

## Measurement reproducibility of Color Diagnosis System

### Introduction

Color is a visually perceived property that is derived from the reflected or transmitted spectrum of light interacting with the eye. (Fig.1).

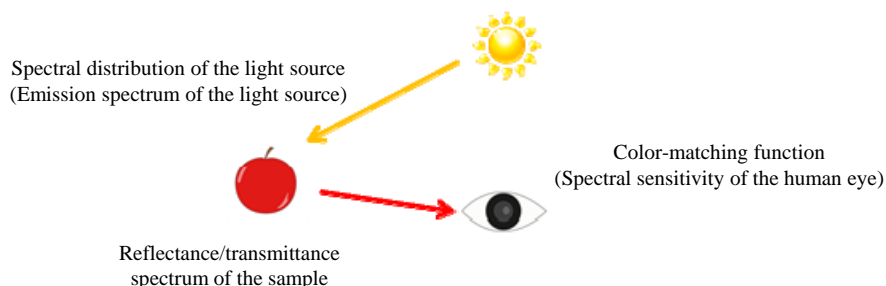


Fig.1 Mechanism of color recognition by human eye

It is important to evaluate and obtain measurable factors describing color for color management during the industrial processes used in the manufacture of products.

JASCO has developed various applications that use the V-700 Series of UV/Vis spectrophotometers for color analysis using both reflectance and/or transmittance spectra of samples. The V-700 spectrophotometer uses a double-beam optical system, which offers high measurement accuracy and stability. Because of the high performance of the V-700 UV/Vis spectrophotometer color coordinates (results for color calculation) can be determined with high reproducibility.

This application note illustrates the reproducibility of color calculations made using JASCO's proprietary color diagnosis system.

**Keyword:** V-700 UV-Visible spectrophotometer color analysis, color diagnosis, chromaticity, XYZ,  $L^*a^*b^*$ ,  $Luv$ ,  $L^*u^*v^*$ , Reproducibility

### Sample

Color pellets (blue, red and yellow) (Fig.2)

### Measurement

Measurement was performed using a V-750 UV-Vis spectrophotometer with ISV-922 integrating sphere. Baseline measurement was performed using a standard white reference plate, then the sample was measured. Both reference and sample measurement was made with the specular reflection component included.

To confirm the measurement reproducibility 10 spectra were collected with the sample removed and replaced in between scans to assess the effects of changing the measurement position.

### Measurement Condition

Bandwidth 5.0 nm  
 Scanning speed 400 nm/min  
 Response 0.96 sec  
 Data interval 1 nm

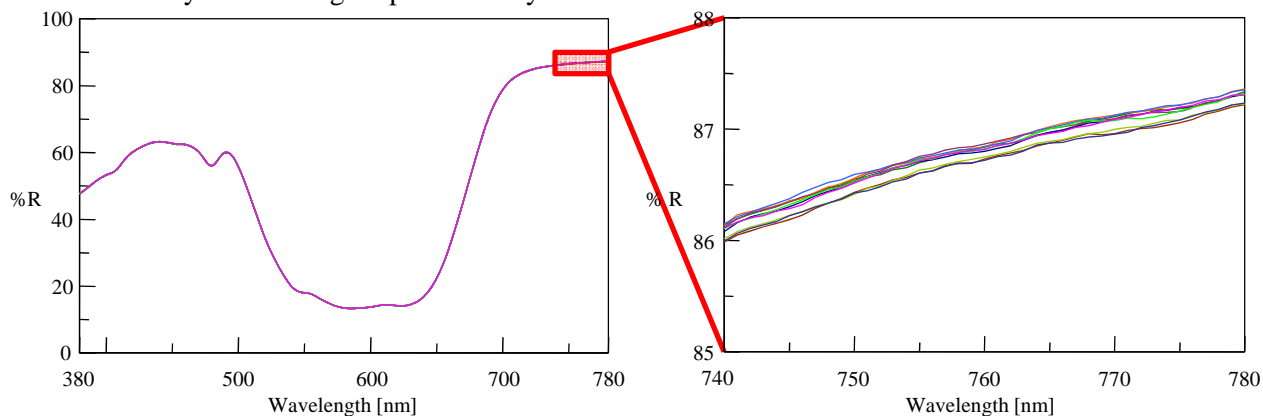


Fig.2 Sample

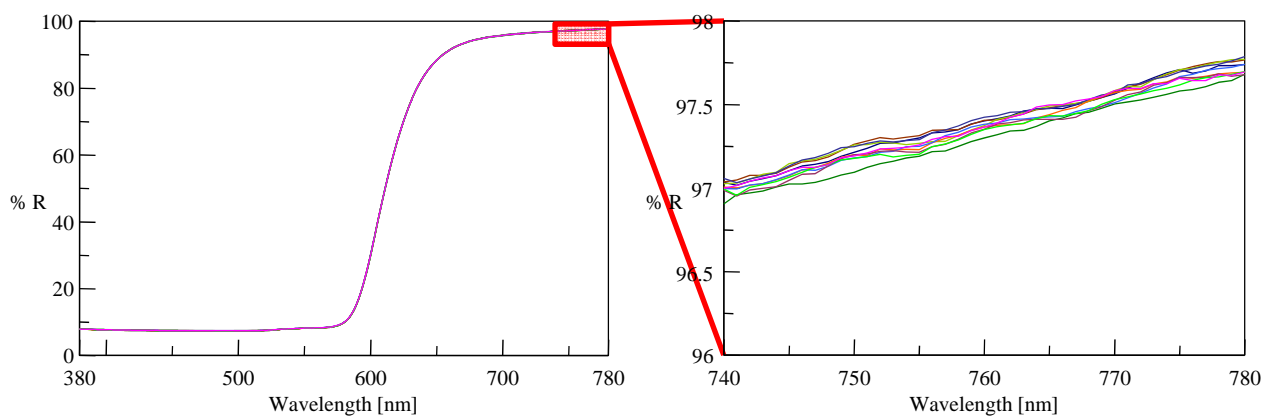
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## Measurement result

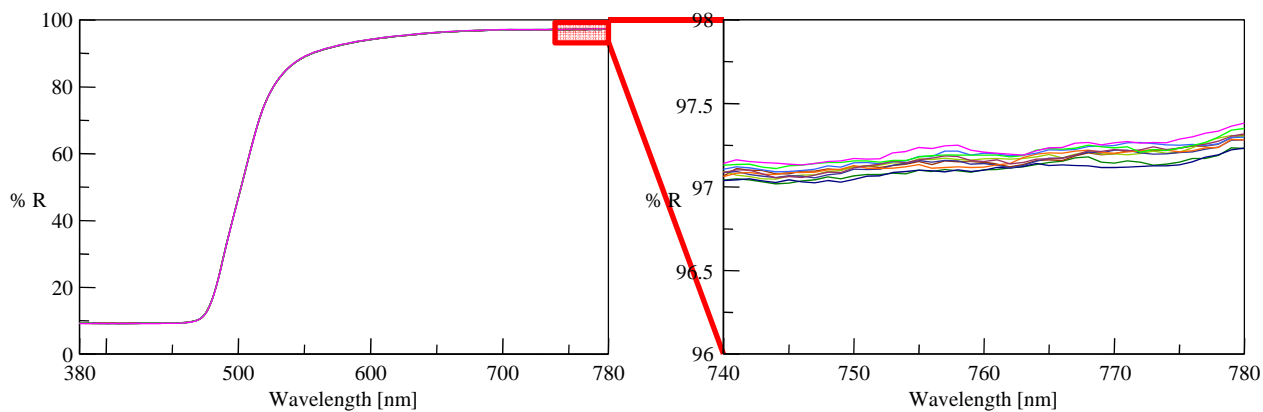
The reflectance spectra measured for each sample are shown in Fig.3. The right side of Fig.3 shows zoomed-in spectra in the wavelength range 740 - 780 nm. As shown in each spectrum, the difference between maxima and minima of the photometric value is less than 0.15%R, this demonstrates that this measurement system has high reproducibility.



Color pellet (Blue)



Color pellet (Red)



Color pellet (Yellow)

Fig.3 Reflectance spectra of color pellets

## Analysis Results

The Color Diagnosis Program (Fig.4) is used to calculate color coordinates from measured spectra. Fig.5 shows the results plotted on XYZ, L\*a\*b\*, Lab and L\*u\*v\* chromaticity diagrams. The calculated values are shown in tables 1, 2 and 3.

For the color coordinates that represent chroma and hue ( $xy$ ,  $a^*b^*$ ,  $ab$ ,  $u^*v^*$ ), the difference between maxima and the minima are;  $x$  and  $y$ , less than 0.0012,  $a^*$  and  $b^*$ , less than 0.31,  $a$  and  $b$ , less than 0.18,  $u^*$  and  $v^*$ , less than 0.50.

For the color coordinates that represent brightness ( $Y$ ,  $L$ ,  $L^*$ ), the difference between the maxima and minima is less than 0.1.

As shown in these results, the JASCO Color Diagnosis system offers high reproducibility.

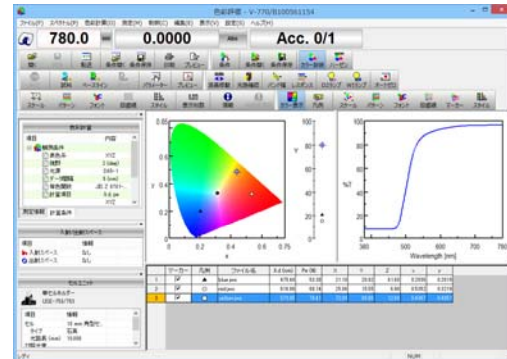


Fig.4 Color Diagnosis Program

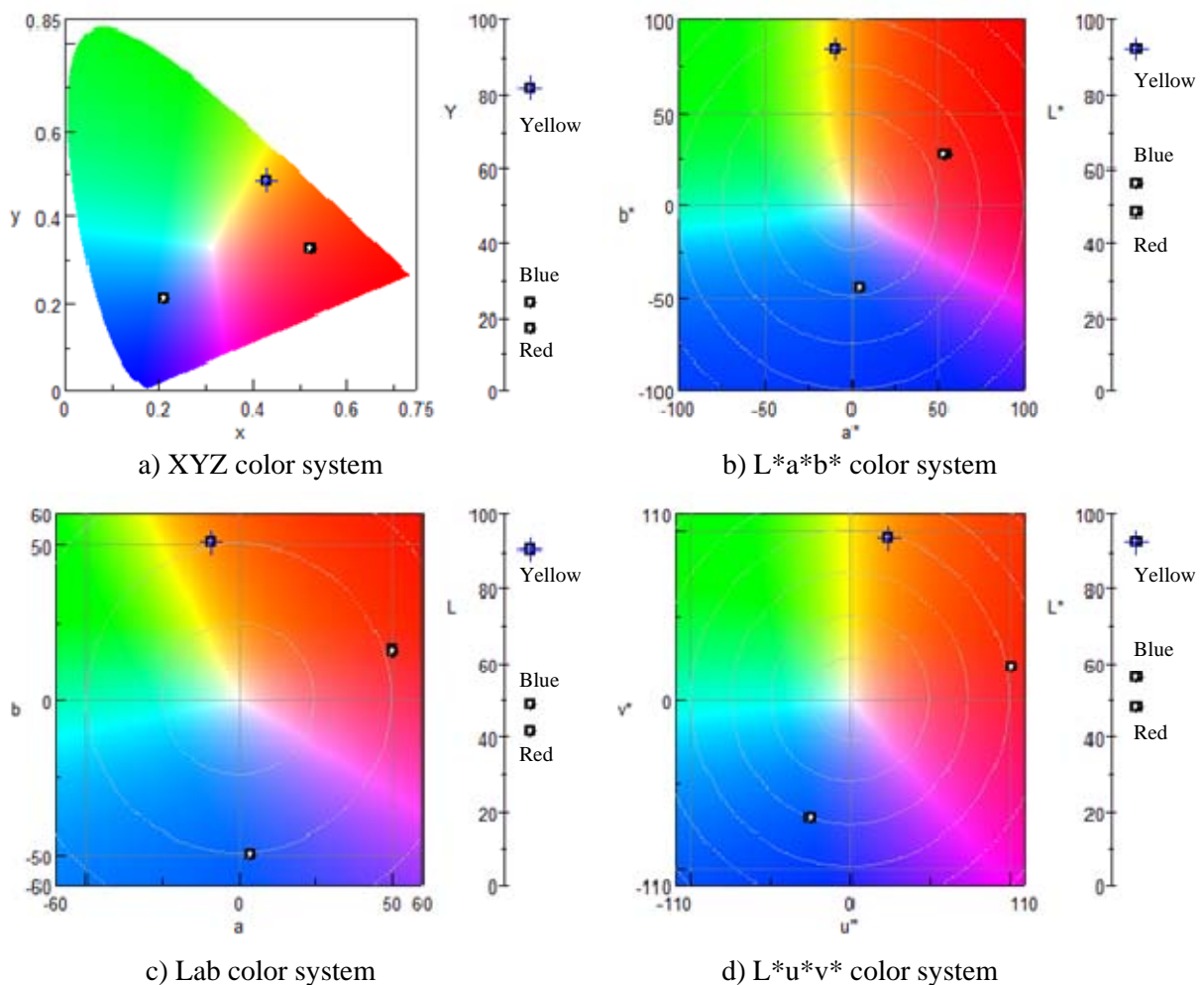


Fig.5 Plots of each sample on chromaticity diagrams



# Application Note

UV-0044

Number of times	X	Y	Z	x	y	L*	a*	b*	L	a	b	u*	v*
1	23.77	23.94	65.84	0.2094	0.2108	56.03	4.58	-44.94	48.93	3.78	-50.19	-24.75	-70.73
2	23.77	23.94	65.81	0.2094	0.2109	56.03	4.57	-44.91	48.93	3.78	-50.15	-24.74	-70.69
3	23.74	23.91	65.70	0.2095	0.2109	55.99	4.57	-44.88	48.89	3.78	-50.09	-24.71	-70.62
4	23.76	23.93	65.72	0.2095	0.2110	56.01	4.57	-44.87	48.91	3.78	-50.08	-24.71	-70.60
5	23.76	23.92	65.71	0.2095	0.2110	56.01	4.56	-44.85	48.91	3.77	-50.06	-24.71	-70.58
6	23.79	23.96	65.85	0.2094	0.2109	56.04	4.57	-44.92	48.95	3.78	-50.16	-24.75	-70.70
7	23.80	23.97	65.85	0.2095	0.2110	56.06	4.55	-44.89	48.96	3.77	-50.12	-24.74	-70.65
8	23.81	23.98	65.83	0.2095	0.2111	56.07	4.55	-44.87	48.97	3.76	-50.08	-24.73	-70.62
9	23.80	23.97	65.79	0.2096	0.2111	56.06	4.55	-44.85	48.96	3.76	-50.06	-24.71	-70.58
10	23.80	23.97	65.81	0.2095	0.2111	56.06	4.55	-44.86	48.96	3.76	-50.08	-24.73	-70.61
<b>Max-Min</b>	0.07	0.07	0.15	0.0002	0.0003	0.07	0.03	0.09	0.07	0.02	0.13	0.05	0.14
<b>Ave.</b>	23.78	23.95	65.79	0.21	0.21	56.04	4.56	-44.88	48.94	3.77	-50.11	-24.73	-70.64
<b>SD</b>	0.02289	0.02509	0.05879	0.00006	0.00008	0.0252	0.0104	0.0312	0.0256	0.0083	0.0456	0.0168	0.0512
<b>CV [%]</b>	0.10	0.10	0.09	0.03	0.04	0.04	0.23	-0.07	0.05	0.22	-0.09	-0.07	-0.07

Table 1 Color calculation results of color pellet (blue)

Number of times	X	Y	Z	x	y	L*	a*	b*	L	a	b	u*	v*
1	27.74	17.16	8.17	0.5226	0.3234	48.47	53.78	26.78	41.43	49.99	15.67	101.05	19.17
2	27.78	17.17	8.09	0.5238	0.3237	48.47	53.94	27.08	41.44	50.17	15.80	101.55	19.40
3	27.76	17.15	8.10	0.5236	0.3236	48.45	53.92	27.02	41.41	50.14	15.77	101.46	19.34
4	27.75	17.15	8.08	0.5238	0.3237	48.45	53.92	27.06	41.41	50.13	15.79	101.48	19.37
5	27.73	17.14	8.10	0.5236	0.3236	48.43	53.90	26.99	41.40	50.11	15.75	101.39	19.31
6	27.70	17.11	8.10	0.5235	0.3235	48.40	53.89	26.94	41.37	50.10	15.73	101.35	19.27
7	27.76	17.18	8.13	0.5231	0.3237	48.49	53.80	26.97	41.45	50.01	15.76	101.21	19.34
8	27.72	17.14	8.11	0.5233	0.3235	48.43	53.85	26.93	41.40	50.06	15.73	101.27	19.27
9	27.72	17.14	8.11	0.5233	0.3235	48.43	53.86	26.93	41.40	50.06	15.73	101.28	19.27
10	27.77	17.19	8.13	0.5231	0.3238	48.50	53.78	26.97	41.46	50.00	15.76	101.18	19.35
<b>Max-Min</b>	0.09	0.08	0.08	0.0012	0.0004	0.10	0.16	0.31	0.09	0.18	0.13	0.50	0.23
<b>Ave.</b>	27.74	17.15	8.11	0.52	0.32	48.45	53.86	26.97	41.42	50.08	15.75	101.32	19.31
<b>SD</b>	0.0270	0.0230	0.0274	0.00038	0.00012	0.0288	0.0613	0.0852	0.0278	0.0640	0.0377	0.1545	0.0670
<b>CV [%]</b>	0.10	0.13	0.34	0.07	0.04	0.06	0.11	0.32	0.07	0.13	0.24	0.15	0.35

Table 2 Color calculation results of color pellet (red)

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Number of times	X	Y	Z	x	y	L*	a*	b*	L	a	b	u*	v*
1	73.34	82.03	14.95	0.4306	0.4816	92.59	-9.44	84.03	90.57	-9.25	50.69	23.70	95.18
2	73.34	82.03	14.95	0.4306	0.4816	92.59	-9.43	84.03	90.57	-9.25	50.69	23.71	95.17
3	73.37	82.06	14.93	0.4307	0.4817	92.60	-9.44	84.11	90.59	-9.26	50.72	23.72	95.23
4	73.37	82.06	14.91	0.4307	0.4817	92.60	-9.44	84.15	90.59	-9.25	50.73	23.74	95.26
5	73.36	82.04	14.93	0.4307	0.4817	92.59	-9.42	84.10	90.58	-9.24	50.71	23.75	95.22
6	73.36	82.05	14.94	0.4307	0.4817	92.60	-9.44	84.09	90.58	-9.25	50.71	23.72	95.22
7	73.38	82.07	14.92	0.4307	0.4817	92.60	-9.44	84.13	90.59	-9.25	50.73	23.74	95.25
8	73.37	82.06	14.93	0.4307	0.4817	92.60	-9.44	84.11	90.59	-9.25	50.72	23.73	95.23
9	73.40	82.07	14.90	0.4308	0.4817	92.61	-9.41	84.18	90.59	-9.22	50.74	23.79	95.27
10	73.41	82.09	14.87	0.4309	0.4818	92.62	-9.41	84.26	90.60	-9.23	50.77	23.81	95.33
<b>Max-Min</b>	0.07	0.07	0.08	0.0003	0.0002	0.03	0.03	0.23	0.04	0.03	0.08	0.11	0.16
<b>Ave.</b>	73.37	82.06	14.92	0.43	0.48	92.60	-9.43	84.12	90.59	-9.24	50.72	23.74	95.24
<b>SD</b>	0.0218	0.0201	0.0232	0.00008	0.00006	0.0089	0.0118	0.0678	0.0111	0.0112	0.0241	0.0348	0.0457
<b>CV [%]</b>	0.03	0.02	0.16	0.02	0.01	0.01	-0.13	0.08	0.01	-0.12	0.05	0.15	0.05

Table 3 Color calculation results of color pellet (yellow)

### Analysis Conditions

Light source	D65 (CIE 15:2004, JIS Z 8781-1:2012, ISO 11664-2:2007)
Color-matching function	CIE 15:2004, JIS Z 8701:1982
Viewing angle	2°
Data interval	5 nm