Transactions of the Materials Research Society of Japan 25 [2] 547-550 (2000)

Properties of Self-cleaning Aluminum Building Materials by Photocatalytic Technology

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Anti-fouling technology of the buildings has increasingly become important recently. Various technologies have been studied to achieve this purpose. Photocatalyst is one of the most effective method of anti-fouling. Photocatalyst has the interesting property of decomposing oily components and washing away with rainfall easily. But, so far the study of applying this to aluminum building materials has not been made practicable. We have studied the making of photocatalyst coated aluminum building materials. As a result, we developed the coating technology which achieves both excellent anti-fouling effect and high durability. Furthermore, the technology was tested on actual buildings, which confirms the excellent anti-fouling effect of phocatalyst coated aluminum panel.

Keywords: Photocatalyst, Self-cleaning, Anti-fouling, Aluminum building materials, Hydrophilication

1. INTRODUCTION

Recently, the need to decrease maintenance cost of the exteriors of buildings and to maintain a new look have become more and more important[1]. Therefore, the demand of anti-fouling building materials is increasing, and a great deal of effort has been made addressing this problem[2]. We have been trying to develop photocatalyst coated aluminum building materials. It is well known that materials coated with photocatalysts exhibit excellent anti-fouling properties as a result of the decomposition of organic substances and super-hydrophilication[3]. However, there are two difficulties encountered when applying this technology to aluminum building materials. The first is the protection of organic coatings applied to the aluminum building materials from strong photocatalytic oxidation. The second is the uniform coating of large areas of various shapes of building materials. To solve these problems, we have developed durable photocatalytic paints and uniform photocatalytic-film coating technology. In consequence, the self-cleaning aluminum building materials we have developed were confirmed to have superior anti-fouling effects with high durability.

2. EXPERIMENTAL

2.1 Coating method

As shown in Figure 1, photocatalyst coated aluminum panel samples were prepared. First, the aluminum panels were coated with selected organic paint, then sprayed with photocatalyst. The structure of photocatalyst film we have developed have double layers. The middle layer protects the organic coatings applied to the aluminum building materials from strong photocatalytic oxidation. It also provides adhesion for the photocatalyst layers.

The other is photocatalyst layer, it contains anatase type TiO_2 and silicate binder. As for the method of coating, the solution for middle layer was coated on the surface of aluminum building materials at first, and then dried at 120℃. The next layer, photocatalyst layer, was applied and dried at 120℃.

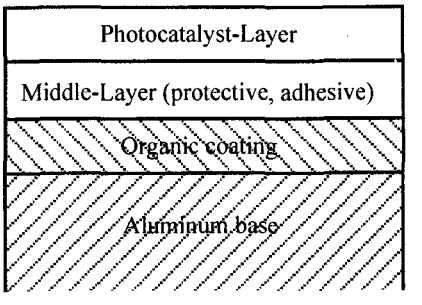


Figure 1. Cross section of photocatalyst coated aluminum building materials.

2.2 Performance test

The two basic properties of the photocatalyst coated aluminum panels, decomposition of organic substances and contact angle of water, were measured after ultraviolet irradiation. Durability is examined based on JIS H 8602. Among which we chose to test adhesion,

pencil scratch, hidrochloric acid resistance, CASS corrosion resistance, boilling water resistance and weathering resistance. Most importantly, weathering resistance is of great concern for exterior building materials due to longevity. So this was tested under conditions even more harsh than specified in JIS test. Anti-fouling effect was examined by exterior exposure test, which measures the difference of surface brightness before and after exposure test, and compared to various types of coating.

3. RESULTS AND DISCUSSION

3.1 Self-cleaning properties

Figure 2 shows the comparison of fouling level between photocatalyst and conventional coatings. These samples were subject to 6 months of exterior exposure tests. Shaded bars represent entire area of each panel's extent of fouling. Unshaded ones are the area under the sealant.

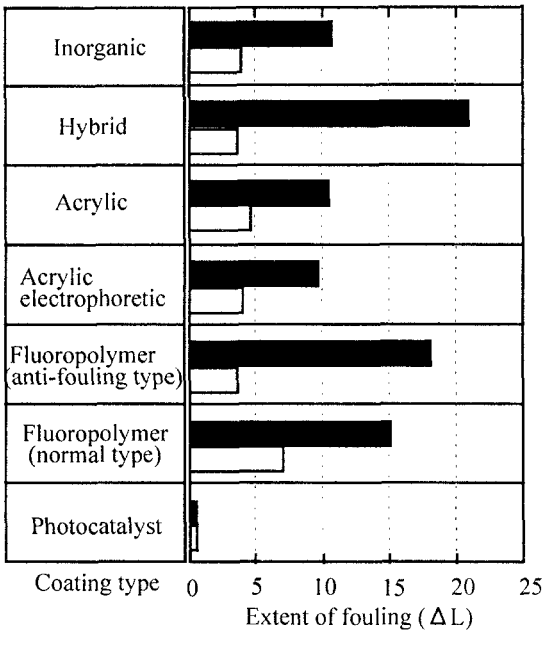


Figure 2. Comparison of photocatalyst and conventional coatings after 6 months of exterior exposure tests.
▮; Under the sealant, ▯; Entire area

The results show anti-fouling effect of photocatalyst compared to other types of coating in both areas. In particular, fluoropolymer of the anti-fouling type is not effective in areas under the sealant compared to other coating types. On the other hand, photocatalyst shows clear effect. There are numbers of reasons for excellent anti-fouling effect of photocatalyst. One is the property of decomposition of organic substances, another reason is super-hydrophilication. Especially, most of the panels outdoor become soiled from automotive exhaust fumes, which contain a lot of oily components[4]. Photocatalyst decompose them by strong oxidation and floats the dirt by water. For that reason, the dirt on the panels is washed away with rainfall and panels remain clean at all times.

3.2 Characterization of panels

Figure 3 shows the relationship between the extent of fouling, ΔL, and the contact angle of water. These are the result of after 6 months of exterior exposure tests.

The result of the experiment shows that the contact angle of water is in proportion to the extent of fouling. Open circles are normal type coatings; closed circles are anti-fouling types coatings. On normal type coatings, these contact angles were typically from 60 to 80 degrees. Most anti-fouling types have contact angle of 40 degrees. Anti-fouling types are more highly hydrophilic compared to normal-type coatings, and therefore show higher anti-fouling effects. The photocatalyst's contact angle is less than 10 degrees, thus it shows super-hydrophilication. For that reason, it shows an excellent anti-fouling effect. In addition, figure 4 shows the property of decomposing organic substances.

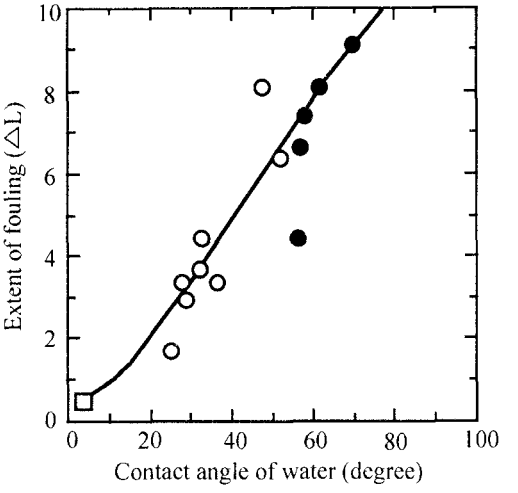


Figure 3. The relationship between fouling and the contact angle for water after 6 months of exterior exposure tests.
□; Photocatalyst, ○;Hydrophilic type's anti-fouling coatings, ●; Normal coatings

Figure 4 shows the relationship between the extent of decomposition of salad oil and the ultraviolet irradiation time. The light intensity is 0.8mW/cm². As the figure indicates, our developed aluminum panel naturally has the property of decomposing organic substances. This effect is characteristic of only photocatalyst. Other anti-fouling type coatings have no such effect. For that reason, the photocatalyst coated aluminum panel shows excellent anti-fouling effects.

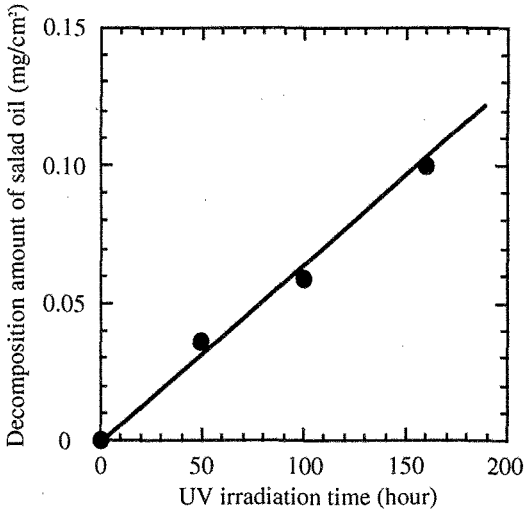


Figure 4. Photodecomposition of salad oil by photocatalyst coated aluminum panel.
Light intensity ; 0.8 mW/cm²

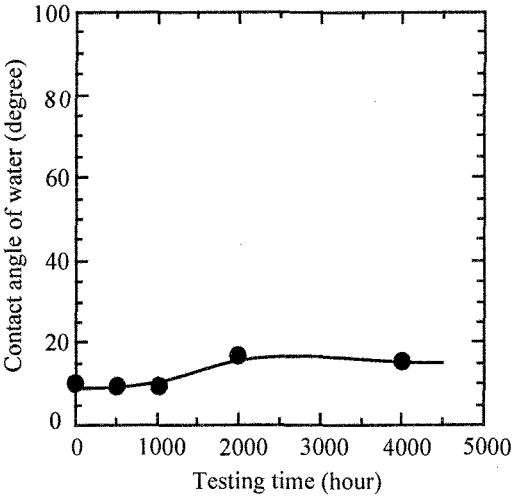


Figure 5. The relationship between the contact angle of water and weathering testing time by dew panel light control wethermeter.

3.4 Durability

Table 1 shows the results of various accelerated tests based on JIS H 8602. Almost all results are good. So it is no problem for practical use. Figure 5 shows the weathering resistance, which is one of the most important measurement of durability. Using dew panel light control wether meter to accelerate, this test was repeated by ultraviolet irradiation and condensation, nearly twice accelerated compared to sunshine weather meter. This figure indicates that the relationships between contact angle of water and testing time. For that reason, after 4000 hours, photocatalyst coated aluminum panel had kept hydrophilication. Thus we see that this panel has enough durability as exterior building materials.

Table 1. Durability of photocatalyst coating aluminum panel.

Testing	Condition	Result
Adhesion	Lattice pattern cutting test	good
Pencil scratch	by MITSUBISHI UNI	good(3H)
Boiling water resistance	Dipping 5 h	good
Hydrochloric acid resistance	5% HCl, 96 h	good
CASS corrosion resistance	96 h	good
Weathering resistance	Sunshine weather meter 63℃waterspray 12min/60min	good

3.5 Application of building exterior

This time, we constructed several buildings and applied this technology to their exterior walls. Figure 6 is a photograph of factory coated with photocatalyst. These panels were made of light gray acrylic coating. Figure 7 is an office building coated with photocatalyst. These panels were made of gray electrophoretic coating. Figure 8 shows an office building having metallic fluoropolymer coated panels. Thus, we coated photocatalyst on the 3 most common types of organic coatings. We produced about 1000 panels at our company's factory for these buildings. Total panel area is about 1000m², and the largest panel size has a length of 1 meter and width of 3 meters. Thus, the technology for producing large quantities continuously was completed this time.

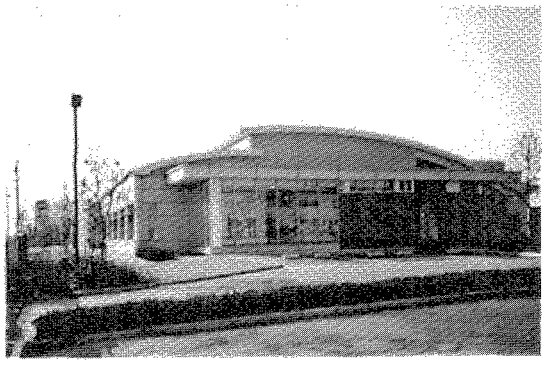


Figure 6. Factory using of photocatalyst coated aluminum panels.

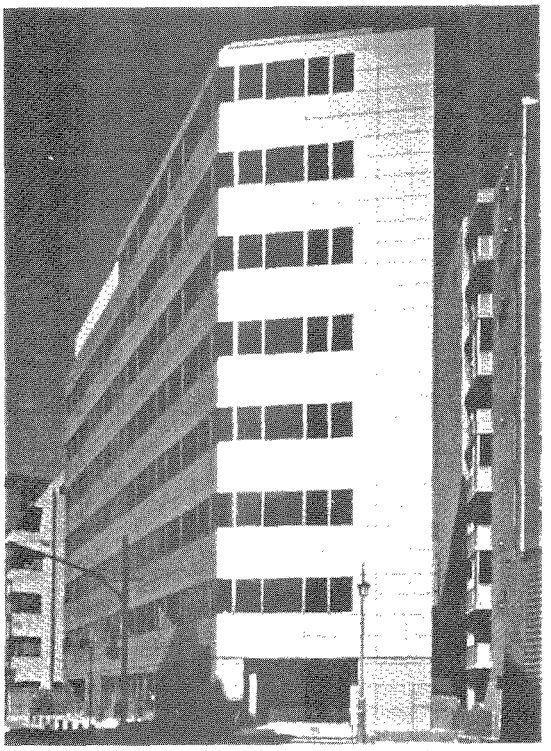


Figure 7. Office building using photocatalyst coated aluminum panels.

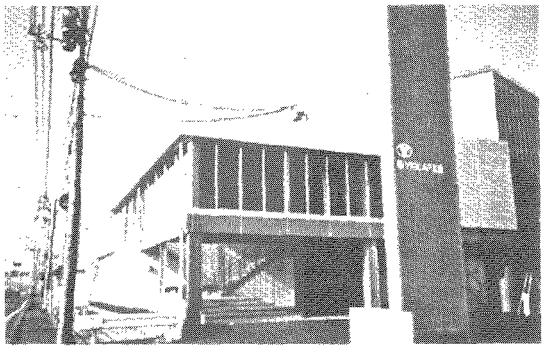
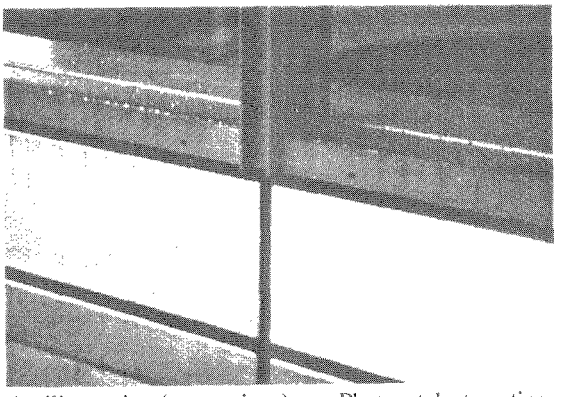


Figure 8. Office building using photocatalyst coated aluminum panels.

Figure 9 shows the enlarged photograph of the most dirty part under the window frame 6 months after completion. Right hand side is a photocatalyst coated panel; left hand side is not coated with photocatalyst, but with only acrylic coating. The effect was quite obvious. Acrylic coated panel became dirty, while photocatalyst remained clean. In the case of actual building, the excellent anti-fouling effect of photocatalyst coated aluminum panel was exactly what we had expected from experimental results.



Acrilic coating (comparison) Photocatalyst coating

Figure 9. Anti-fouling effect of photocatalyst coated aluminum panel at the factory.

4. CONCLUSION

1) Photocatalyst coated aluminum panel that we developed has an anti-fouling effect better than other types of coating. This panel has the property of decomposition of organic substances and super-hydrophilication.

2) It has enough durability as an exterior building material.

3) Its excellent anti-fouling effect was confirmed when applied to actual buildings.

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(Received December 16, 1999; accepted February 7, 2000)