 769	0.032 344	68.701 5
5	400	0.019 110	0.002 004	0.086 011	82.754 9
6	405	0.043 400	0.004 509	0.197 120	87.120 4
7	410	0.084 736	0.008 756	0.389 366	91.486 0
8	415	0.140 638	0.014 456	0.656 760	92.458 9
9	420	0.204 492	0.021 391	0.972 542	93.431 8
10	425	0.264 737	0.029 497	1.282 500	90.057 0
11	430	0.314 679	0.038 676	1.553 480	86.682 3
12	435	0.357 719	0.049 602	1.798 500	95.773 6
13	440	0.383 734	0.062 077	1.967 280	104.865 0
14	445	0.386 726	0.074 704	2.027 300	110.936 0
15	450	0.370 702	0.089 456	1.994 800	117.008 0
16	455	0.342 957	0.106 256	1.900 700	117.410 0
17	460	0.302 273	0.128 201	1.745 370	117.812 0
18	465	0.254 085	0.152 761	1.554 900	116.336 0
19	470	0.195 618	0.185 190	1.317 560	114.861 0
20	475	0.132 349	0.219 940	1.030 200	115.392 0
21	480	0.080 507	0.253 589	0.772 125	115.923 0
22	485	0.041 072	0.297 665	0.570 060	112.367 0
23	490	0.016 172	0.339 133	0.415 254	108.811 0
24	495	0.005 132	0.395 379	0.302 356	109.082 0
25	500	0.003 816	0.460 777	0.218 502	109.354 0
26	505	0.015 444	0.531 360	0.159 249	108.578 0
27	510	0.037 465	0.606 741	0.112 044	107.802 0

表 A.1 (续)

序号	波长 λ nm	CIE 1964 标准色度观察者(色匹配函数)			CIE 标准光源相对光谱功率分布 (标准照明体 D65)
		$\bar{X}_{10(\lambda)}$	$\bar{Y}_{10(\lambda)}$	$\bar{Z}_{10(\lambda)}$	
28	515	0.071 358	0.685 660	0.082 248	106.296 0
29	520	0.117 749	0.761 757	0.060 709	104.790 0
30	525	0.172 953	0.823 330	0.043 050	106.239 0
31	530	0.236 491	0.875 211	0.030 451	107.689 0
32	535	0.304 213	0.923 810	0.020 584	106.047 0
33	540	0.376 772	0.961 988	0.013 676	104.405 0
34	545	0.451 584	0.982 200	0.007 918	104.225 0
35	550	0.529 826	0.991 761	0.003 988	104.046 0
36	555	0.616 053	0.999 110	0.001 091	102.023 0
37	560	0.705 224	0.997 340	0	100.000 0
38	565	0.793 832	0.982 380	0	98.167 1
39	570	0.878 655	0.955 552	0	96.334 2
40	575	0.951 162	0.915 175	0	96.061 1
41	580	1.014 160	0.868 934	0	95.788 0
42	585	1.074 300	0.825 623	0	92.236 8
43	590	1.118 520	0.777 405	0	88.685 6
44	595	1.134 300	0.720 353	0	89.345 9
45	600	1.123 990	0.658 341	0	90.006 2
46	605	1.089 100	0.593 878	0	89.802 6
47	610	1.030 480	0.527 963	0	89.599 1
48	615	0.950 740	0.461 834	0	88.648 9
49	620	0.856 297	0.398 057	0	87.698 7
50	625	0.754 930	0.339 554	0	85.493 6
51	630	0.647 467	0.283 493	0	83.288 6
52	635	0.535 110	0.228 254	0	83.493 9
53	640	0.431 567	0.179 828	0	83.699 2
54	645	0.343 690	0.140 211	0	81.863 0
55	650	0.268 329	0.107 633	0	80.026 8
56	655	0.204 300	0.081 187	0	80.120 7
57	660	0.152 568	0.060 281	0	80.214 6
58	665	0.112 210	0.044 096	0	81.246 2
59	670	0.081 261	0.031 800	0	82.277 8
60	675	0.057 930	0.022 602	0	80.281 0
61	680	0.040 851	0.015 905	0	78.284 2

表 A.1 (续)

序号	波长 λ nm	CIE 1964 标准色度观察者(色匹配函数)			CIE 标准光源相对光谱功率分布 (标准照明体 D65)
		$\bar{X}_{10(\lambda)}$	$\bar{Y}_{10(\lambda)}$	$\bar{Z}_{10(\lambda)}$	
62	685	0.028 623	0.011 130	0	74.002 7
63	690	0.019 941	0.007 749	0	69.721 3
64	695	0.013 842	0.005 375	0	70.665 2
65	700	0.009 577	0.003 718	0	71.609 1
66	705	0.006 605	0.002 565	0	72.979 0
67	710	0.004 553	0.001 768	0	74.349 0
68	715	0.003 145	0.001 222	0	67.976 5
69	720	0.002 175	0.000 846	0	61.604 0
70	725	0.001 506	0.000 586	0	65.744 8
71	730	0.001 045	0.000 407	0	69.885 6
72	735	0.000 727	0.000 284	0	72.486 3
73	740	0.000 508	0.000 199	0	75.087 0
74	745	0.000 356	0.000 140	0	69.339 8
75	750	0.000 251	0.000 098	0	63.592 7
76	755	0.000 178	0.000 070	0	55.005 4
77	760	0.000 126	0.000 05	0	46.418 2
78	765	0.000 09	0.000 036	0	56.611 8
79	770	0.000 065	0.000 025	0	66.805 4
80	775	0.000 046	0.000 018	0	65.094 1
81	780	0.000 033	0.000 013	0	63.382 8

注 1: CIE 1964 标准色度观察者(色匹配函数)引自 GB/T 3979—2008《物体色的测量方法》表 3。

注 2: CIE 标准光源相对光谱功率分布(标准照明体 D65)引自 GB/T 3979—2008《物体色的测量方法》表 1。

附 录 B
(资料性附录)

CIE 照明体在 CIE 1964 标准色度观察者下的三刺激值

在 CIE 1976($L^*a^*b^*$)色空间中,CIE 标准照明体在 CIE 1964 标准色度观察者下的三刺激值见表 B.1。

表 B.1 CIE 照明体在 CIE 1964 标准色度观察者下的三刺激值

刺激值	X_{10}	Y_{10}	Z_{10}
标准照明体 D65	94.81	100.00	107.32
注:引自 GB/T 7921—2008《均匀色空间和色差公式》表 2。			

附 录 C

(资料性附录)

计算不同刺激值时计算选择公式的条件

在利用式(6)、式(7)、式(8)、式(9)和式(10)进行计算时,参照式(C.1)、式(C.2)、式(C.3)、式(C.4)、式(C.5)和式(C.6)的条件进行选择:

$$\text{当} \left(\frac{X}{X_{10}} \right) > \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{X}{X_{10}} \right) = \left(\frac{X}{X_{10}} \right)^{\frac{1}{3}} \dots\dots\dots (\text{C.1})$$

$$\text{当} \left(\frac{X}{X_{10}} \right) \leq \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{X}{X_{10}} \right) = \left(\frac{841}{108} \right) \left(\frac{X}{X_{10}} \right) + \frac{16}{116} \dots\dots\dots (\text{C.2})$$

$$\text{当} \left(\frac{Y}{Y_{10}} \right) > \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{Y}{Y_{10}} \right) = \left(\frac{Y}{Y_{10}} \right)^{\frac{1}{3}} \dots\dots\dots (\text{C.3})$$

$$\text{当} \left(\frac{Y}{Y_{10}} \right) \leq \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{Y}{Y_{10}} \right) = \left(\frac{841}{108} \right) \left(\frac{Y}{Y_{10}} \right) + \frac{16}{116} \dots\dots\dots (\text{C.4})$$

$$\text{当} \left(\frac{Z}{Z_{10}} \right) > \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{Z}{Z_{10}} \right) = \left(\frac{Z}{Z_{10}} \right)^{\frac{1}{3}} \dots\dots\dots (\text{C.5})$$

$$\text{当} \left(\frac{Z}{Z_{10}} \right) \leq \left(\frac{24}{116} \right)^3 \text{ (即} 0.008\ 856\ 5 \text{) 时, } f\left(\frac{Z}{Z_{10}} \right) = \left(\frac{841}{108} \right) \left(\frac{Z}{Z_{10}} \right) + \frac{16}{116} \dots\dots\dots (\text{C.6})$$

附 录 D

(资料性附录)

使用不同光程比色皿的色度值参数表示方法

本部分默认使用 10 mm 光程比色皿的测定值为标准测定值表示方法。如果使用其他光程比色皿的测定,应换算为 10 mm 光程比色皿的测定值,并在测定参数右下角注明使用的比色皿光程数值。

例 1:使用 10 mm 光程比色皿相关色度值参数的表示方法:

$$L^* 23.4, a^* 22.36, b^* 1.67, C_{ab}^* 2.3, h_{ab} 0.7$$

例 2:使用 5 mm 光程比色皿的测定结果换算为 10 mm 光程比色皿后相关色度值参数的表示方法:

$$L_5^* 23.4, a_5^* 22.36, b_5^* 1.67, C_{ab5}^* 2.3, h_{ab5} 0.7$$

附录 E (资料性附录)

计算实例(以分光光度计为例)

E.1 设定测定条件:380 nm~780 nm,间隔 5 nm,狭缝 2.0,中速或低速,积分时间 2.0;具体波长为 380 nm、385 nm、390 nm、395 nm、400 nm、405 nm、410 nm、415 nm、420 nm、425 nm、430 nm、435 nm、440 nm、445 nm、450 nm、455 nm、460 nm、465 nm、470 nm、475 nm、480 nm、485 nm、490 nm、495 nm、500 nm、505 nm、510 nm、515 nm、520 nm、525 nm、530 nm、535 nm、540 nm、545 nm、550 nm、555 nm、560 nm、565 nm、570 nm、575 nm、580 nm、585 nm、590 nm、595 nm、600 nm、605 nm、610 nm、615 nm、620 nm、625 nm、630 nm、635 nm、640 nm、645 nm、650 nm、655 nm、660 nm、665 nm、670 nm、675 nm、680 nm、685 nm、690 nm、695 nm、700 nm、705 nm、710 nm、715 nm、720 nm、725 nm、730 nm、735 nm、740 nm、745 nm、750 nm、755 nm、760 nm、765 nm、770 nm、775 nm 和 780 nm。

E.2 用比色皿 10 mm 光程的光学玻璃比色皿测量某葡萄酒的在 380 nm~780 nm、间隔 5 nm 的吸光度值(Abs)依次为:0.008 76,0.012 91,0.018 02,0.023 63,0.028 79,0.033 51,0.040 11,0.049 32,0.061 92,0.079 32,0.101 28,0.127 73,0.160 23,0.198 37,0.240 70,0.284 20,0.322 82,0.351 92,0.377 28,0.403 01,0.422 54,0.439 29,0.462 13,0.490 61,0.518 79,0.540 39,0.551 53,0.548 38,0.530 89,0.501 56,0.460 58,0.409 63,0.352 19,0.296 22,0.244 93,0.198 73,0.157 57,0.122 37,0.094 58,0.074 03,0.059 66,0.049 95,0.043 69,0.039 78,0.037 00,0.034 62,0.032 85,0.031 73,0.030 90,0.030 21,0.029 42,0.028 52,0.027 38,0.026 10,0.024 58,0.023 02,0.021 20,0.019 42,0.017 51,0.015 49,0.013 68,0.011 85,0.010 02,0.008 25,0.006 73,0.005 21,0.003 81,0.002 86,0.001 76,0.001 00,0.000 27,-0.000 33,-0.000 76,-0.000 93,-0.001 09,-0.001 11,-0.001 08,-0.000 98,-0.000 72,-0.000 38和0.000 05。

E.3 在 380 nm~780 nm、间隔 5 nm 的吸光度换算为光谱透射比 $\tau(\lambda)$,依次为:0.980 03,0.970 71,0.959 36,0.947 04,0.935 86,0.925 74,0.911 78,0.892 65,0.867 12,0.833 07,0.791 99,0.745 20,0.691 46,0.633 33,0.574 51,0.519 76,0.475 53,0.444 71,0.419 49,0.395 36,0.377 97,0.363 67,0.345 04,0.323 14,0.302 84,0.288 14,0.280 85,0.282 89,0.294 52,0.315 09,0.346 27,0.389 38,0.444 44,0.505 57,0.568 94,0.632 81,0.695 71,0.754 45,0.804 30,0.843 28,0.871 65,0.891 35,0.904 29,0.912 47,0.918 33,0.923 38,0.927 15,0.929 54,0.931 32,0.932 80,0.934 50,0.936 44,0.938 90,0.941 67,0.944 97,0.948 37,0.952 36,0.956 27,0.960 48,0.964 96,0.968 99,0.973 08,0.977 19,0.981 18,0.984 62,0.988 08,0.991 27,0.993 44,0.995 96,0.997 70,0.999 38,1.000 76,1.001 75,1.002 14,1.002 51,1.002 56,1.002 49,1.002 26,1.001 66,1.000 88和0.999 88。

E.4 CIE 标准光源 D65 相对光谱功率分布 $S(\lambda)$ 在 380 nm~780 nm、间隔 5 nm 的值依次为:49.975 50,52.311 80,54.648 20,68.701 50,82.754 90,87.120 40,91.486 00,92.458 90,93.431 80,90.057 00,86.682 30,95.773 60,104.865 00,110.936 00,117.008 00,117.410 00,117.812 00,116.336 00,114.861 00,115.392 00,115.923 00,112.367 00,108.811 00,109.082 00,109.354 00,108.578 00,107.802 00,106.296 00,104.790 00,106.239 00,107.689 00,106.047 00,104.405 00,104.225 00,104.046 00,102.023 00,100.000 00,98.167 10,96.334 20,96.061 10,95.788 00,92.236 80,88.685 60,89.345 90,90.006 20,89.802 60,89.599 10,88.648 90,87.698 70,85.493 60,83.288 60,83.493 90,83.699 20,81.863 00,80.026 80,80.120 70,80.214 60,81.246 20,82.277 80,80.281 00,78.284 20,74.002 70,69.721 30,70.665 20,71.609 10,72.979 00,74.349 00,67.976 50,61.604 00,65.744 80,69.885 60,72.486 30,75.087 00,69.339 80,63.592 70,55.005 40,46.418 20,56.611 80,66.805 40,65.094 10和63.382 80。

34.909 08, 29.029 69, 23.611 74, 19.057 82, 15.051 46, 11.478 09, 8.613 52, 6.504 76, 4.835 42, 3.582 63, 2.616 43, 1.814 51, 1.245 11, 0.823 65, 0.540 27, 0.379 83, 0.266 24, 0.187 19, 0.131 45, 0.083 07, 0.052 12, 0.038 53, 0.028 44, 0.020 59, 0.014 94, 0.009 71, 0.006 23, 0.003 85, 0.002 32, 0.002 04, 0.001 67, 0.001 17和0.000 82。

[illegible]

E.9 按照式(2)、式(3)、式(4),计算出样品的三刺激值分别为 $X=74.102\ 28$, $Y=61.245\ 98$, $Z=62.566\ 32$ 。

E.10 按照式(6)、式(7)、式(8)、式(9)、式(10),计算出样品在 CIE 1976($L^* a^* b^*$)色空间中的色度值参数 $L^*=82.5, a^*=35.95, b^*=2.77, C_{ab}^*=36.06$ 和 $h_{ab}=0.08$ 。

附 录 F
(资料性附录)

CIE 1976($L^*a^*b^*$)色空间色差公式

样品在 CIE 1976($L^*a^*b^*$)色空间中的相关参数为:

CIELAB 明度差公式(简称明度差 ΔL^*),见式(F.1):

$$\Delta L^* = L_1^* - L_n^* \quad \text{..... (F.1)}$$

式中:

L_1^* 和 L_n^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的心理明度坐标值。

CIELAB 红-绿色品指数差(简称色品指数差 Δa^*),见式(F.2):

$$\Delta a^* = a_1^* - a_n^* \quad \text{..... (F.2)}$$

式中:

a_1^* 和 a_n^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的红-绿色品指数值。

CIELAB 黄-蓝色品指数差(简称色品指数差 Δb^*),见式(F.3):

$$\Delta b^* = b_1^* - b_n^* \quad \text{..... (F.3)}$$

式中:

b_1^* 和 b_n^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的黄-蓝色品指数值。

CIELAB 彩度差(简称彩度差 C_{ab}^*),见式(F.4):

$$\Delta C_{ab}^* = C_{ab,1}^* - C_{ab,n}^* \quad \text{..... (F.4)}$$

式中:

$C_{ab,1}^*$ 和 $C_{ab,n}^*$ 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的彩度值。

CIELAB 色调角差(色调角差 ΔH_{ab}^*),见式(F.5)和式(F.6):

$$\Delta H_{ab}^* = h_{ab,1}^* - h_{ab,n}^* \quad \text{..... (F.5)}$$

式中:

$h_{ab,1}^*$ 和 $h_{ab,n}^*$ 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的色调角值,单位是弧度($^\circ$)。

$$\Delta H_{ab}^* = [(\Delta E_{ab}^*)^2 - (\Delta L^*)^2 - (\Delta C_{ab}^*)^2]^{\frac{1}{2}} \quad \text{..... (F.6)}$$

式中:

ΔE_{ab}^* 是通过公式(F.8)计算得到的。

CIELAB 色差(也称 CIELAB 色差 ΔE_{ab}^*),见式(F.7)和式(F.8):

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\frac{1}{2}} \quad \text{..... (F.7)}$$

式中:

ΔL^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的明度差值;

Δa^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的红-绿色品指数值;

Δb^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的黄-蓝色品指数值。

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta C_{ab}^*)^2 + (\Delta H_{ab}^*)^2]^{\frac{1}{2}} \quad \text{..... (F.8)}$$

式中:

ΔL^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的明度差值;

ΔC_{ab}^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的彩度差值;

ΔH_{ab}^* 分别是样品 1 和样品 n 在 CIE 1976($L^*a^*b^*$)色空间中的色调角差值,单位是弧度($^\circ$)。

Foreword

Standard (SN/T 4675) "Methods of export wine analysis" includes 30 parts;

- SN/T 4675.1: Determination of glycerol in wine for export—Enzymatic method;
- SN/T 4675.2: Determination of 2,3-butanediol in wine for export—GC method;
- SN/T 4675.3: Determination of stable carbon isotope ratio of ethanol in wine for export;
- SN/T 4675.4: Determination of lactic acid in wine for export—Enzymatic method;
- SN/T 4675.5: Determination of organic acid in wine for export—Ion chromatography method;
- SN/T 4675.6: Determination of glucose, fructose and sucrose in wine for export;
- SN/T 4675.7: Determination of acetaldehyde in wine for export—GC/MS method;
- SN/T 4675.8: Determination of 5-hydroxymethylfurfural in wine for export—HPLC method;
- SN/T 4675.9: Determination of diethylene in wine for export—GC/MS method;
- SN/T 4675.10: Determination of ochratoxin A in wine for export—HPLC/MS/MS method;
- SN/T 4675.11: Determination of 7 anthocyanins in wine for export—UHPLC method;
- SN/T 4675.12: Determination of lysozyme in wine for export—HPLC method;
- SN/T 4675.13: Determination of 2,4,6-trichloroaniline in wine for export—HPLC/MS/MS method;
- SN/T 4675.14: Determination of natamycin in wine for export—HPLC/MS/MS method;
- SN/T 4675.15: Determination of salicylic acid, dehydroacetic acid and 4-chlorobenzoic acid in wine for export—HPLC method;
- SN/T 4675.16: Determination of fumaric acid in wine for export—HPLC/MS/MS method;
- SN/T 4675.17: Determination of butyltin compounds in wine for export—GC/MS/MS method;

- SN/T 4675.18: Determination of dithiocarbamates residues in wine for export—Headspace GC method;
- SN/T 4675.19: Determination of sodium, magnesium, potassium, calcium, chromium, manganese, iron, copper, zinc, arsenic, selenium, silver, cadmium and lead in wine for export;
- SN/T 4675.20: Determination of rare-earth elements in wine for export—ICP-MS method;
- SN/T 4675.21: Determination of soluble inorganic salts in wine for export—Ion chromatography method;
- SN/T 4675.22: Determination of total sulfur dioxide in wine for export—Colorimetric method;
- SN/T 4675.23: Determination of ammonium nitrogen in wine and grape juice for export—Continuous flow analysis(CFA) method;
- SN/T 4675.24: Determination of Folin & Ciocalteu index of wine for export—Spectrophotometry method;
- SN/T 4675.25: Determination of chromatic characteristics of wine for export—CIE Lab color space system;
- SN/T 4675.26: Determination of turbidity of wine for export—Diffused radiation method;
- SN/T 4675.27: Determination of alkaline ash of wine for export;
- SN/T 4675.28: Method for enumeration of colony-forming units of yeasts, moulds and bacteria in cork stoppers and wine for export;
- SN/T 4675.29: Determination of brettanomyces in wine for export—Real-time PCR method;
- SN/T 4675.30: Determination of zygosaccharomyces bailii in wine for export—Real-time PCR method.

This part is part 25 of the standard.

This part is drafted according to GB/T 1.1—2009.

This part is revised by adopting method OIV-MA-AS2-11 II Determination of Chromatic Characteristics according to CIELab of International Organization of Vine and Wine (OIV). This section is consistent with this method in terms of technical contents. However, in view of characteristics of Chinese standard and Chinese idiomatic expression, some contents of OIV-MA-AS2-11 II have been subject to editorial modification and validation.

Main modified contents include:

- Adding the definition;
- Adding the computational formula of various parameters of CIE 1976 ($L^* a^* c^*$) color space;
- Adding the computational formula of chromatic aberration of CIE 1976 ($L^* a^* c^*$) color space;
- Adding tristimulus values of CIE illuminant under CIE 1964 standard colorimetric observer;
- Adding CIE 1964 standard colorimetric observer (color matching function);
- Adding relative spectral power distribution of CIE standard light source;
- Adding expressive methods of chromatic value parameter of cuvette with different optical lengths;

Please note that some of the content of the standard may involve patents. Publication of the present standard does not bear the responsibility of identifying these patents.

This part was proposed by and was under the jurisdiction of Certification and Accreditation Administration of the People's Republic of China.

This part was drafted by Qinhuangdao Entry-Exit Inspection and Quarantine Bureau of the People's Republic of China, Guangdong Entry-Exit Inspection and Quarantine Bureau of the People's Republic of China, Beijing Entry-Exit Inspection and Quarantine Bureau of the People's Republic of China, and Jinan Hanon Instruments.

Wang fei, Zhang ang, Han, shen, Liu fang, Gao fei, Li xiang, Liu xiaomao, Zhao yuqiang, Cao yanzhong, Wang zhigang, Zhang zhenfang, Liu qing, Li zhiyong.

Determination of chromatic characteristics of wine for export based on CIELAB color space system

1 Scope

This section specifies the determination method of CIE 1976 ($L^* a^* b^*$) color space for determination of chromatic characteristics of wines.

This section is applicable to the qualitative detection of wine color.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 3978 Standard Illuminants and geometric conditions

GB/T 3979 Methods for the measurement of object color

GB/T 6682 Water for Analytical Laboratory Use—Specification and Test Methods

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1 color space

Color space means a three-dimensional space indicating color.

3.2 Uniform Color Space

Refer to a color space which indicates the same color perception difference by the same distance.

3.3 CIE 1976 ($L^* a^* b^*$) Color Space (CIE LAB Color Space)

Refer to a uniform color space recommended by CIE in 1976, which is a three-dimensional rectangular coordinates system.

3.4 Color Difference

Mean quantitative representation of color difference, which is expressed by ΔE .

3.5 Lightness

Stand for the visual perception characteristic value of the lightness of object surface color, and the graduation is determined using absolute white and absolute black as the benchmark, which is one of three attributes of color.

3.6 Curoma

Adopt the distance iso-lightness achromatic visual perception characteristics to indicate the color intensity of object surface, and determine the graduation, which is one of three attributes of color.

3.7 Hue

Indicate attributes of red, yellow, green, blue, purple and other colors, which is one of three attributes of color.

3.8 Psychometric Lightness

In the uniform color space, psychometric lightness equals to the coordinates of lightness. L^* is defined as CIE 1976 psychometric lightness in the $L^* a^* b^*$ color space.

3.9 psychometric chroma coordinates

Refer to two coordinates in the iso-lightness surface in the uniform color space. For example, two coordinates, a^* and b^* in $L^* a^* b^*$ color space.

3.10 Trlstimulos Values

Refer to the measurement of three kinds of reference color stimulus necessary to reach to color matching with colorstimulus to be measured in the trichromatic system. In the CIE 1964 standard chromatic system, use X_{10} , Y_{10} and Z_{10} to indicate the trlstimulos values.

3.11 Color Matching Function

A group of normalized monochromatic radiation tristimulus values for reference color stimulus X_{10} , Y_{10} and Z_{10} necessary to match with each wavelength of equal energy spectrum.

3.12 CIE standard illuminants

A specific spectral power distribution incoming on the object as described by CIE, including average daylight with standard illuminant D_{56} and the related color temperature of 6 504 K;

3.13 CIE 1964 standard Colorimetric Observer

Colorimetric characteristics of CIE 1964 standard colorimetric observer are consistent with the color matching function $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$ and $\bar{z}_{10}(\lambda)$ in the CIE 1964 standard colorimetric system, which is applicable to visual field scope $>4^\circ$.

3.14 Color Stimulus Function

Spectral concentration expression of color stimulus using radiation measurement such as radiance or radiant power as the wavelength function.

3.15 Relative Color Stimulus Function

Refer to relative spectral power distribution of color stimulus function.

3.16 Spectral Transmittance

Mean the ratio between radial flux or luminous flux ϕ_{λ} of the wavelength λ of object transmission and radial flux or luminous flux ϕ_{λ} of the wavelength λ incoming on the object surface, and the spectral transmittance is expressed as $\tau(\lambda)$.

3.17 Psychophysical Color Specification

Refer to the measurement of attributes of colour stimulus expressed by the tristimulus values.

4 Abstract of Methods

After purifying samples, measure the absorbance of samples within 380 nm~780 nm wavelength, calculate the integral of relative color stimulus function and color matching function for the absorbance, and then compare integral results with standards tristimulus values to calculate L^* , a^* , b^* values and C_{ab}^* value of chroma as well as h_{ab} value of hue angle.

5 Reagent Materials

5.1 Water: Grade I water as specified in GB/T 6682.

5.2 Methyl alcohol: analytically pure.

6 Instruments and Equipment

6.1 After all instruments contacting samples to be measured are cleaned by water (5.1), residual grease and pigments and other impurities are eliminated using methyl alcohol (5.2), and then dried in the shade for standby application.

6.2 Spectrometer or other color measuring instrument: Spectral scope: 380 nm~780 nm; interval: 5 nm; slit: 2.0; medium speed or low speed; integral time: 2.0.

6.3 Cuvette: Optical glass cuvette with 1.0 mm, 2.0 mm, 5.0 mm, 10 mm and 20 mm optical length;

6.4 Filter film: 0.45 μ m watery filter film.

7 Specimen Preparation and Storage

7.1 Specimen Preparation

Sparkle wine needs to be degassed. Pour the wine sample of about 100 mL into a beaker flask with air evacuation valve. Placed the wine in an ultrasonic water tank (or horizontal oscillator) at room temperature after a certain period of time until no gas escapes.

7.2 Purification

Specimens are centrifuged for 10 min at 8 000 r/mtn, and about 10 mL supernatant is taken and then filtered via the filter film for measurement.

7.3 Conditions of Instruments

Select color measuring instrument or spectrometer depending on needs:

a) Measurement (Spectrophotometry)

Set the instrument as required in the instruction, and make blank calibration of the spectrophotometry (6.2) with water (5.1) as the control.

Sample solution is filled into the cuvette for measurement, and read the absorbance value within 380 nm~780 nm with the interval of 5 nm.

b) Measurement (Color Measuring Instrument)

Set instrument parameters as required in the instruction, and make blank calibration of the color measuring instrument (6.2) with water (5.1) as the control.

Sample solution is filled into the cuvette for measurement and apply the software treatment system of the instrument to read chromatic value parameters of CIE 1976 ($L^* a^* b^*$) color space.

8 Calculation and Expression of Results

8.1 As for the CIE 1976 ($L^* a^* b^*$) chromatic value of specimens, directly read the related chromatic value parameters from data treatment software of color measuring instrument (5.1), or after the absorbance value is obtained from the spectrometer, calculate tristimulus values X , Y and Z of specimens in CIE 1964 standard chromatic system as per the formula (2), (3), (4), (5) and (1), and then calculate psychometric lightness L^* and psychometric chroma coordinates a^* and b^* of CIE 1976 ($L^* a^* b^*$) color space as per the formula (6), (7), (8), (9) and (10).

8.2 Calculation Formula of Color Stimulus Function, see formula(1):

$$\phi(\lambda) = \tau(\lambda) S(\lambda) \dots\dots\dots (1)$$

Where:

$\phi(\lambda)$ —Color stimulus function in the calculation of tristimulus values for specimens;

$\tau(\lambda)$ —Spectral transmittance of specimens, calculated by the antilog of the absorbance value as per the method specified in GB/T 3979;

$S(\lambda)$ —Relative spectral power distribution factor of CIE standard illuminants, obtained as per D65 as specified in GB/T 3978 (see Table A.1 in the appendix A).

8.3 Calculation Formula of Psychophysical Color Specification, see formula(2)~(5):

$$X = \kappa_{10} \sum_{380}^{780} \phi(\lambda) \bar{x}_{10}(\lambda) \Delta\lambda \dots\dots\dots (2)$$

$$Y = \kappa_{10} \sum_{380}^{780} \phi(\lambda) \bar{y}_{10}(\lambda) \Delta\lambda \dots\dots\dots (3)$$

$$Z = \kappa_{10} \sum_{380}^{780} \varphi(\lambda) \bar{z}_{10}(\lambda) \Delta\lambda \quad \dots\dots\dots (4)$$

$$\kappa_{10} = \frac{100}{\sum S(\lambda) \bar{y}_{10}(\lambda) \Delta\lambda} \quad \dots\dots\dots (5)$$

Where:

X —Psychophysical color specification X of specimens;

Y —Psychophysical color specification Y of specimens;

Z —Psychophysical color specification Z of specimens;

$\bar{x}_{10}(\lambda)$ —Color matching function of CIE 1964 standard colorimetric observer (see Table A.1 in the appendix A);

$\bar{y}_{10}(\lambda)$ —Color matching function of CIE 1964 standard colorimetric observer (see Table A.1 in the appendix A);

$\bar{z}_{10}(\lambda)$ —Color matching function of CIE 1964 standard colorimetric observer (see Table A.1 in the appendix A);

κ_{10} —Normalization coefficient;

$\Delta\lambda$ —Wavelength interval in the measurement of specimens, 5 nm.

8.4 Calculation Formula of Chromatic Value, see formula (6) ~ (10):

$$L^* = 116f\left(\frac{Y}{Y_{10}}\right) - 16 \quad \dots\dots\dots (6)$$

$$a^* = 500 \left[f\left(\frac{X}{X_{10}}\right) - f\left(\frac{Y}{Y_{10}}\right) \right] \quad \dots\dots\dots (7)$$

$$b^* = 200 \left[f\left(\frac{Y}{Y_{10}}\right) - f\left(\frac{Z}{Z_{10}}\right) \right] \quad \dots\dots\dots (8)$$

$$C_{ab}^* = [(a^*)^2 + (b^*)^2]^{\frac{1}{2}} \quad \dots\dots\dots (9)$$

$$h_{ab} = \arctan\left(\frac{b^*}{a^*}\right) \quad \dots\dots\dots (10)$$

Where:

L^* —Psychometric lightness coordinate value of specimens in CIE 1976 ($L^* a^* b^*$) color space (also named lightness value);

a^* —Psychometric chroma coordinate value of specimens in CIE 1976 ($L^* a^* b^*$) color space (also named red-green color index value);

b^* —Psychometric chroma coordinate value of specimens in CIE 1976 ($L^* a^* b^*$) color space (also named yellow-blue color index value);

C_{ab}^* —Curoma value of specimens in CIE 1976 ($L^* a^* b^*$) color space;

h_{ab} —Hue angle value of specimens in CIE 1976 ($L^* a^* b^*$) color space, unit:°;

X_{10} —Psychophysical color specification X of CIE 1964 standard colorimetric observer (see Table B.1 in the appendix B);

Y_{10} —Psychophysical color specification Y of CIE 1964 standard colorimetric observer (see Table B.1 in the appendix B);

Z_{10} —Psychophysical color specification Z of CIE 1964 standard colorimetric observer (see Table B.1 in the appendix B).

Lightness L^* shall be not less than 20 during the measurement. If lower than 20, use the cuvette with shorter optical length for re-determination.

Select as per conditions as specified in formula (C.1), (C.2), (C.3), (C.4), (C.5) and (C.6) while calculating as per the formula (6), (7), (8), (9) and (10) (see the appendix C).

This standard takes measuring results of cuvette with 10 mm optical length as the standard expression method. If using measuring results of cuvette with other optical length, they must be converted into measuring values under the standard expression method, and the optical length value of cuvette used shall be marked at the lower right corner of measuring parameters.

Examples of calculation (see the appendix E).

Results are expressed by the arithmetic mean value of results of two independent measurements under repeatability conditions. Retain one digit after the decimal point for L^* , and two digits after the decimal point for a^* , b^* , C_{ab}^* and h_{ab}^* .

9 Degree of Precision

The chromatic aberration ΔE_{ab} of results of two independent measurements cannot exceed 1.5 under repeatability conditions (For calculation method of chromatic aberration, see the appendix F).

Annex A

(Informative Annex)

CIE 1964 standard colorimetric observer (color matching function) and relative spectral power distribution of CIE standard light source

In CIE 1976 ($L^* a^* b^*$) color space, CIE 1964 standard colorimetric observer (color matching function) value and relative spectral power distribution value of CIE standard light source are shown in Table A.1.

Table A.1—CIE 1964 Standard Colorimetric Observer (Color Matching Function) and Relative Spectral Power Distribution of CIE Standard Light Source

S/N	Wave Length λ (nm)	CIE 1964 Standard Colorimetric Observer (Color Matching Function)			Relative Spectral Power Distribution of CIE Standard Light Source (Standard Illuminant D65)
		$\bar{X}_{10(\lambda)}$	$\bar{Y}_{10(\lambda)}$	$\bar{Z}_{10(\lambda)}$	
1	380	0.000 160	0.000 017	0.000 705	49.975 5
2	385	0.000 662	0.000 072	0.002 928	52.311 8
3	390	0.002 362	0.000 253	0.010 482	54.648 2
4	395	0.007 242	0.000 769	0.032 344	68.701 5
5	400	0.019 110	0.002 004	0.086 011	82.754 9
6	405	0.043 400	0.004 509	0.197 120	87.120 4
7	410	0.084 736	0.008 756	0.389 366	91.486 0
8	415	0.140 638	0.014 456	0.656 760	92.458 9
9	420	0.204 492	0.021 391	0.972 542	93.431 8
10	425	0.264 737	0.029 497	1.282 500	90.057 0
11	430	0.314 679	0.038 676	1.553 480	86.682 3
12	435	0.357 719	0.049 602	1.798 500	95.773 6
13	440	0.383 734	0.062 077	1.967 280	104.865 0
14	445	0.386 726	0.074 704	2.027 300	110.936 0
15	450	0.370 702	0.089 456	1.994 800	117.008 0
16	455	0.342 957	0.106 256	1.900 700	117.410 0
17	460	0.302 273	0.128 201	1.745 370	117.812 0
18	465	0.254 085	0.152 761	1.554 900	116.336 0
19	470	0.195 618	0.185 190	1.317 560	114.861 0
20	475	0.132 349	0.219 940	1.030 200	115.392 0
21	480	0.080 507	0.253 589	0.772 125	115.923 0
22	485	0.041 072	0.297 665	0.570 060	112.367 0
23	490	0.016 172	0.339 133	0.415 254	108.811 0
24	495	0.005 132	0.395 379	0.302 356	109.082 0
25	500	0.003 816	0.460 777	0.218 502	109.354 0
26	505	0.015 444	0.531 360	0.159 249	108.578 0
27	510	0.037 465	0.606 741	0.112 044	107.802 0

Table A.1 (continued)

S/N	Wave Length λ (nm)	CIE 1964 Standard Colorimetric Observer (Color Matching Function)			Relative Spectral Power Distribution of CIE Standard Light Source (Standard Illuminant D65)
		$\bar{X}_{10(\lambda)}$	$\bar{Y}_{10(\lambda)}$	$\bar{Z}_{10(\lambda)}$	
28	515	0.071 358	0.685 660	0.082 248	106.296 0
29	520	0.117 749	0.761 757	0.060 709	104.790 0
30	525	0.172 953	0.823 330	0.043 050	106.239 0
31	530	0.236 491	0.875 211	0.030 451	107.689 0
32	535	0.304 213	0.923 810	0.020 584	106.047 0
33	540	0.376 772	0.961 988	0.013 676	104.405 0
34	545	0.451 584	0.982 200	0.007 918	104.225 0
35	550	0.529 826	0.991 761	0.003 988	104.046 0
36	555	0.616 053	0.999 110	0.001 091	102.023 0
37	560	0.705 224	0.997 340	0	100.000 0
38	565	0.793 832	0.982 380	0	98.167 1
39	570	0.878 655	0.955 552	0	96.334 2
40	575	0.951 162	0.915 175	0	96.061 1
41	580	1.014 160	0.868 934	0	95.788 0
42	585	1.074 300	0.825 623	0	92.236 8
43	590	1.118 520	0.777 405	0	88.685 6
44	595	1.134 300	0.720 353	0	89.345 9
45	600	1.123 990	0.658 341	0	90.006 2
46	605	1.089 100	0.593 878	0	89.802 6
47	610	1.030 480	0.527 963	0	89.599 1
48	615	0.950 740	0.461 834	0	88.648 9
49	620	0.856 297	0.398 057	0	87.698 7
50	625	0.754 930	0.339 554	0	85.493 6
51	630	0.647 467	0.283 493	0	83.288 6
52	635	0.535 110	0.228 254	0	83.493 9
53	640	0.431 567	0.179 828	0	83.699 2
54	645	0.343 690	0.140 211	0	81.863 0
55	650	0.268 329	0.107 633	0	80.026 8
56	655	0.204 300	0.081 187	0	80.120 7
57	660	0.152 568	0.060 281	0	80.214 6
58	665	0.112 210	0.044 096	0	81.246 2
59	670	0.081 261	0.031 800	0	82.277 8
60	675	0.057 930	0.022 602	0	80.281 0
61	680	0.040 851	0.015 905	0	78.284 2

Table A.1 (continued)

S/N	Wave Length λ (nm)	CIE 1964 Standard Colorimetric Observer (Color Matching Function)			Relative Spectral Power Distribution of CIE Standard Light Source (Standard Illuminant D65)
		$\bar{X}_{10(\lambda)}$	$\bar{Y}_{10(\lambda)}$	$\bar{Z}_{10(\lambda)}$	
62	685	0.028 623	0.011 130	0	74.002 7
63	690	0.019 941	0.007 749	0	69.721 3
64	695	0.013 842	0.005 375	0	70.665 2
65	700	0.009 577	0.003 718	0	71.609 1
66	705	0.006 605	0.002 565	0	72.979 0
67	710	0.004 553	0.001 768	0	74.349 0
68	715	0.003 145	0.001 222	0	67.976 5
69	720	0.002 175	0.000 846	0	61.604 0
70	725	0.001 506	0.000 586	0	65.744 8
71	730	0.001 045	0.000 407	0	69.885 6
72	735	0.000 727	0.000 284	0	72.486 3
73	740	0.000 508	0.000 199	0	75.087 0
74	745	0.000 356	0.000 140	0	69.339 8
75	750	0.000 251	0.000 098	0	63.592 7
76	755	0.000 178	0.000 070	0	55.005 4
77	760	0.000 126	0.000 05	0	46.418 2
78	765	0.000 09	0.000 036	0	56.611 8
79	770	0.000 065	0.000 025	0	66.805 4
80	775	0.000 046	0.000 018	0	65.094 1
81	780	0.000 033	0.000 013	0	63.382 8

Note 1: CIE 1964 standard colorimetric observer (color matching function) is quoted from Annexed Table 3 in GB/T 3979—2008 *Methods for the Measurement of Object Color*.

Note 2: Relative spectral power distribution of CIE standard light source (standard illuminant D65) is quoted from Annexed Table 1 in GB/T 3979—2008 *Methods for the Measurement of Object Color*.

Annex B
(Informative Annex)

Tristimulus values of CIE illuminant under CIE 1964 standard colorimetric observer

In CIE 1976($L^* a^* b^*$) color space, tristimulus values of CIE standard illuminant under CIE 1964 standard colorimetric observer are shown in Table B.1.

Table B.1 Tristimulus Values of CIE Illuminant under CIE 1964 Standard Colorimetric Observer

Stimulus Value	X_{10}	Y_{10}	Z_{10}
Standard illuminant D65	94.81	100.00	107.32
Note: quoted from Annexed Table 2 in GB/T 7921—2008 <i>Uniform Color Space and Color Difference Formula</i> .			

Annex C

(Informative Annex)

Conditions of formula selected in calculating different stimulus values

When calculating by formula(6)、(7)、(8)、(9) and (10), selection shall be done in accordance with conditions in formula(C.1) (C.2) (C.3) (C.4)(C.5)and(C.6):

$$\text{When } \left(\frac{X}{X_{10}}\right) > \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{X}{X_{10}}\right) = \left(\frac{X}{X_{10}}\right)^{\frac{1}{3}} \dots\dots\dots (C.1)$$

$$\text{When } \left(\frac{X}{X_{10}}\right) \leq \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{X}{X_{10}}\right) = \left(\frac{841}{108}\right) \left(\frac{X}{X_{10}}\right) + \frac{16}{116} \dots\dots (C.2)$$

$$\text{When } \left(\frac{Y}{Y_{10}}\right) > \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{Y}{Y_{10}}\right) = \left(\frac{Y}{Y_{10}}\right)^{\frac{1}{3}} \dots\dots\dots (C.3)$$

$$\text{When } \left(\frac{Y}{Y_{10}}\right) \leq \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{Y}{Y_{10}}\right) = \left(\frac{841}{108}\right) \left(\frac{Y}{Y_{10}}\right) + \frac{16}{116} \dots\dots\dots (C.4)$$

$$\text{When } \left(\frac{Z}{Z_{10}}\right) > \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{Z}{Z_{10}}\right) = \left(\frac{Z}{Z_{10}}\right)^{\frac{1}{3}} \dots\dots\dots (C.5)$$

$$\text{When } \left(\frac{Z}{Z_{10}}\right) \leq \left(\frac{24}{116}\right)^3 \text{ (namely, } 0.008\ 856\ 5), f\left(\frac{Z}{Z_{10}}\right) = \left(\frac{841}{108}\right) \left(\frac{Z}{Z_{10}}\right) + \frac{16}{116} \dots\dots\dots (C.6)$$

Annex D

(Informative Annex)

Expressive method of relevant chromatic value parameters using cuvette with different optical lengths

This standard applies the determined value of cuvette with 10 mm of optical length by default as the standard determined value. If determination of cuvette with other optical length is applied, it shall be converted to the determined value of cuvette with 10 mm of optical length. Besides, the optical length value of cuvette used shall be noted at the lower right corner of determination parameter.

Example 1: expressive method of relevant chromatic value parameters using cuvette with 10 mm of optical length:

$$L^* 23.4, a^* 22.36, b^* 1.67, C_{ab}^* 2.3, h_{ab} 0.7$$

Example 2: expressive method of relevant chromatic value parameters using cuvette with 10 mm of optical length converted from determination result of cuvette with 5 mm of optical length:

$$L_5^* 23.4, a_5^* 22.36, b_5^* 1.67, C_{ab52}^* .3, h_{ab50} .7$$

Appendix E

(Informative Appendix)

Examples of Calculation(e. g. spectrometer)

E.1 Set measuring conditions: 380 nm ~ 780 nm, interval: 5 nm; slit: 2.0; medium speed or low speed; integral time: 2.0; Specific wavelength is as follows:

380 nm, 385 nm, 390 nm, 395 nm, 400 nm, 405 nm, 410 nm, 415 nm, 420 nm, 425 nm, 430 nm, 435 nm, 440 nm, 445 nm, 450 nm, 455 nm, 460 nm, 465 nm, 470 nm, 475 nm, 480 nm, 485 nm, 490 nm, 495 nm, 500 nm, 505 nm, 510 nm, 515 nm, 520 nm, 525 nm, 530 nm, 535 nm, 540 nm, 545 nm, 550 nm, 555 nm, 560 nm, 565 nm, 570 nm, 575 nm, 580 nm, 585 nm, 590 nm, 595 nm, 600 nm, 605 nm, 610 nm, 615 nm, 620 nm, 625 nm, 630 nm, 635 nm, 640 nm, 645 nm, 650 nm, 655 nm, 660 nm, 665 nm, 670 nm, 675 nm, 680 nm, 685 nm, 690 nm, 695 nm, 700 nm, 705 nm, 710 nm, 715 nm, 720 nm, 725 nm, 730 nm, 735 nm, 740 nm, 745 nm, 750 nm, 755 nm, 760 nm, 765 nm, 770 nm, 775 nm and 780 nm.

E.2 Use optical glass cuvette with 10 mm optical length to measure the absorbance value of a wine within 380 nm ~ 780 nm at the interval of 5 nm (Abs), respectively, and results are as follows: 0.008 76, 0.012 91, 0.018 02, 0.023 63, 0.028 79, 0.033 51, 0.040 11, 0.049 32, 0.061 92, 0.079 32, 0.101 28, 0.127 73, 0.160 23, 0.198 37, 0.240 70, 0.284 20, 0.322 82, 0.351 92, 0.377 28, 0.403 01, 0.422 54, 0.439 29, 0.462 13, 0.490 61, 0.518 79, 0.540 39, 0.551 53, 0.548 38, 0.530 89, 0.501 56, 0.460 58, 0.409 63, 0.352 19, 0.296 22, 0.244 93, 0.198 73, 0.157 57, 0.122 37, 0.094 58, 0.074 03, 0.059 66, 0.049 95, 0.043 69, 0.039 78, 0.037 00, 0.034 62, 0.032 85, 0.031 73, 0.030 90, 0.030 21, 0.029 42, 0.028 52, 0.027 38, 0.026 10, 0.024 58, 0.023 02, 0.021 20, 0.019 42, 0.017 51, 0.015 49, 0.013 68, 0.011 85, 0.010 02, 0.008 25, 0.006 73, 0.005 21, 0.003 81, 0.002 86, 0.001 76, 0.001 00, 0.000 27, - 0.000 33, - 0.000 76, - 0.000 93, - 0.001 09, - 0.001 11, - 0.001 08, - 0.000 98, - 0.000 72, - 0.000 38 and 0.000 05.

E.3 The absorbance value within 380 nm ~ 780 nm at the interval of 5 nm is converted into spectral transmittance $\tau(\lambda)$ below: 0.980 03, 0.970 71, 0.959 36, 0.947 04, 0.935 86, 0.925 74, 0.911 78, 0.892 65, 0.867 12, 0.833 07, 0.791 99, 0.745 20, 0.691 46, 0.633 33, 0.574 51, 0.519 76, 0.475 53, 0.444 71, 0.419 49, 0.395 36, 0.377 97, 0.363 67, 0.345 04, 0.323 14, 0.302 84, 0.288 14, 0.280 85, 0.282 89, 0.294 52, 0.315 09, 0.346 27, 0.389 38, 0.444 44, 0.505 57, 0.568 94, 0.632 81, 0.695 71, 0.754 45, 0.804 30, 0.843 28, 0.871 65, 0.891 35, 0.904 29, 0.912 47, 0.918 33, 0.923 38, 0.927 15, 0.929 54, 0.931 32, 0.932 80, 0.934 50, 0.936 44, 0.938 90, 0.941 67, 0.944 97, 0.948 37, 0.952 36, 0.956 27, 0.960 48, 0.964 96, 0.968 99, 0.973 08, 0.977 19, 0.981 18, 0.984 62, 0.988 08, 0.991 27, 0.993 44, 0.995 96, 0.997 70, 0.999 38, 1.000 76, 1.001 75, 1.002 14, 1.002 51, 1.002 56, 1.002 49, 1.002 26, 1.001 66, 1.000 88 and 0.999 88.

E.4 Relative spectral power distribution value $S(\lambda)$ of CIE standard illuminant D65 within 380 nm ~ 780 nm at the interval of 5 nm is as follows: 49.975 50, 52.311 80, 54.648 20, 68.701 50, 82.754 90, 87.120 40, 91.486 00, 92.458 90, 93.431 80, 90.057 00, 86.682 30, 95.773 60, 104.865 00, 110.936 00,

117.008 00, 117.410 00, 117.812 00, 116.336 00, 114.861 00, 115.392 00, 115.923 00, 112.367 00, 108.811 00, 109.082 00, 109.354 00, 108.578 00, 107.802 00, 106.296 00, 104.790 00, 106.239 00, 107.689 00, 106.047 00, 104.405 00, 104.225 00, 104.046 00, 102.023 00, 100.000 00, 98.167 10, 96.334 20, 96.061 10, 95.788 00, 92.236 80, 88.685 60, 89.345 90, 90.006 20, 89.802 60, 89.599 10, 88.648 90, 87.698 70, 85.493 60, 83.288 60, 83.493 90, 83.699 20, 81.863 00, 80.026 80, 80.120 70, 80.214 60, 81.246 20, 82.277 80, 80.281 00, 78.284 20, 74.002 70, 69.721 30, 70.665 20, 71.609 10, 72.979 00, 74.349 00, 67.976 50, 61.604 00, 65.744 80, 69.885 60, 72.486 30, 75.087 00, 69.339 80, 63.592 70, 55.005 40, 46.418 20, 56.611 80, 66.805 40, 65.094 10 and 63.382 80.

E.5 As per the formula(1), the product of spectral transmittance of specimens and relative spectral power distribution value $S(\lambda)$ is the color stimulus function $\varphi(\lambda)$ in the calculation of tristimulus values of specimens within 380 nm~780 nm at the interval of 5 nm below: 48.977 56, 50.779 65, 52.427 10, 65.063 32, 77.446 84, 80.651 02, 83.415 09, 82.533 21, 81.016 73, 75.023 53, 68.651 56, 71.370 02, 72.510 44, 70.259 09, 67.222 64, 61.024 62, 56.023 41, 51.736 15, 48.182 86, 45.621 09, 43.815 69, 40.864 74, 37.544 20, 35.248 70, 33.116 52, 31.286 13, 30.275 88, 30.070 24, 30.862 41, 33.475 26, 37.289 91, 41.292 23, 46.401 42, 52.692 88, 59.196 41, 64.560 68, 69.571 28, 74.062 09, 77.481 94, 81.006 07, 83.493 20, 82.215 60, 80.197 92, 81.525 72, 82.655 63, 82.921 84, 83.071 81, 82.403 06, 81.675 75, 79.748 70, 77.833 32, 78.187 04, 78.585 30, 77.088 16, 75.623 27, 75.984 45, 76.392 97, 77.693 21, 79.026 49, 77.468 08, 75.856 73, 72.010 79, 68.131 11, 69.335 49, 70.507 97, 72.108 74, 73.699 60, 67.530 32, 61.354 85, 65.593 59, 69.842 17, 72.541 40, 75.218 51, 69.488 44, 63.752 51, 55.146 17, 46.533 78, 56.739 69, 66.916 25, 65.151 08 and 63.375 50.

E.6 From the table, $\bar{x}_{10}(\lambda)$ values within 380 nm~780 nm at the interval of 5 nm are as follows: 0.000 16, 0.000 66, 0.002 36, 0.007 24, 0.019 11, 0.043 40, 0.084 74, 0.140 64, 0.204 49, 0.264 74, 0.314 68, 0.357 72, 0.383 73, 0.386 73, 0.370 70, 0.342 96, 0.302 27, 0.254 09, 0.195 62, 0.132 35, 0.080 51, 0.041 07, 0.016 17, 0.005 13, 0.003 82, 0.015 44, 0.037 47, 0.071 36, 0.117 75, 0.172 95, 0.236 49, 0.304 21, 0.376 77, 0.451 58, 0.529 83, 0.616 05, 0.705 22, 0.793 83, 0.878 66, 0.951 16, 1.014 16, 1.074 30, 1.118 52, 1.134 30, 1.123 99, 1.089 10, 1.030 48, 0.950 74, 0.856 30, 0.754 93, 0.647 47, 0.535 11, 0.431 57, 0.343 69, 0.268 33, 0.204 30, 0.152 57, 0.112 21, 0.081 26, 0.057 93, 0.040 85, 0.028 62, 0.019 94, 0.013 84, 0.009 58, 0.006 61, 0.004 55, 0.003 15, 0.002 18, 0.001 51, 0.001 05, 0.000 73, 0.000 51, 0.000 36, 0.000 25, 0.000 18, 0.000 13, 0.000 09, 0.000 07, 0.000 05 and 0.000 03; $\bar{y}_{10}(\lambda)$ values are as follows: 0.000 02, 0.000 07, 0.000 25, 0.000 77, 0.002 00, 0.004 51, 0.008 76, 0.014 46, 0.021 39, 0.029 50, 0.038 68, 0.049 60, 0.062 08, 0.074 70, 0.089 46, 0.106 26, 0.128 20, 0.152 76, 0.185 19, 0.219 94, 0.253 59, 0.297 67, 0.339 13, 0.395 38, 0.460 78, 0.531 36, 0.606 74, 0.685 66, 0.761 76, 0.823 33, 0.875 21, 0.923 81, 0.961 99, 0.982 20, 0.991 76, 0.999 11, 0.997 34, 0.982 38, 0.955 55, 0.915 18, 0.868 93, 0.825 62, 0.777 41, 0.720 35, 0.658 34, 0.593 88, 0.527 96, 0.461 83, 0.398 06, 0.339 55, 0.283 49, 0.228 25, 0.179 83, 0.140 21, 0.107 63, 0.081 19, 0.060 28, 0.044 10, 0.031 80, 0.022 60, 0.015 91, 0.011 13, 0.007 75, 0.005 38, 0.003 72, 0.002 57, 0.001 77, 0.001 22, 0.000 85, 0.000 59, 0.000 41, 0.000 28, 0.000 20, 0.000 14, 0.000 10, 0.000 07, 0.000 05, 0.000 04, 0.000 03, 0.000 02 and 0.000 01; $\bar{z}_{10}(\lambda)$ values are as follows: 0.000 71, 0.002 93, 0.010 48, 0.032 34, 0.086 01, 0.197 12, 0.389 37, 0.656 76, 0.972 54, 1.282 50, 1.553 48, 1.798 50, 1.967 28, 2.027 30, 1.994 80, 1.900 70, 1.745 37, 1.554 90, 1.317 56, 1.030 20, 0.772 13, 0.570 06, 0.415 25, 0.302 36, 0.218 50, 0.159 25, 0.112 04, 0.082 25, 0.060 71, 0.043 05, 0.030 45, 0.020 58,

0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00, 0.000 00and 0.000 00.

E.9 As per the formula(2),(3)and(4), tristimulus values of specimens are $X = 74.102\ 28$, $Y = 61.245\ 98$, $Z = 62.566\ 32$.

E.10 As per the formula(6),(7),(8),(9)and(10), chromatic value parameters of specimens are $L^* = 82.5$, $a^* = 35.95$, $b^* = 2.77$, $C_{ab}^* = 36.06$ 和 $h_{ab} = 0.08$.

Appendix F

(Informative Appendix)

Color Difference Formula of CIE 1976 ($L^* a^* b^*$) Color Space

Related parameters of specimens in CIE 1976 ($L^* a^* b^*$) color space are as follows:

CIELAB lightness difference formula (referred to as “lightness difference ΔL^* ”), see formula (F.1):

$$\Delta L^* = L_1^* - L_n^* \quad \text{..... (F.1)}$$

Where:

L_1^* and L_n^* are psychometric lightness coordinate values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively.

CIELAB Red—green Chroma Index difference formula (referred to as “chroma index difference Δa^* ”), see formula (F.2):

$$\Delta a^* = a_1^* - a_n^* \quad \text{..... (F.2)}$$

Where:

a_1^* and a_n^* , are red—green chroma index values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively.

CIELAB Yellow—blue Chroma Index difference formula (referred to as “chroma index difference Δb^* ”), see formula (F.3):

$$\Delta b^* = b_1^* - b_n^* \quad \text{..... (F.3)}$$

Where:

b_1^* and b_n^* are yellow—blue chroma index values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively.

CIELAB Curoma Difference Formula (referred to as “Curoma Difference C_{ab}^* ”), see formula(F.4):

$$\Delta C_{ab}^* = C_{ab \cdot 1}^* - C_{ab \cdot n}^* \quad \text{..... (F.4)}$$

Where:

$C_{ab \cdot 1}^*$ and $C_{ab \cdot 2}^*$ are curoma values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space,

respectively.

CIELAB Hue Angle Difference Formula (Hue Angle Difference ΔH_{ab}^*), see formula (F.5) and (F.6):

$$\Delta H_{ab}^* = h_{ab \cdot 1}^* - h_{ab \cdot n}^* \dots\dots\dots (F.5)$$

Where:

$h_{ab \cdot 1}^*$ and $h_{ab \cdot n}^*$ are hue angle values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively; [Unit: radian ($^\circ$)].

$$\Delta H_{ab}^* = [(\Delta E_{ab}^*)^2 - (\Delta L^*)^2 - (\Delta C_{ab}^*)^2]^{\frac{1}{2}} \dots\dots\dots (F.6)$$

Where:

ΔE_{ab}^* is calculated as per the formula

CIELAB Color Difference Formula (also named CIELAB color difference ΔE_{ab}^*), see formula (F.7) and (F.8):

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\frac{1}{2}} \dots\dots\dots (F.7)$$

Where:

ΔL^* values are lightness difference values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively;

Δa^* values are red —green chroma index values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively;

Δb^* values are yellow —blue chroma index values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively.

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta C_{ab}^*)^2 + (\Delta H_{ab}^*)^2]^{\frac{1}{2}} \dots\dots\dots (F.8)$$

Where:

ΔL^* values are lightness difference values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively;

ΔC_{ab}^* values are curoma difference values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively;

ΔH_{ab}^* values are hue angle difference values of specimen 1 and specimen n in CIE 1976 ($L^* a^* b^*$) color space, respectively; [Unit: radian($^\circ$)].

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