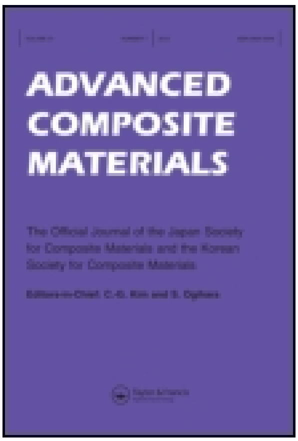

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Development of new decorating method for FRP and FRA

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Abstract—This paper describes a new decorating method developed for FRP products and FRA bathtubs. This method enables us to decorate not only flat surfaces but also uneven surfaces of FRP products. Furthermore, the method enables FRA bathtubs to be transparent, have high gloss and have novel designs. The new decorating method also allows FRA bathtubs to have resistance against hot water, UV-rays and many kinds of cleansers.

Keywords: Decorating FRP; FRA; dye; light resistance; hot water; bathtub durability.

1. INTRODUCTION

We have been developing a innovative decorating method for artificial marble with a high degree of design, such as simulated marble (Fig. 1) and flow patterns (Fig. 2) for counter tops and Menolyna (R) with simulated marble patterns and Grande (R) with a sense of depth for bathtubs.

This article reports a new decorating method that gives FRP and FRA a pattern with unprecedented sense of high quality.

2. DECORATING METHODS FOR FRP, ARTIFICIAL MARBLE AND FRA

Table 1 shows the available decorating methods for FRP, artificial marble and FRA. For Menolyna with simulated marble, the shape of bathtubs is restricted to a box (Fig. 1) as it is necessary to glue glass fiber mats that have marble patterns which resulted in severe restrictions for design purposes. In addition, FRA in which decorated sheets are glued on the boards, has a restricted molding condition and its use location is also limited from the standpoint of hot water durability.

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The developed decorating method in this report uses dye as a colorant to print a pattern on sheets, then heat from the back of the sheets to transfer the pattern by embedding the dye itself into the interior of the acrylic sheet on the product side using the sublimation energy.

Table 1.
Decorating method for artificial marble (AM) and FRA

AM	①	Spray with multi-colored gel-coat
	②	Cultured granite with colored filler
	③	Cast molding of colored compound
	④	Decorated glass cloth laminating sheet (Fig. 1)
	⑤	Cast molding of transparent compound
FRA	⑥	Extruded sheet with multi-colored pattern (Fig. 2)
	⑦	Spray with colored gel-coat after molding sheet
	⑧	Decorated film adhesive sheet

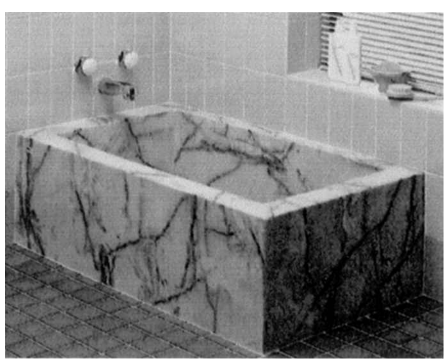

Figure 1. Menorina®.

Figure 2. Scandi • Spa®.

This method enables a surface with an uneven texture to be decorated. Another advantage is that even when the thickness is varied to less than 1/5 during vacuum molding, the surface can still be deformed seamlessly following its extension and a seamless design with a sense of depth as well as reproducibility is possible as the coloring layer is only within 10 μm of the board (see Fig. 3). On the other hand, it is not possible to follow the extension during thermal transfer in which the colorant is glued to the surface of the sheet (see Fig. 4) and cracks may be formed in the coloring layer. In addition, it is necessary to select the coloring layer by taking the adhesivity with the back layer into account for FRA but a layer that embosses the pattern acts as a primary role with the back layer; hence, our method is more advantageous than the thermal transfer method against water absorption expansion and thermal expansion.

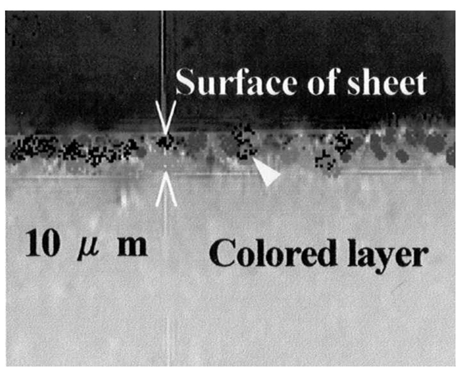

Figure 3. Sublimation transfer method.

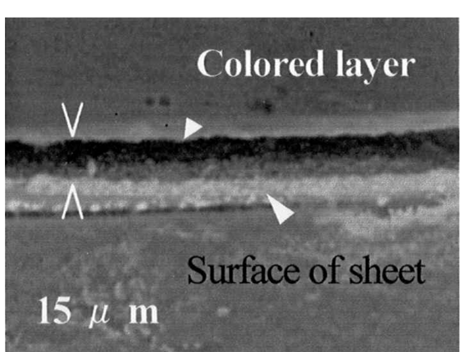

Figure 4. Heat transfer method.

3. DURABILITY

3.1. FRP board decoration

As the main component of the new decorating method is a dye, we measured the change in discoloration as a measure of weather resistance, chemical resistance and heat resistance. First, a comparison was made between a sample with decoration on SMC and a sample with clear coating applied to the SMC decorated surface.

3.1.1. Weather durability (indoor dew exposure test). The three primary colors were transferred to SMC boards. The boards were then left on the window side facing east for approximately one month. Samples with a clear coating and without the clear coating were laid out alternately so that they were evaluated under the same conditions.

It was revealed in the indoor dew exposure test that there was a large difference in discoloration depending on the type of dye color as well as the presence or absence of a clear coating. Clear coating significantly improved the weather resistance (see Figs 5 and 6). After 200 h, the change in discoloration may be seen clearly for each type of clear coating (see Fig. 7).

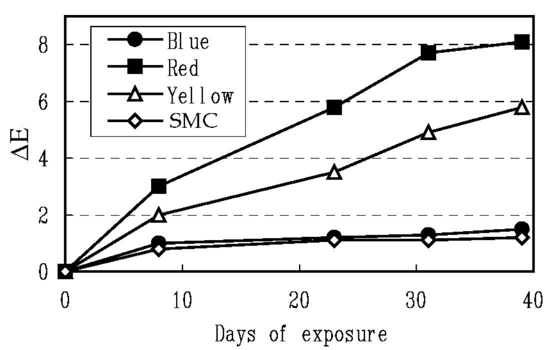

Figure 5. Discoloration during indoor exposure (non-coated).

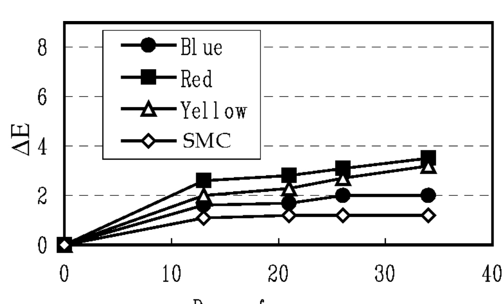

Figure 6. Discoloration during indoor exposure (coated).

3.1.2. Chemical resistance. Discoloration due to immersion for 210 h at 40°C in different chemicals such as 10% NaOH, 10% HCl, isopropylalcohol and sodium hypochlorite and ten types of commercially available detergents revealed that the blue color was very significantly influenced in this test (Table 2).

3.1.3. Hot water resistance. One-sided boiling for each color at 80°C, 60°C and 40°C was conducted in order to observe discoloration tendency. It is seen that the red color was influenced (see Fig. 8) similar to the results from the other durability tests. The blue color also showed a similar tendency. However, the yellow color was only slightly affected by warm water temperatures up to 60°C compared

Table 2.
Discoloration by chemicals after 210 h (ΔE)

Chemicals	Red	Blue	Yellow	Black
10% HCl	2.3	7.6	0.9	1.7
10% NaOH	1.5	6.1	0.5	1.2
IPA	1.8	3.3	5.1	0.8
10% NH_3OH	4.3	7.7	0.8	2.7
NaClO	1.5	5.5	1.0	1.4

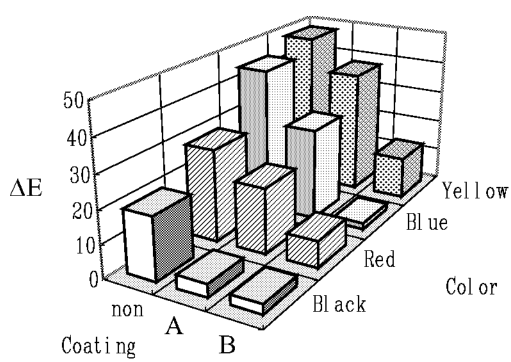

Figure 7. Weather meter: color change after 200 h.

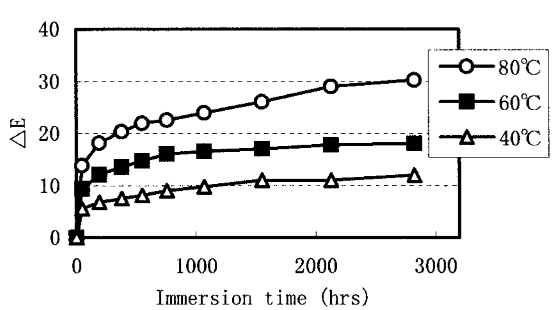

Figure 8. Discoloration of red *vs.* water temperature.

with the degree of discoloration at 80°C (see Fig. 9). For the red and blue colors, the relationship between immersion time and warm water temperature follows the Arrhenius equation (see Fig. 10).

3.2. Durability of acrylic sheet decoration

3.2.1. Influence of thickness. The discoloration was investigated by applying decoration on acrylic transparent sheets with different thicknesses using a UV ray device (see Fig. 11). Similar to the results for the decorated SMC boards, the red and blue colors showed a color change of the same degree but there was very little change in the yellow color. The greater the thickness, the less the change in the blue

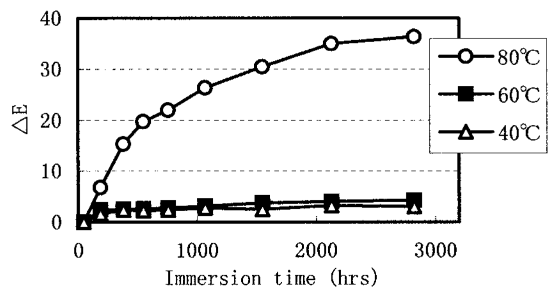

Figure 9. Discoloration of yellow *vs.* water temperature.

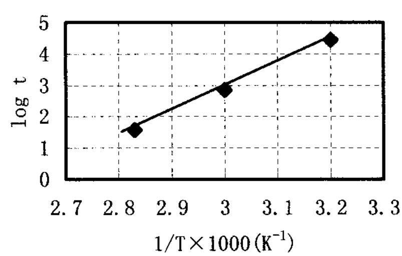

Figure 10. Relationship between water temperature and discoloration of red color.

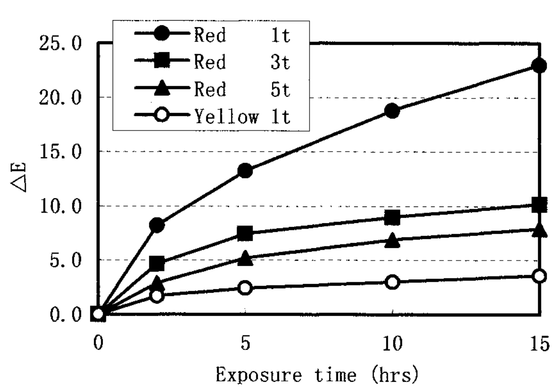

Figure 11. UV-rays testing (Effect of sheet thickness).

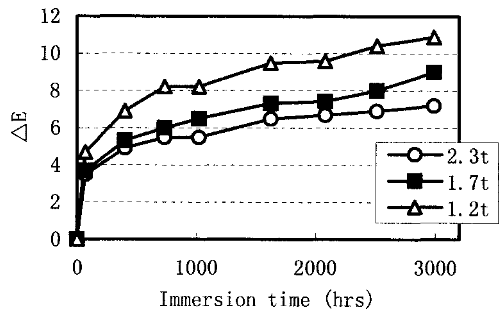

Figure 12. Effect of sheet thickness using 70°C water.

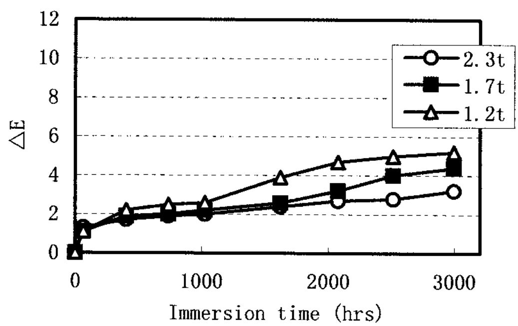

Figure 13. Effect of sheet thickness using 50°C water.

color. This may be due to the difference in the light energy absorption regions on the acrylic sheets.

3.2.2. Heat resistance of dye. Bathtubs which were coated with the three primary colors were fabricated to investigate the difference in the discoloration due to thickness and boiling temperatures. Although the thickness significantly influenced the discoloration rate at temperatures higher than 60°C, there was little the difference in discoloration due to the thickness at temperatures less than 50°C for 3000 h (see Figs 12 and 13).

The rate of discoloration for the sheets with the same thickness in warm water was shown to satisfy the Arrhenius equation, similar to the result of the SMC decorations. We have been examining the possibility of predicting durability using forced tests as the main testing method and in actual usage through monitoring, and recording the correlation of discoloration over one year and it was confirmed that no problem has been found under normal usage.

4. CONCLUSIONS

(i) We have developed a decorating method on FRP surfaces with a large uneven texture. By applying a clear coating, the use may be extended to more severe environments.

Figure 14. Bathtub.

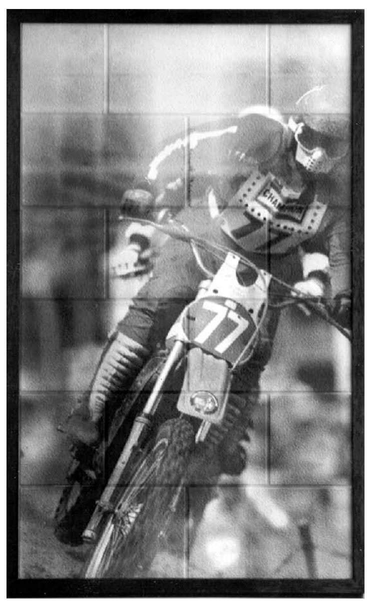

Figure 15. Decorated uneven surface of SMC.

(ii) The conventional decorating method did not work well for gluing sheets with patterns or for flowing patterns using a casting. We developed a new decorating method which enables reproducible patterns to be imprinted in a short period with high productivity.

(iii) The present method was found to have a high durability in the environmental promotion test for decorated FRA bathtubs.