# Technical Information (vol.21)

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## [Kayalon Polyester PL-HC Series for dyeing of Polylactic Acid (PLA) fibers]

### Introduction

Polylactic acid fibers are attracting attention as a non-petroleum-based, biodegradable fiber amid recent environmental concerns such as the Sustainable Development Goals (SDGs). Unlike conventional petroleum-based plastics, polylactic acid fibers are derived from plant resources such as corn, which can be harvested annually, making them a promising material for contributing to the realization of a sustainable society. In addition to their biodegradability, polylactic acid fibers offer novel benefits not found in conventional synthetic fibers, such as a soft texture, lightweight, moisture-wicking, quick-drying, antibacterial properties, and a mild acidity that is gentle on the skin. These features make them highly anticipated as a versatile alternative to polyester fibers.

This article introduces the new Kayalon Polyester PL-HC series for polylactic acid fibers and provides important considerations for dyeing and processing polylactic acid fibers.

### Features of the Kayalon Polyester PL-HC Series

It is well known that polylactic acid (PLA) fiber can be dyed with disperse dyes, but not all commercially available disperse dyes will effectively dye PLA fiber.

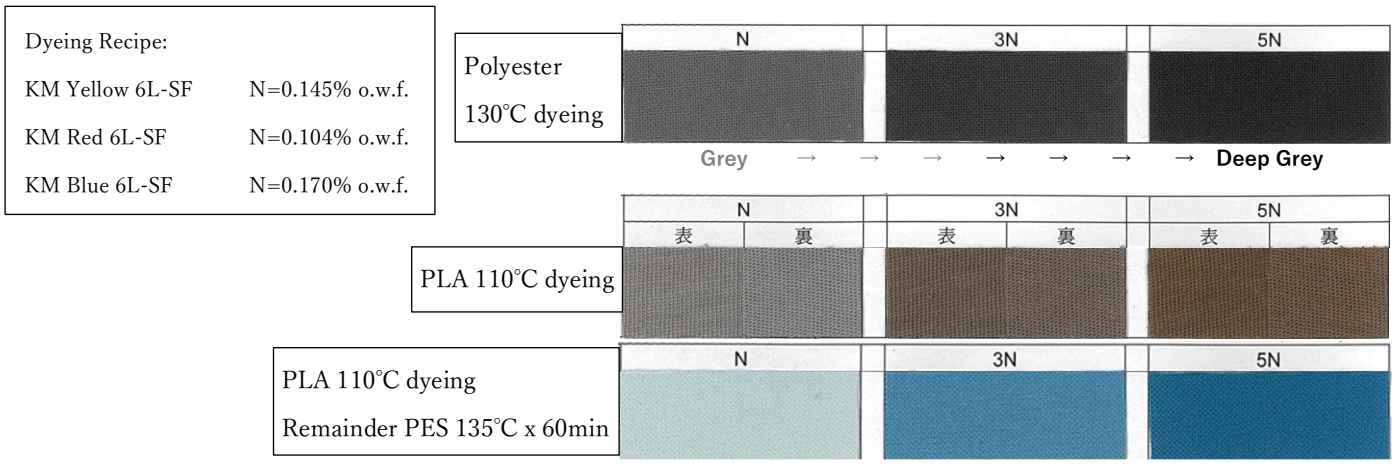



*Figure 1 Dyeing test results for polyester and PLA fibers using our KM 6L-SF trichromatic disperse dye*

When dyeing polyester fiber, the gray hue at N concentration becomes deep gray as the concentration is increased to 3N and 5N. In contrast, when dyeing PLA fiber, the gray hue at N concentration becomes brown as the concentration is increased to 3N and 5N. This phenomenon was found to be caused by the presence of blue components in the residual bath that do not dye PLA fiber.

Therefore, not all existing disperse dyes will dye PLA fiber, and careful selection of the dye is necessary. In fact, when

dyeing PLA fiber with commercially available black disperse dye, the color may turn brownish or reddish, failing to achieve the typical black color.

Therefore, we developed dyes for PLA fiber that are dyeable and have practical fastness levels: KP PL-HC series, consisting of three primary colors and black.

| Product Name | %o.w.f. | Color sample | Light JIS L0843 Xenon-Arc Grade 4 | Washing JIS L0844 A-2 50℃ | | | Perspiration JIS L0848 Alkali | |
|---|---|---|---|---|---|---|---|---|
| | | | | Cotton | Nylon | Washing Liquor | Cotton | Nylon |
| KP Yellow Brown PL-HC | 2.0 | | **4** | **4-5** | **4** | **3** | **4** | **3-4** |
| KP Rubine PL-HC | 2.0 | | **4** | **4-5** | **4-5** | **3** | **3-4** | **3** |
| KP Navy Blue PL-HC | 2.0 | | **3-4** | **4-5** | **4** | **3** | **3-4** | **3** |
| KP Yellow Brown PL-HC<br>KP Rubine PL-HC<br>KP Navy Blue PL-HC | 1.0<br>1.0<br>1.0 | | **3-4** | **4-5** | **4-5** | **3** | **3-4** | **3** |
| KP Black PL-HC(B) | 5.0 | | **3-4** | **4-5** | **4-5** | **3** | **3-4** | **3** |

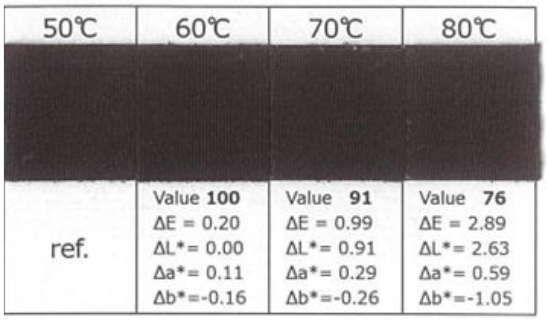
*Figure 2 Color samples and various fastness of KP PL-HC series*

Figure 2 shows the fastness levels for each. A key feature is the consistent dyeing rate of the trichromatic colors, resulting in a product design with excellent reproducibility.

## Cautions for Dyeing Polylactic Acid (PLA) Fiber

(1) Reduction Clearing process after dyeing

One of the precautions to take when dyeing PLA fiber is reduction clearing temperature. Polyester fibers are typically reduction cleared at 80-90℃; however, reduction clearing PLA fibers at 80℃ can cause a loss of dyeing concentration, as shown in Figure 3. Depending on the type of PLA, a loss in concentration can even occur at 65℃. Therefore, reduction clearing at 60℃ or below is recommended for PLA fibers. The reduction clearing temperature is thought to be related to the glass transition temperature of PLA fiber.




| Dyeing Recipe: | |
|---|---|
| KP Yellow Brown PL-HC | N=1.0% o.w.f. |
| KP Rubine PL-HC | N=1.0% o.w.f. |
| KP Navy Blue PL-HC | N=1.0% o.w.f. |

*Figure 3 Effect of Reduction Clearing temperature on dyeing depth of PLA fibers*

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(2) Heat setting or drying process after reduction clearing

The second thing to be aware of when dyeing PLA fiber is the heat setting or drying process after reduction clearing. While the heat setting temperature for typical polyester fibers is 180℃, PLA fiber requires a lower heat setting temperature because the fibers will harden if heat set at 180℃.

Table 1: Wet Fastness Test Results After Heat Setting at various temperatures

| KP Black PL-HC(B) 5.0% o.w.f. | Washing Fastness JIS L0844 A-2 | | | Perspiration Fastness JIS L0848 | |
|---|---|---|---|---|---|
| | Cotton | Nylon | Residual washing liquor | Cotton | Nylon |
| 100℃×3min. | 4-5 | 4-5 | 3 | 3 | 2-3 |
| 120℃×3min. | 4-5 | 4 | 2-3 | 2-3 | 2 |
| 140℃×3min. | 4 | 3-4 | 1 | 2-3 | 1 |

Table 1 shows the fastness test results for KP Black PL-HC(B) at a dyeing depth of 5.0% o.w.f., heat set at various temperatures. At a heat set temperature of 100℃ x 3 min., perspiration fastness to nylon staining was below Grade 3, demonstrating the significant impact of heat on fastness. Heat-setting at higher temperatures tends to further deteriorate washing fastness and perspiration fastness. Our recommended heat setting temperature is 90℃ for 3 minutes (Figure 2 shows the fastness test results).

## Conclusion

Based on our extensive dyeing expertise, we offer safe, reliable products with excellent quality and dyeing reproducibility. We also intend to continue providing technical support as a comprehensive dye manufacturer.

Please note that while the technical information and recommended formulations presented here are based on our latest knowledge, they are based on limited, small-scale testing. Therefore, we recommend preliminary testing in all cases.

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