Canon

PIXMA

ChromaLife100

Technology and Performance Overview

CANON INC.

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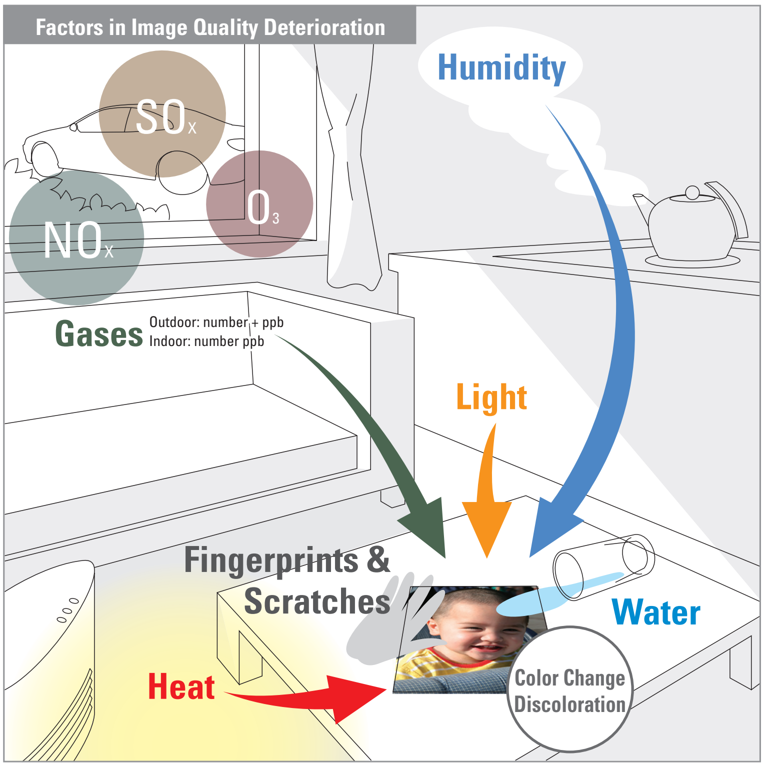
1 Dye Ink Characteristics and Issues

Dye Ink Characteristics

Printing photos at home has become commonplace as the image quality of inkjet printers has improved and digital cameras have increased in popularity. The photo quality provided by PIXMA printers has already achieved a level that rivals that of silver halide photos, and particularly because of the good coloration capabilities and strong glossy photo paper compatibility possessed by dye ink, PIXMA printers are being used not only by home users but also by semi-professional and professional photographers in their works.

Dye Ink Issues

Good coloration and compatibility with glossy photo paper are characteristics of dye ink, but when compared to silver halide photos and pigment ink, photos printed with dye ink and left exposed (without putting into a frame or pasting in an album) are more susceptible to change under the impact of gases (pollutants in the air), light and humidity.



2 New Dye Ink Development and ChromaLife100

Exceptional coloration and glossy paper compatibility, but susceptibility to the impact of light, gases and humidity—this has been the predicament of dye ink, but Canon devoted itself to creating a system in order to solve this problem. As a result of these efforts, Canon developed genuine dye inks (CLI-8/CLI-36, CL-41/CL-51/CL-52, BCI-16) that are highly resistant to gases, light and humidity, the causes of image deterioration.

The genuine dye inks have been prepared so that maximum image permanence is exhibited when combined with genuine Canon photo media. ChromaLife100 is the name given to this system to improve the image permanence of photos, which is made possible with this combination. ChromaLife100 provides high levels for both image quality and image permanence, so printed photos are resistant to fading even when displayed in a room, allowing their beauty to be enjoyed for a longer period of time.

This guide explains technological issues in the development of Canon's new dye inks, along with the methods used to resolve them, from the three perspectives of gas fastness (which refers to resistance to pollutants in the air), light fastness and humidity fastness.

The guide further explains improvements that were made to the black ink, which is important for printing high contrast photos with high density.

New Dye Inks

CLI-8/CLI-36

CL-41/CL-51/CL-52

BCI-16

ChromaLife100

3 Improved Gas Fastness

Realizing 10-Year Gas Fastness

3-1 Developing Highly Reliable, Fair Testing Methods

Gases Causing Image Deterioration in Indoor Environments Where Photos are Displayed

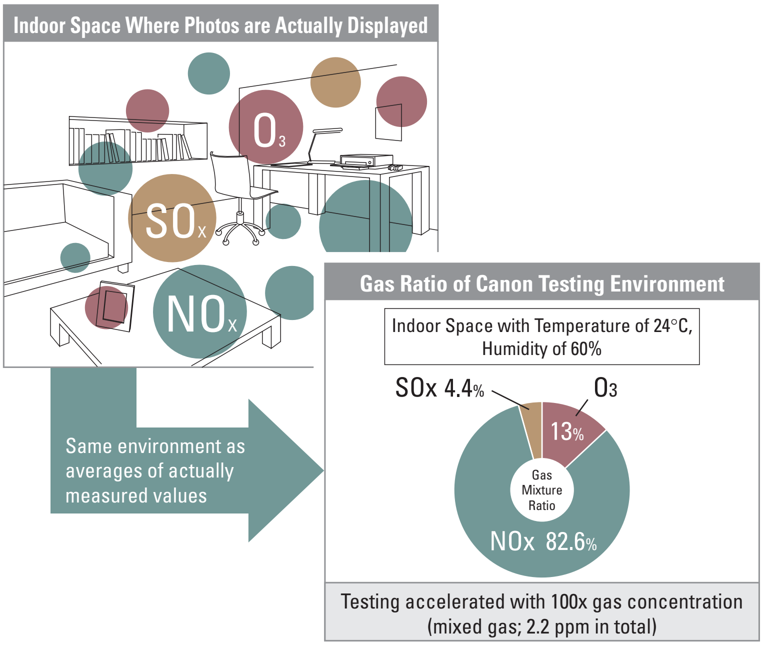
Beginning in the 1990's Canon used a test involving exposure only to ozone gas (O_3) as its evaluation method for gas fastness. However, there were differences between the color changes when displaying a printed item in an actual environment and the changes produced by an O_3 exposure test. Why these differences occurred was a point of inquiry for many years. Canon's approach to improving gas fastness began with the question of whether ozone-only environments accurately reproduce actual indoor spaces.

Over a one year period Canon investigated to verify correlations between gases and image deterioration in several homes and offices. As a result, it was found that images printed out with inkjet printers deteriorate under the influence not only of O_3 but also of nitrogen oxide (NOx) and sulfur oxide (SOx). It was also discovered that non-O_3 gases affect photos printed with methods other than inkjet printing.

Average gas concentration estimated through simplified measurement using a passive sampler.

Preparing a Testing Environment Close to an Actual Indoor Space

Based on the above results, Canon decided to prepare a mixed gas testing environment containing not just O_3 but SOx and NOx as well in order to simulate gas-induced image deterioration. The temperature of the environment was set at 24°C, humidity at 60%, and the ratio of the gases at O_3 : NOx : SOx = 3: 19: 1, which is equivalent to average ratio taken from actual measurements in an indoor environment. Under these settings, accelerated tests with 100 times concentration were conducted. (mixed gas; 2.2 ppm in total)

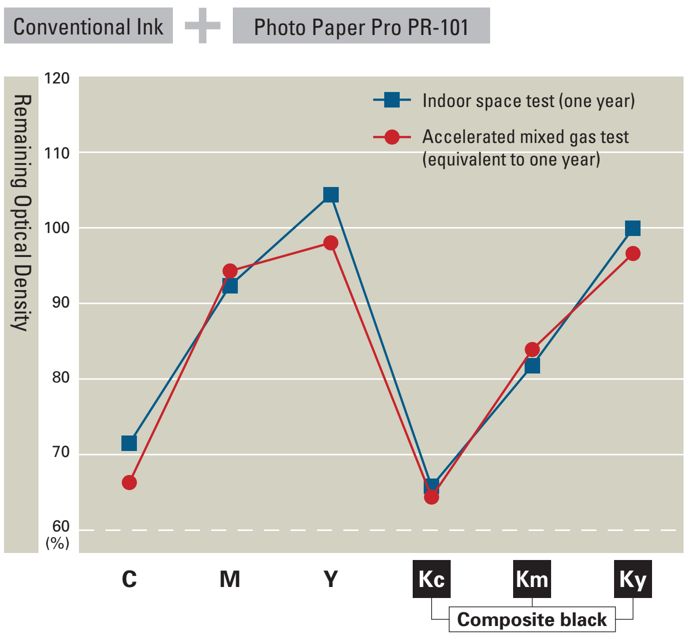


Mixed Gas Environment Favorably Reproduces Typical Indoor Environment

Next, examination was made to verify how typically Canon's testing method in mixed gas environments can reproduce the results of exposure in an actual indoor environment. The results, shown in the graph below, are a comparison of the remaining optical density (OD) of a sample subject to an accelerated test in the mixed gas environment and of a sample left exposed in an indoor space for a period of one year. The lower the remaining OD ratio*, the more prominent the degradation. This test was conducted on conventional dye inks.

*OD stands for optical density. It expresses the density of an image as seen to the eye in terms of a numerical value. Remaining optical density is a numerical value for the amount of change in density as seen to the eye. The initial density is 100 and the remaining density is expressed as a percentage of the initial density. If it is 100% there has been no change. If it is 50%, the density is about half of what it initially was.

Image Degradation Comparison Between Mixed Gas Environment and Indoor Space



■ **Indoor space test:** Average values of samples left exposed in several homes and offices.

● **Mixed gas environment test:** 24°C, 60% RH, O_3: NOx: SOx = 3: 19: 1, fixed concentration in container, calculated with 72 hours as the equivalent of one year

Comparing the two, it was found that the remaining OD ratios for cyan, magenta, yellow and composite black* were extremely similar. It was also seen that there is a strong correlation between the mixed gas environment and indoor space in terms of the color balance following discoloration.

*Composite black is black made with the three colors yellow, magenta and cyan. If yellow, magenta, and cyan dots are printed on the paper in a given density, the color appears black to the eye. It is called composite black to distinguish it from black printed with black ink.
Kc, Km, and Ky express the yellow, magenta and cyan components of composite black. Black turns brown if the cyan component fades relatively early.

Based on the result of this experiment, Canon uses an environment with a mixture of three types of gases for testing gas fastness.

3-2 Improving Gas Fastness

There are two important factors involved in improving gas fastness. The first is to develop dye ink strongly resistant to molecular breakdown due to gases. The second is to bring the respective degrees of discoloration in cyan, magenta and yellow into alignment to the extent possible.

Curbing Gas-Induced Breakdown of Dye Molecules and the Bronzing Phenomenon

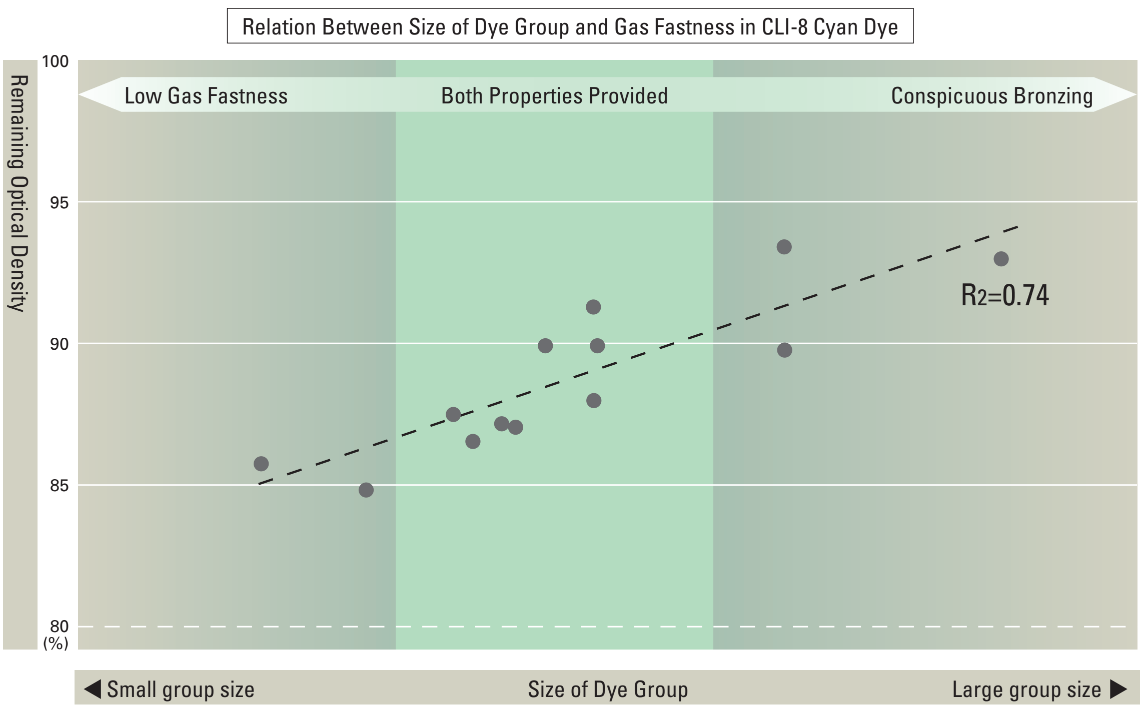
Ink discoloration occurs when its component molecules are broken down by gases in the air, namely, O_3, NOx, and SOx. Dye inks tend to fade more easily than pigment inks for the following reason. With pigment inks the molecules that are the basis of color form into groups, whereas with dye inks the molecules stick to the paper individually. To the extent the molecules bind into groups, pigment inks are stronger against the impact of gases and the pace of fading is slower.

So the question is what can be done in order to curb the discoloration of dye ink.

Let us take cyan as an example, which is susceptible to the impact of gases. The more easily cyan dye forms into groups like a pigment, the stronger it becomes. However, when this happens, with cyan dye, a problem known as bronzing occurs more readily. Bronzing substantially reduces photo quality. For example, when displaying a picture of the blue sky, the blue will take on a red tone in the reflection of fluorescent lighting.

In order to solve this problem, Canon introduced groups into the molecules to protect the important portions that generate color from the impact of gases. At the same time, the degree of group formation was controlled so bronzing would not occur while groups were formed.

Development of Dye Ink with Gas Fastness and Bronzing Resistance



Maintaining Color Balance during Discoloration

Gas-induced ink discoloration occurs at the molecular level, so while it is possible to slow discoloration it is impossible to prevent it completely. This is why it is necessary to try to make discoloration less apparent to the eye even when it does occur.

With Canon's conventional dye inks, the speed of discoloration differed substantially with each type of ink. Yellow was the slowest, followed by magenta and cyan. As a result the difference in yellow and cyan colors would grow larger as time passed and the color balance would break down. This kind of color change can be instantly identified and it is not visually appealing.

For the new dye inks, in addition to improving the gas fastness of the cyan ink as described above, optimal dyes from the standpoint of gas fastness were selected for the yellow ink. By doing so, Canon brought the discoloration speeds of the cyan, magenta and yellow inks into alignment to the extent possible. As a result, Canon succeeded in reducing the breakdown in the color balance during discoloration, so that colors in printed photos show little change to the eye over a long period of time.

Using this ink and printing on Photo Paper Pro PR-101 provides image permanence of approximately ten years in an accelerated test with a mixture of three gases that closely resembles an actual indoor environment.

Gas Fastness of New Dye Ink

CLI-8 + Photo Paper Pro II PR-201

Original After 10 Years

(Conceptual Image)

For its new dye inks Canon succeeded in improving gas fastness, particularly for cyan ink, and in aligning the discoloration speed of each color, enabling a longer lifespan while maintaining a favorable color balance.

<Criteria for estimation>
Estimated gas fastness is made under the following test conditions:
Temperature (24°C) and humidity (60% RH) are controlled in an environment of mixed gases of O_3, NOx and SOx. The ratio of the gases is typical to indoor air composition (O_3: NOx: SOx = 3:19:1) with 100 times concentration in order to accelerate color fading.

<Criteria for estimation of print longevity shown above>
Estimates for image permanence are made using the Wilhelm Imaging Research, Inc. endpoint criteria "WIR Visually-Weighted Endpoint Criteria Set v3.0" as follows;
Samples are printed with an optical density of 1.0 and 0.6 (each black, cyan, magenta, yellow) by default printer driver setting of each media.
The point where monochromatic/ reflective optical density shows loss of 20-35% (figure set respectively for each color, starting density of 1.0 and 0.6). The point where the difference in color balance of yellow, magenta and cyan (each component in composite black) reaches 12-18%.

4 Improving Light Fastness

Achieving 30-Year Light Fastness

Properties of Canon Photo Paper

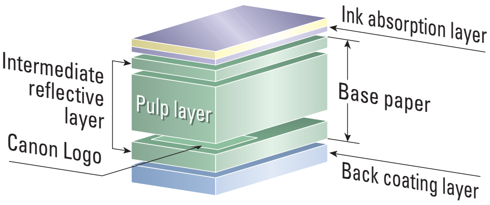
The quality and permanence of inkjet images depend largely on the properties of the paper, not just on the ink. Inkjet photo papers roughly fall into two categories: porous and swellable. All the photo papers developed and sold by Canon are of the porous type.

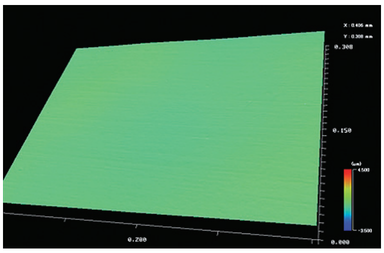
With porous paper, the water content of the ink is absorbed by the base paper and so it tends not to overflow on the paper surface, making it possible to obtain precise image quality. On the other hand, the ink dye is absorbed by the ink absorption layer, making sharp printouts possible. Canon's Photo Paper Pro has an ink absorption layer—one of the keys to image quality—with a smooth surface, for glossiness and sharpness that rival silver halide photographs.

In addition, porous paper is also characterized by excellent ink absorption and drying. Ink mixture and bleeding can also be curtailed, enabling continuous ink ejecting over a short interval to realize high-speed printing.

In this way, porous-type photo paper plays an important role in supporting high-quality, high-speed printing by PIXMA printers.

Structure of Photo Paper Pro





The smoother the surface of the paper, the more glossy it will be. There is hardly any surface texture on Canon's Photo Paper Pro.

Improving Light Fastness with Porous Photo Paper

It is well known that photos and printed materials fade when exposed to light. This is because light breaks down colorants in the dyes.

Particularly, there are many magenta dyes that are problematic with respect to light fastness, and it was very difficult to make improvements. We considered the use of metallic dyes, which are said to have high light fastness. However, within our examination scope, gas fastness tended to decrease when metallic dyes were combined with Canon photo paper. Light fastness would improve, but gas fastness would worsen. This was a dilemma.

Given this situation, Canon chose to develop new non-metallic magenta dyes with high light fastness. As a result of testing many different dyes we succeeded in improving light fastness while preserving the advantages of porous media, namely, high image quality and fast drying properties.

With the combination of Canon's new dye inks and Photo Paper Pro, photos stored in glass photo frames in an indoor space not exposed to direct sunlight exhibit image permanence of approximately 30 years.

Light Fastness Comparison Between Conventional Ink and New Dye Ink

Conventional Ink + Photo Paper Pro PR-101

Original

After 30 Years

CLI-8 + Photo Paper Pro II PR-201

Original

After 30 Years

(Conceptual Image)

<Criteria for estimation>
Estimated lightfastness is made under the following test conditions.
Light source: White fluorescent light 70,000lux; Temperature: 24°C; Humidity: 60% RH; A 2-mm thick glass is placed on the sample during accelerated testing.

<Criteria for estimation of print longevity shown above>
Estimates for image permanence are made using the Wilhelm Imaging Research, Inc. endpoint criteria "WIR Visually-Weighted Endpoint Criteria Set v3.0" as follows;
Samples are printed with an optical density of 1.0 and 0.6 (each black, cyan, magenta, yellow) by default printer driver setting of each media.
The point where monochromatic/ reflective optical density shows loss of 20-35% (figure set respectively for each color, starting density of 1.0 and 0.6). The point where the difference in color balance of yellow, magenta and cyan (each component in composite black) reaches 12-18%.

5 Improving Humidity Fastness

Making Long-Lasting, Sharp Images

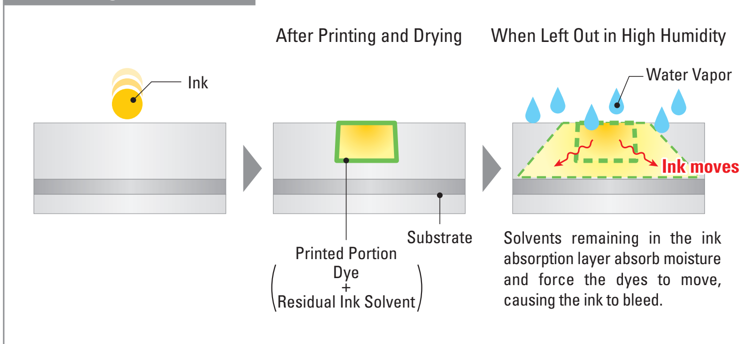
Raising Humidity Fastness While Preserving Dye Coloration Properties

If inkjet images are left in an environment with high humidity, residual solvents in the ink absorption layer of the paper absorb moisture in the air and cause the dyes to move. This is the cause of ink bleeding, and the smaller the molecular weight of the dye, the greater the amount moved and the more pronounced the bleeding. As a result, adjacent colors mix together, change color, and the image is degraded.

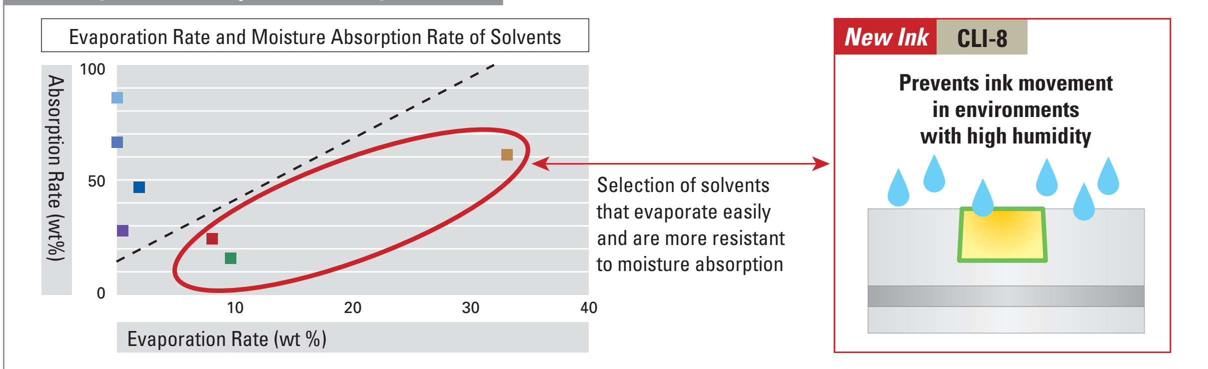
Dyes with large molecular weights should be used in order to reduce this bleeding, but there is a dilemma: the larger the molecular weight, the lower the coloration efficiency. It is difficult to provide both humidity fastness and good coloration with dyes alone.

Given this, Canon focused attention on the solvents used in the ink. If the solvents themselves evaporate easily and tend not to absorb moisture in the air, then movement of the dyes is lessened and bleeding is reduced. Selection of appropriate solvents followed measurements of the evaporation and moisture absorption rates of multipurpose solvents. Thus, Canon's new dye inks use the optimal solvents for each color.

Bleeding Mechanism



New Dye Inks with Improved Humidity Fastness



Canon's new dye inks use solvents with a high evaporation rate and low absorption rate. Combined with Professional Photo Paper, humidity fastness is improved compared to conventional inks. Even in environments with high humidity, there is little color bleeding and hardly any color change.

6 Creating "Neutral Black" with Exceptional Gas Fastness and Light Fastness

Aiming for Black Without Color Saturation

Importance of Black Ink

Black ink not only handles printing in the gray to black range, but is also a determining factor in the density and contrast of the image as a whole. Depending on the coloration properties of the black ink, an image can provide a dynamic three-dimensional feel, or end up giving a flat impression.

The dye's color tone is also extremely important to image quality. Creating a perfect, colorless black with inks is extremely difficult. At the same time, however, black that does not take on any color sharpens the photo and brings out its beauty.

Furthermore, the tone of gray needs consideration. Referred to as the foundation of color, gray substantially affects objects with low coloration, like skin tones, clouds, walls, buildings, and the ground. If the tone of the gray is poor, image quality declines considerably.

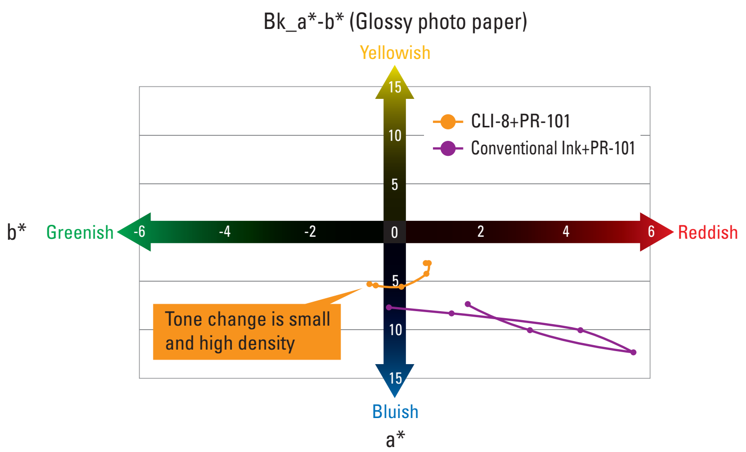
Making Black Ink More Neutral

Canon succeeded in bringing the tone of its black ink closer to neutral, thus improving its visual blackness by combining a variety of dyes. The ratios of the dyes were adjusted so that differences in color under different light sources—sunlight, fluorescent lighting, etc.—would be as small as possible. As a result, even when changing the tone to gray the black ink takes on little color.

Canon's CLI-8 dye-based black ink has high gas fastness and light fastness owing to increasing the size of the molecules. It also helps produce sharp images with high contrast and high density, reproduces dynamic skin tones, and has favorable low coloration.

Conceptual Diagram

Black Ink Tone Comparison Between Conventional Ink and New Dye Ink



Test sample were created ranging from white-like gray to jet black. The colors were measured and plotted on a coordinate system with a* and b* as axes. The more the points are grouped together, the less the color change. When printed in a gradation pattern from light gray to black, the gray sometimes takes on a reddish color or yellowish color. This is unappealing when printing out a black-and-white photo.