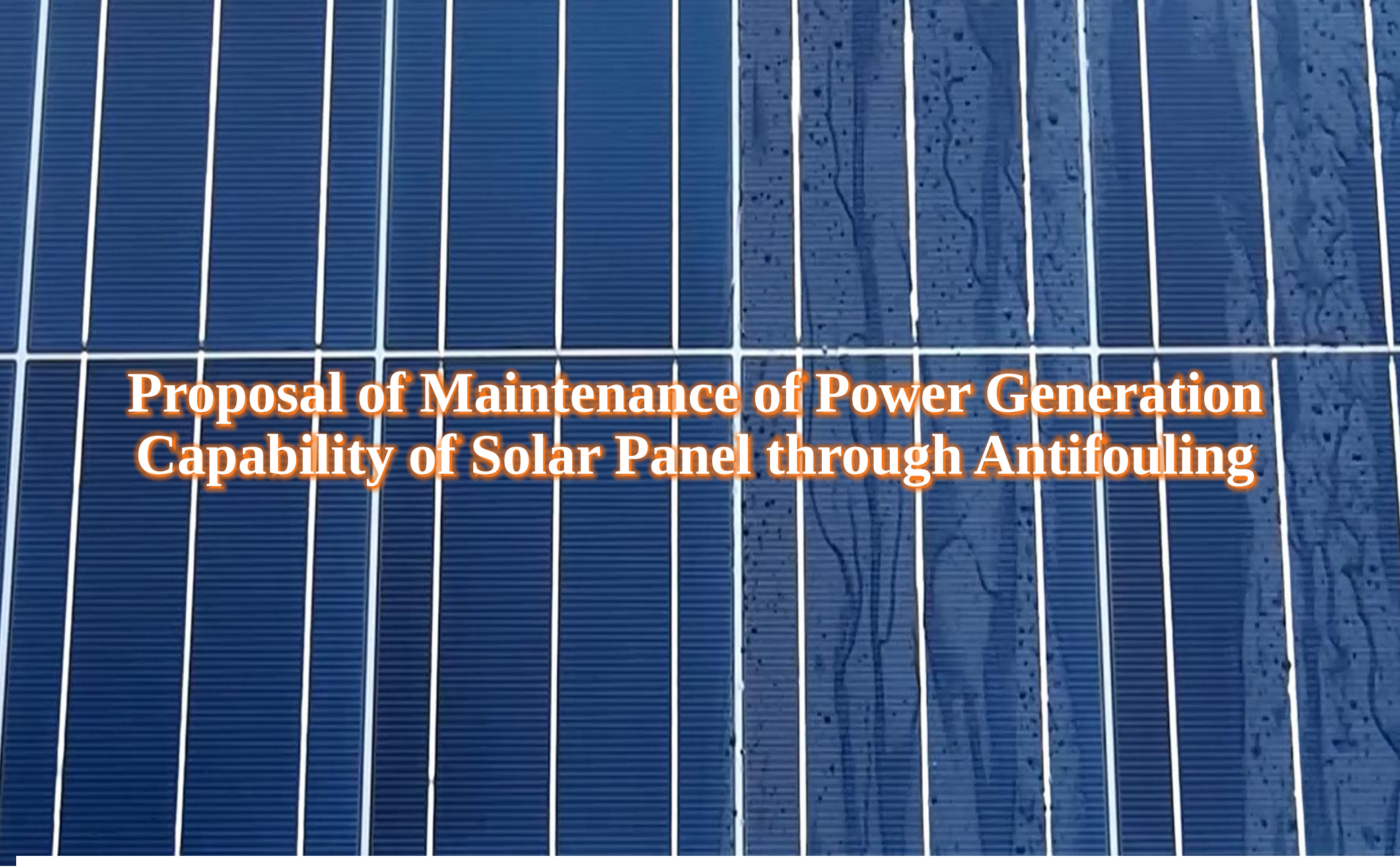

Proposal of Maintenance of Power Generation Capability of Solar Panel through Antifouling

Nihon Keisou Co., Ltd

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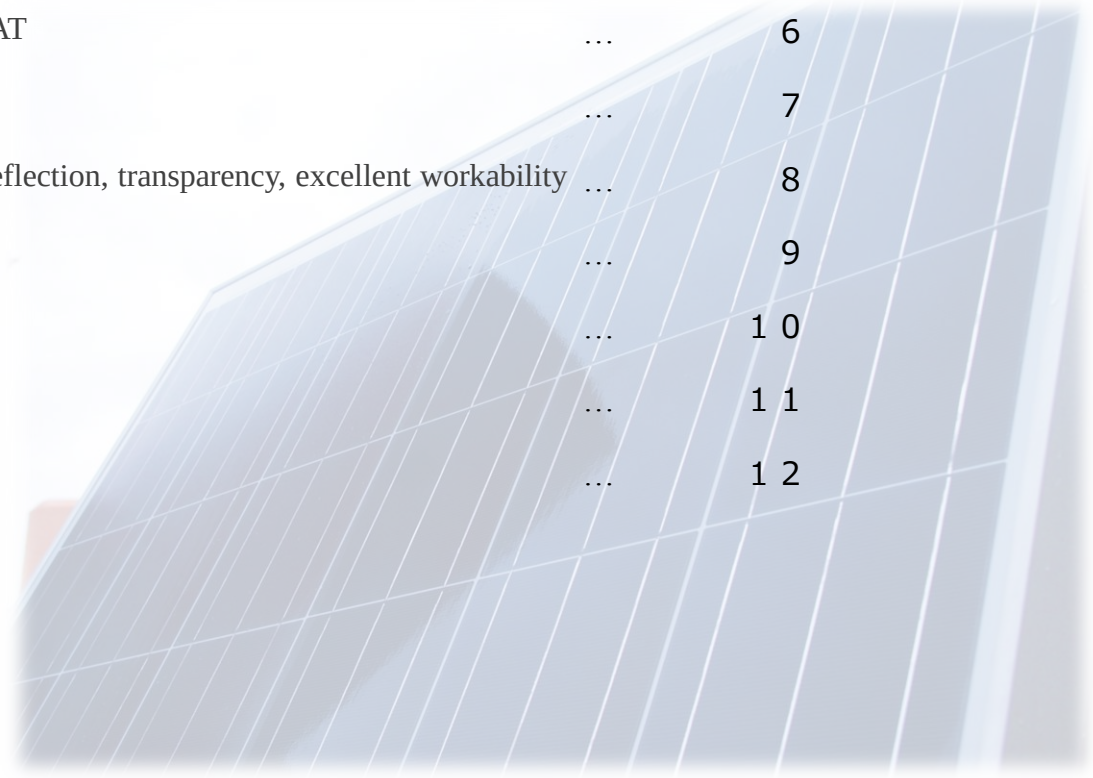
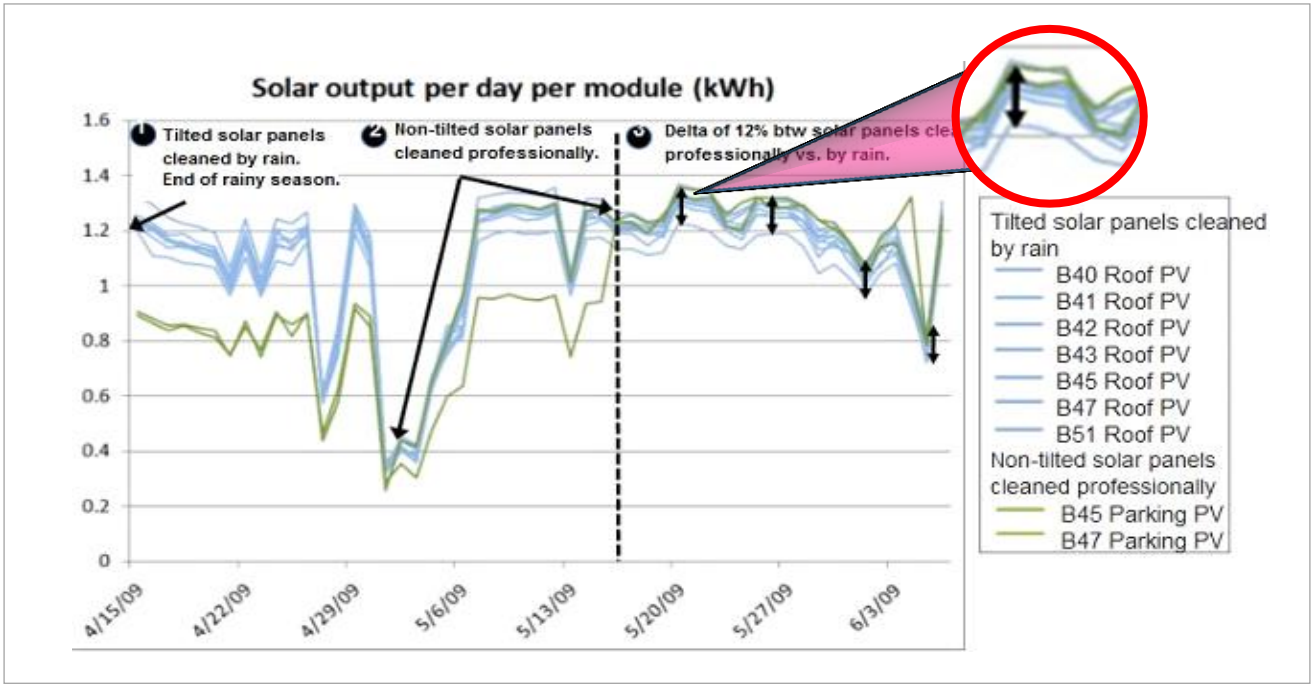


Necessity of Cleaning of Solar Panel

In July 2009, **Google** published a report on dirt on its solar panels. The power generation efficiency dropped in a part of the solar panels (1.6 MW) installed in the summer of 2007, and the members of Google investigated the cause. The report concluded that solar panels installed with no tilt angle **necessitate periodic cleaning**. The graph below shows that the power generation efficiency of non-tilted solar panels that were cleaned professionally increased greater compared to that of solar panels tilted 15 degrees that were cleaned by rain only.

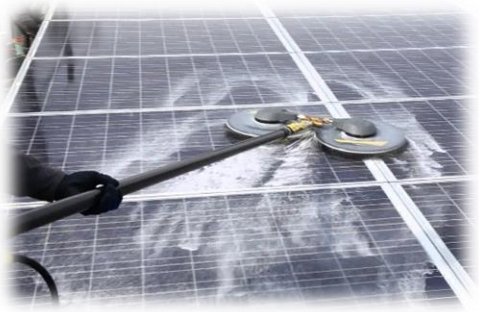


Comparison between two types of panel: The blue line indicates solar panels tilted 15 degrees that were cleaned by rain only. The green line indicates solar panels with no tilt that were cleaned twice by a professional.
This demonstrates that the power generation of non-tilted panels increases greater when they have been **cleaned**. ⇒ **Panels should be cleaned.**

Antifouling Coating Exhibiting Better Practical Effect than Cleaning

Introduction of machines like cleaning robot and cleaning by professional inevitably increase the running cost, and the time required to recover investment on solar panel lengthens. In addition, cleaning of mega solar equipment is impossible.

This indicates that applying coating during initial installation is most practical in terms of cost and effect.



Photocatalyst Coating is Inappropriate

The drawing below shows the result of an application experiment of photocatalyst coating agent on solar panel.

The power generation amount as of immediately after application dropped by 13%, and that as of after certain time period dropped by 17%.

Reflection loss and temperature rise at cell surface are the causes of drop of power generation amount. ⇒ Conclusion: Photocatalyst lowers power generation amount.

Titanium oxide coating is thick. = **temperature rise**

Decrease of transparency due to titanium oxide particles and organic solvent

= **attenuation of incident light**

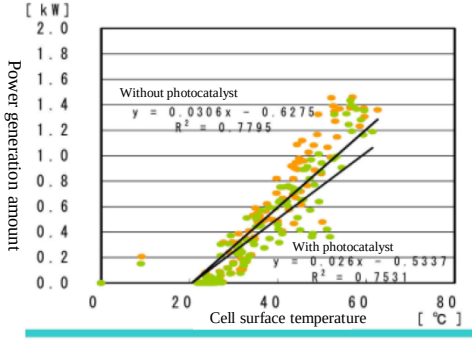
If test is conducted further for an extended time,

accumulation of inorganic contamination and deterioration of binder due to organic solvent

are also anticipated

As stated above, use outdoors in the burning sun is an extremely harsh condition for organic solvent.

(3) Difference in power generation in a certain period according to presence or absence of photocatalyst coating



Power generation as of immediately after application -> dropped by 13%
Power generation as of after certain time period -> dropped by 17%

- **When solar radiation is large, power generation decreases due to the influence of reflection loss.**
- **Application of coating increases temperature on the cell surface, causing power generation to decrease.**

As a result, antifouling measure with photocatalyst coating decreases the power generation.

KEPCO Miyazu Energy Research Center News Kenkyu 2004.5

What is the Optimum Coating Agent for Solar Panel?

In solar panels, power generation capability gradually lowers due to aged deterioration including contamination. However, solar panels on roofs and field standing solar panels to which access is inconvenient are left uncleaned in many cases. The panels themselves have a certain level of self-cleaning effect, but in reality, they are considerably dirty. If this condition continues for 10 to 20 years, contamination will accumulate on the panel surface and the power generation efficiency will inevitably decrease. However, ordinary coating agents for preventing aged deterioration have been unsuitable for solar panels because they are principally composed of organic solvent.

The conditions for coating agent suitable for solar panel are:

(1)	Film is infinitely thin.	>>	Avoidance of attenuation of incident light
(2)	Color is infinitely transparent.	>>	Securing of transparency
(3)	Surface is fractal.	>>	Diffused heat radiation and collection of light in wide wavelength range
(4)	Number of coating processes is small.	>>	Workability and productivity improvement, low cost
(5)	Drying time is not necessary.	>>	Workability and productivity improvement, low cost
(6)	Solvent and chemical compound are inorganic.	>>	Avoidance of deterioration by ultraviolet ray/durability
(7)	Self-cleaning effect	>>	Antifouling by natural force

Water-Based Completely-Inorganic AD-Tech COAT

Water-based completely-inorganic coating agent

AD-Tech COAT

Patents acquired (one in Japan, one in the U.S.)

Completely-inorganic coating agent based on water and silica

Completely inorganic: Composed of nano-size silica, inorganic additive and water only.

Workability: Allows you to work easily and briefly to finish beautifully. Overcoating and repair are also easy.

Eco-friendliness: Carbon free, VOC free, no distasteful odor caused by volatilization

Hydrophilicity: Coated surface of inorganic base material has high hydrophilicity brought about by silica and absorbent.

Safety: Water-based inorganic chemical compound in neutral regions, friendly to people and the environment, and noncombustible

Appearance: Slightly opaque transparent liquid (it will be transparent after application because it is ultrathin film)

Transparency: 50-nm ultrathin film whose light refractive index is lower than that of glass improves transparency.

Satisfies the conditions for coating agent suitable for solar panel

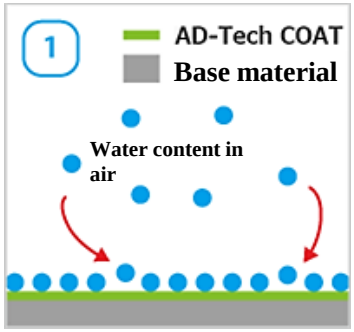
(1) Film thickness is below 50 nanometers.	>>	Avoidance of attenuation of incident light
(2) Chemical compound is nano-size particles, and coating surface is colorless.	>>	Securing of transparency
(3) Over 300 fractal protrusions of 50 namometers in size in 1000 nanometer square of coating surface	>>	Diffused heat radiation and collection of light in wide wavelength range
(4) Short-time work with coating of one-pack type liquid	>>	Workability and productivity improvement, low cost
(5) Quickly dries at room temperature	>>	Workability and productivity improvement, low cost
(6) Completely inorganic product with inorganic chemical compound and inorganic water-based solvent (water)	>>	No deterioration by ultraviolet ray, high durability
(7) Exhibits self-cleaning effect as glass surface retains water to reproduce hydrophilicity.	>>	Antifouling power of washing contamination by rain

Features of Water-Based Completely-Inorganic AD-Tech COAT

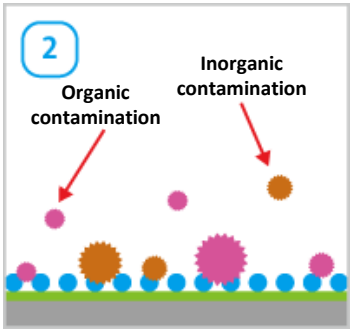
Antifouling power by means of hydrophilicity

■ Mechanism of hydrophilic antifouling

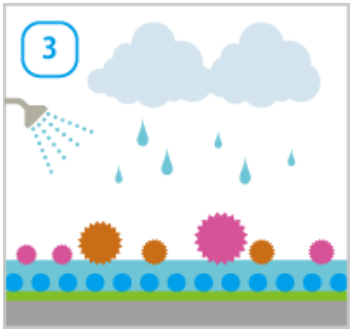
The extremely fine texture (irregularities) formed on the surface of the film due to the coating and the water film formed through absorption of water in the atmosphere make the contamination float. When water is poured there, the water in the film swells due to the added water and the contamination floats away with the water. In addition, film containing water makes dust unlikely to attach due to its antistatic effect.



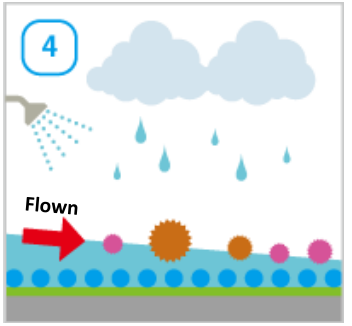
AD-Tech COAT exhibits its effect immediately after its application to the target base material, and absorbs water from the air onto the coating surface forming the water film.



As the surface of the base material is covered with a water film, attached contamination floats on the water film.



When rain or showers are poured over the coating surface, it exhibits an affinity to the water below and the contamination further floats.

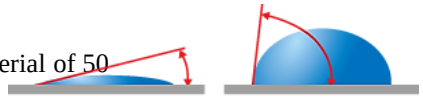


When rain or showers are further poured over the coating surface, the contamination floats away with the water.

[What is hydrophilicity?]

The contact angle of water with base material of 50 degrees or less is generally called hydrophilic or less is called super hydrophilic.

* The contact angle varies depending on the surface condit



Hydrophilicity

[Contact angle of water with base material]

- Less than 40 to 50 degrees: hydrophilic
- 10 degrees or less: superhydrophilic

Hydrofuge

[Contact angle of water with base material]

- Less than 90 to 110 degrees: hydrofuge
- 150 degrees or more: superhydrofuge

[Effects of hydrophilicity]

- It is possible to obtain a self-cleaning effect in which contamination can be removed by rain or showers.
- Water droplets do not remain on the surface, enabling prevention of annular stains due to the lens effect.
- It is possible to wash away oil stains with water.

* Always-brilliant snail shell is also hydrophilic.

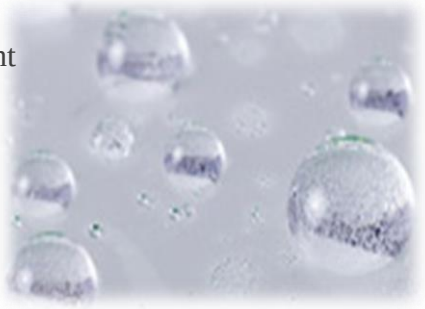
Features of Water-Based Completely-Inorganic AD-Tech COAT

Durability, weather resistance

As AD-Tech COAT is based on silica and uses water as a solvent, it contains no chemical compounds that cause deterioration from ultraviolet rays. Therefore, the film remains unless the base ages. A weather resistance test demonstrates that little deterioration and discoloration occur due to ultraviolet rays for over 20 years. Also, it tightly adheres to inorganic base material due to hydrogen bonding, and its film is resistant to friction, such as cleaning, so it will not detach even by brushing of train car washing machine.

AD-Tech COAT also delivers performance without problem in on-site tests under poor conditions including areas suffering salt erosion or factory neighborhoods.

Suppression of reflection, transparency



When a solar panel (glass part) let sunlight pass through it, light reflection loss occurs due to the thickness of the glass. However, by changing the quality of the glass surface through the coating process, reflection of useless light has been successfully suppressed.

Suppression of reflection leads to improvement of transparency, and contribute significantly to prevent power generation decrease as well as to increase power generation.

Excellent workability

As this product is one-pack type, you can start work immediately.

As it does not contain any harmful substance, it is odor free and safe and secure.

You do not need to wait after work, and the hydrophilic effect is exerted immediately after coating.

Work Method

[Agent used]

- For new and unused object . . . K-1006v
- For installed and used object . . . K-1006CP05

(It is possible to apply coating while removing contamination.)

[Used tools]

- Orbital sander or polisher (application machine)
- Squeegee (dewatering)
- Stepping board (for installed object)

(1) Application

Take the agent on the orbital sander or polisher, and apply the agent until the agent does not spread.

(2) Cleaning

Pour water to wash the agent away, and check that the surface has become hydrophilic at the same time.

* On parts where hydrophilic effect is not observed (hydrofuge condition), apply the agent again.

(3) Dewatering

Positively perform dewatering using the squeegee.

* If tap water is left, its chlorine content can remain white.

Examples of Application

■ Location: Roof of a company's headquarter building



■ Location: Misawa City, Aomori Prefecture



■ Location: Fukui Prefecture



■ Location: Roof of Tarumizu City Office, Kagoshima Prefecture



Physical Property Test Data

Test item	Standard and device	Result
Weather resistance	SUV 1000h	No abnormality for over 20 years
High-temperature high-humidity test	85°C, 85%, -40°C	No abnormality observed in 200 cycles
Salt water spraying test	5%	No change
Chemical resistance test (hydrochloric acid PH4)	25°C - 24 h	No change
Wear test	Taper abrading machine	No deterioration
Water resistance test	50°C x 72 h, submersion in water	No change
Simulator test (JIS C 8192)	IEC 60904-1, 700 to 1100 W/m^2, 30 minutes or less	No decrease in efficiency (*increase)
Outdoor exposure test	210 days / Kyoto City	No decrease in efficiency (*increase)
Transparency	HITACHI U-4100, 300 to 2000 nm	No decrease (*increase)
AR layer bonding property	sol-gel method, etching	No abnormality

Supplement: Anticipated Effect

Power generation efficiency after coating to thin film tandem panel from company E

The following is the graph created based on data on a field test of thin film tandem panel from company E in the following period, which we have periodically obtained from company E. These values indicate that similar effects can be anticipated from application to both in multi-crystal materials and single crystal materials.

Also, by taking in more incident light in the morning and evening, increase of total power generation amount can also be anticipated.

[Test module model]

Thin film tandem type solar panel (a-Si/p-Si) from company E

[Size]

700 x 275 x t4

[Period]

July 22, 2009 to February 16, 2010