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◆Research Paper◆

Study on the Preparation and Properties of a Novel Photocatalytic Foam Concrete

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Abstract: The preparation method of the new type of foam concrete board was studied. The influence of different amount of fly ash on the compressive strength, water absorption and thermal conductivity of foamed concrete was studied. The experimental results show that under the same bulk density, the 28 day compressive strength of foamed concrete increases with the increase of the content of fly ash, and the compressive strength is the highest when the amount of fly ash is 30%, and the strength of the case of the larger design weight is smaller. And the water absorption rate is as the increase of the amount of fly ash and the overall tends to decline, and in the design of bulk density of 600 kg•m-3, water cement ratio is 0.42, the amount of fly ash is 30%, the water absorption rate of foam concrete. The thermal conductivity of foamed concrete has no obvious effect on the thermal conductivity, which can reduce the thermal conductivity of concrete, and the minimum thermal conductivity is 0.55 w•(m•K)-1. the influence of different dosage of silica fume, water absorption, thermal conductivity, different dosage and different time on the degradation rate is discussed. The results show that, with the increase of silica fume, the compressive strength of foamed concrete is increased by 28 days, and the strength of foamed concrete can be improved by 10%. And the water absorption rate of the whole tends to decrease with the increase of the amount of silica fume, and the water absorption rate of foamed concrete is greatly reduced when the amount of silica fume is 10%. When mixed with 10%, the thermal conductivity of concrete is reduced, the thermal conductivity of the concrete is 0.62 w / (m·K). The degradation rate increased with the increase of the amount of titanium dioxide, and the degradation rate was 96% in 80 hours when the amount of nano-TiO2 was 0.9. In the specimen curing time, the shorter the spraying time, the better the degradation rate.

Keywords: fly ash; foam concrete; photocatalysis; nano-TiO2

With the rapid development of modern industry, the harmful gas in the air increase rapidly and harm to people's health seriously. This paper studied the

preparation method of the new type of foam concrete board, it could be used on building wall, not only can reduce the energy dissipation of the wall, also light and non-combustion performance. Above all, the board is a new building energy-saving insulation materials could decomposite harmful gas in the air under the photocatalyst [1-2]. This studied the influence of different amount of fly ash on the compressive strength, water absorption and thermal conductivity of foamed concrete.

1 Experimental design

1.1 Test materials

Cement: there are two type, one is Dingxin brand sulphate aluminium cement, another is Dingxin brand ordinary Portland cement (P.O42.5). Flyash: first level of ash produced by Shijiazhuang thermal power plant. Vesicant: rosin type. Water reducer: polycarboxylic acid type efficient water reducer, water-reducing rate is 25%. Foam stabilizer: stabilizer made by ourself, mixing amount is 0.1%. Polypropylene fiber: produced by Shijiazhuang shengfeng engineering materials co.,LTD. Nano-TiO2: produced by ourselves.

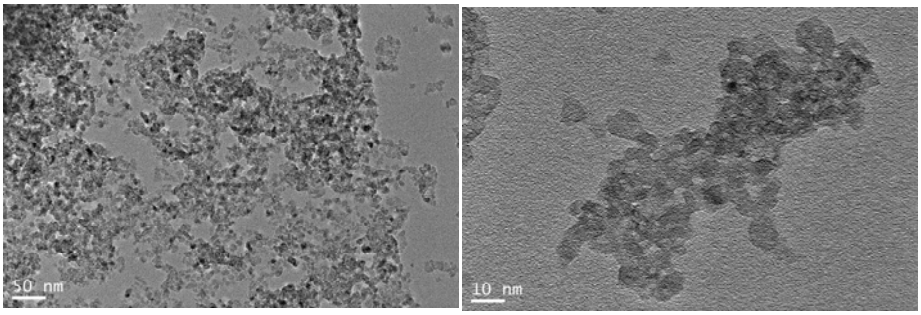

Fig.1 TEM photos of nano TiO_2

1.2 Experiment Process

1.2.1 Preparation of foam concrete

(1) The experiment uses the air pump gas, join the proporation water and foaming agent to foam machine, inflating to 0.8MPa by air pump, and prepare small, uniform, good viscosity and stability foam by foam machine.

(2) Foam concrete mixture ratio design: the foam concrete commonly used in the structure of the internal and external walls, floor level, such as pillar structure due to the density is small. This material could make the buildings reduce about 25% weight. density degree is 400~1200 kg•m^{-3}. Because foam concrete heat preservation performance would be decline when density degree more than 700 kg•m^{-3}, density degree in this experiment design conclude 400 kg•m^{-3}, 500 kg•m^{-3}, 600 kg•m^{-3}, 700 kg•m^{-3}. Cement should be weighted proportionally well, the sulphur aluminate cement accounted for one over one thousand of ordinary silicate. The flyash mixing amount occupies compared to cement are 0%,10%,20%,30%. water-binder ratio are

0.42,0.44,0.44,0.48, water reducer occupies compared to binding material is 5‰, polypropylene fiber is 1‰, foam stabilizer is 1‰. Standard mix design of foamed concrete shown in table1.

(3) Add all kinds of raw materials into the mixing pot one by one, start the foaming machine after 60s, pour foam slowly into well mixing slurry, and then stir quickly in the mortar mixer about 30s until it prepared to be uniform flow slurry.

(4) Molding specimens indoor, floating slurry after filling into the mould 30s, form removal after standing 1 day, and then maintain the specimens in standard curing room until test age.

(5)Use foam concrete that unit weight-flyash-water/cement ratio is 400-0.3-0.42, amount of silica fume is 5%,7.5%,10%,12.5%,15% occupies compared bin ding material, test the influence to compressive strength, water absorption and heat conductivity coefficient of foam concrete.

(6) Use foam concrete that unit weight-flyash-water/cement ratio is 400-0. 3-0.42,size of board shape specimen is 60mm ×100mm×200mm, and then do st andard curing.

(7) After form removal, standard curing board shape specimen 7d, and then spraying nano TiO_2 to surface of specimen. Concentration of TiO_2 solution are 3 $g \cdot L^{-1}$,5 $g \cdot L^{-1}$,7 $g \cdot L^{-1}$,9 $g \cdot L^{-1}$,11 $g \cdot L^{-1}$. The volume of spray solution is 100ml. And then confirm optimum concentration of nano TiO_2 by photocatalytic degradation test of methyl orange.

(8) After standard curing board shape specimen 1d, 3d, 7d, and then spraying nano TiO_2 to surface of specimen. Concentration of TiO_2 solution are 3 $g \cdot L^{-1}$,5 $g \cdot L^{-1}$,7 $g \cdot L^{-1}$,9 $g \cdot L^{-1}$,11 $g \cdot L^{-1}$. The volume of spray solution is 100ml. And then confirm the optimal spraying time of nano TiO_2 by photocatalytic degradation test of methyl orange.

Performance test

Maintenance foam concrete test specimen moulding already 28d, do compressive strength experiments, do Water absorption test for foam concrete that design unit weight are 400 $kg \cdot m^{-3}$,600 $kg \cdot m^{-3}$, do heat conductivity coefficient test for foam concrete that design unit weight is 600 $kg \cdot m^{-3}$.

Photocatalysis performance test: cutting foam concrete board to small specimen that size is 30 mm×50 mm×100 mm, catalytic light source adopt 20W UV lamp, the object of catalytic degradation adopt methyl orange, do absorbance test at the location that wave length is 443nm adopt spectrophotometer. Convert of methyl orange solution concentration according to the standard curve, Thus concluding the degradation of methyl orange and evaluate the effect of the evaluation of photocatalytic.

Table 1 Standard mix design of foamed concrete

unit weight	cement (kg)	sulphate aluminium cement(kg)	foam stabilizer(kg)	flyash (kg)	water volume(kg)	water reducer(kg)	fiber(kg)
400	333	0.33	0.33	0	140	1.7	0.33
500	366	0.36	0.42	0	175	2.08	0.42
600	500	0.50	0.50	0	210	2.5	0.50
700	583	0.58	0.58	0	245	2.92	0.58

2 Analysis and discussion of experimental results

2.1 The influence of different dosage of fly ash to compressive strength performance

Fig.2~Fig.5 are of influence diagrams that different wate cement ratio, different content of fly ash on the compressive strength of bulk density are 400 kg•m^{-33}, 500 kg•m^{-33}, 600 kg•m^{-33}, 700 kg•m^{-33}. Under the same density, The compressive strength of 28 days is a rising trend along with the content of fly ash increasing. The larger the density, the smaller the influence of strength to water cement ratio. The more the amount of fly ash, the smaller the influence of intensity difference to water cement ratio.

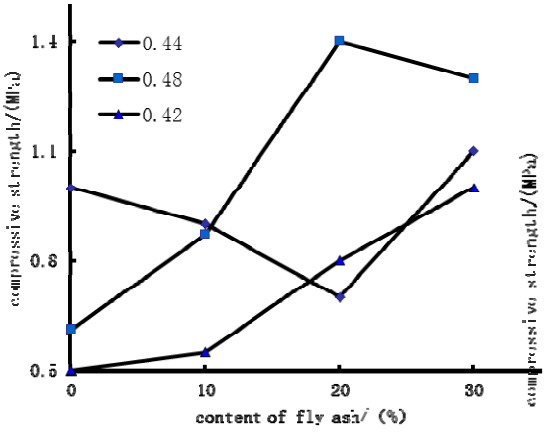

Fig.2 Bulk density of 400 kg•m^{-3} different water cement ratio, different content of fly ash on the compressive strength of the influence diagram

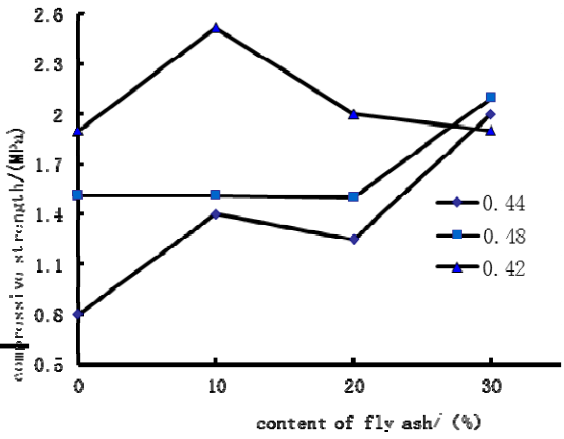

Fig.3 Bulk density of 500 kg•m^{-3}different water cement ratio, different content of fly ash on the compressive strength of the influence diagram

2.2 Analysis of the influence of fly ash to foam concrete water absorption

The figure 6 and 7 shows that the relationship of water absorption of foam concrete

and amount of fly ash. The smaller the water absorption, the more the amount of fly ash. The reason of the phenomenon is that fly ash particles is very fine, the more the amount of fly ash be, the more dense the cement pore is. Because the structure compactness increase, the water absorption becomes small. The change of the dosage of fly ash, which leads to the changes inside the concrete pore structure and water absorption ratio[3-4].

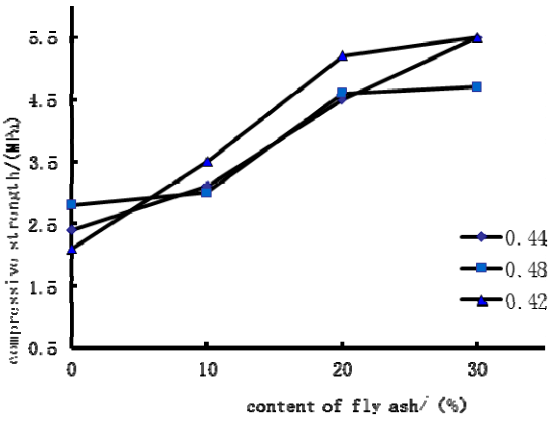

Fig.4 Bulk density of 600 kg•m^{-33}different water cement ratio, different content of fly ash on the compressive strength of the influence diagram

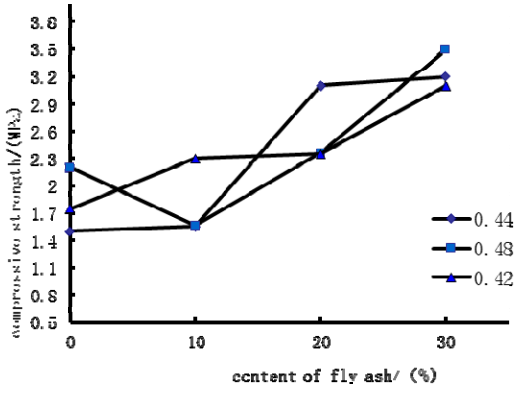

Fig.5 Bulk density of 700 kg•m^{-3} different water cement ratio, different content of fly ash on the compressive strength of the influence diagram

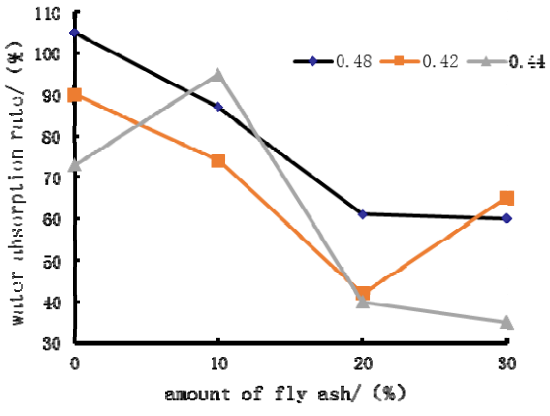

Fig.6 Bulk density 400 kg•m^{-3} of different Change of water absorption rate of water cement ratio

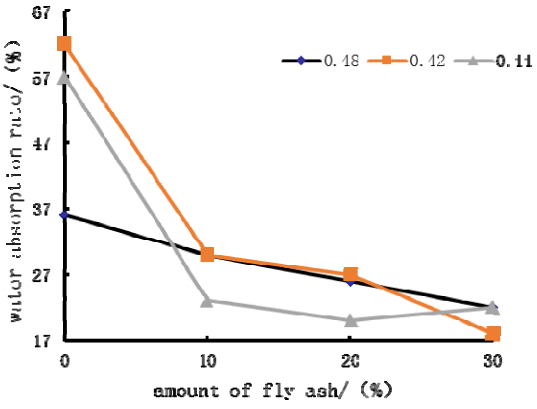

Fig.7 Bulk density 600 kg•m^{-3} of different Change of water absorption rate of water cement ratio

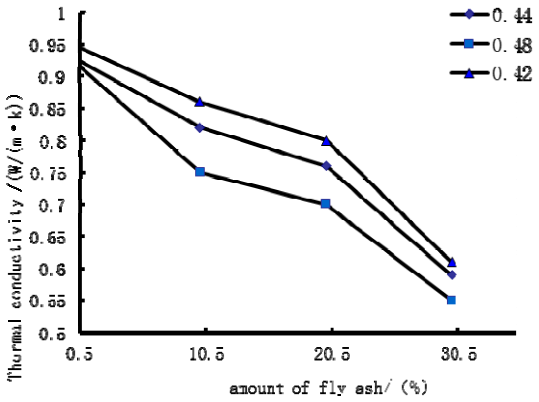

Fig.8 Bulk density 600 kg•m^{-3} of different Change of Thermal conductivity of water cement ratio

2.3 The influence of fly ash to foam concrete heat conductivity coefficient

The test results of coefficient of thermal conductivity as shown in figure 8. The figure can be seen, different dosage of fly ash on the foam concrete the influence of coefficient of thermal conductivity and its development trend. The resulting: the coefficient of thermal conductivity of foam concrete change along with the increase of the dosage of fly ash, when small dosage of fly ash, fly ash had no significant effect coefficient of thermal conductivity of concrete; When the dosage of 30% fly ash can obviously reduce the coefficient of thermal conductivity of concrete, and the minimum thermal conductivity is only 0.55 w. (m. K) - 1. As a result of the fly ash content increased, the porosity change inside the foam concrete, its internal pore was optimized, decrease the coefficient of thermal conductivity [5-6].

2.4 The influence of silica fume on foam concrete

Finishing on the test data for foam concrete 7 days, 28 days strength change with silica fume content and graph, as shown in figure 9. With the increase of dosage of silica fume of foam concrete 7 days, 28 days compressive strength continuously increased, and 7 days strength value in silicon ash content above 12.5%, the strength slightly down, the main reason is mixed with silica fume, as a result of the silica fume particles very fine, for the formation of hydration products can provide a certain amount of crystal nucleus, and silicon ash composition such as the active silica, the hydration products of calcium silicate gel formation has great promoting effect, make the structure compact, intensity increases, but due to the large content of silica fume, due to its great specific surface area, mixing time, increased water consumption, on the contrary make foam concrete strength slightly down. Foam concrete strength of 28 days in silicon ash content less than 10%, the strength is growing rapidly, more than 10% after strength of relatively slow growth. So adding 10% silica fume, can effectively improve the strength of the foam concrete.

Figure 10 shows, foam concrete bibulous rate with the increase of dosage of silica fume is gradually reduced. Dosage when less than 10%, bibulous rate is fast, more than 10%, slowly down, this is due to the silicon ash particles relative to the cement very fine, increase in content of silica fume concrete, can make the small particles of silica fume the space between the cement particles constantly, make the system more compact, and silica fume generated more hydrated calcium silicate gel of active substances, makes concrete structure is more compact, bibulous rate is lower. Adding 10% silica fume, foam concrete can effectively reduce water absorption.

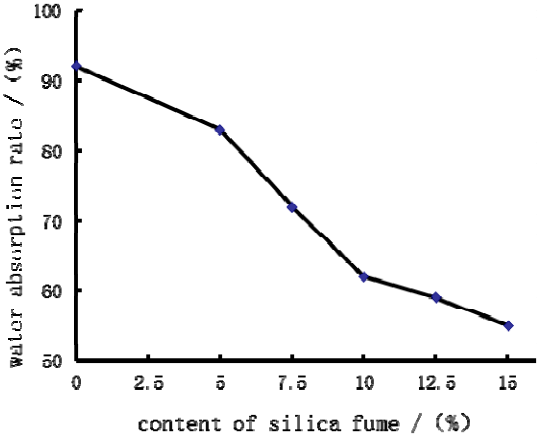

Fig.9 Different content of silica fume on the compressive strength of the influence diagram

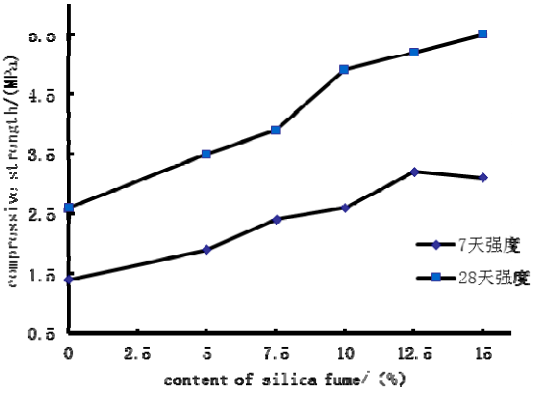

Fig.10 Different Change of water absorption rate of different content of silica fumeh

Figure 11 shows, different dosage of silica fume on foam concrete the influence of coefficient of thermal conductivity and its development trend. The coefficient of thermal conductivity of foam concrete with silica fume content increase constantly change with the increase the amount of silica fume, the declining trend coefficient of thermal conductivity, but by the content of 10%, the coefficient of thermal conductivity change is very small, when the dosage of gelled material 15%, coefficient of thermal conductivity for a minimum of 0.62 w/(m K). As a result of the silicon ash content increased, progressively decrease the porosity of the foam concrete internal and tiny pore. The coefficient of thermal conductivity of foam concrete falling [4-5].

2.5 Different dosage of nanometer tio2 light catalytic efficiency

To different concentrations of nanometer titanium dioxide solution spray to the foam concrete specimen surface, homogeneous spraying, through photocatalytic performance test, the result is shown in figure 12. Can be concluded from the figure 12, photocatalytic effect with the increase of the added amount of nano titanium dioxide, enhances unceasingly, the concentration of solution for 9 g ·L -1, with 11 g ·L-1 solution catalytic efficiency in the top 40 hours, almost the same, more than 40 hours after the catalytic efficiency, also were similar, shows that at the time of 9 g·L 1,

titanium dioxide mix basic saturated, basically each titanium dioxide injection quantity is 0.9 g, at the time of 80 hours, 11 g· L 1 solution catalytic efficiency reached 100%, 9 g·L 1 solution is 96%. Because not only is sprayed to the surface of titanium dioxide has catalytic effect, due to the porous foamed concrete, seeping into the 5 mm below the surface, uv wavelength is shorter, can be shot, about 5 mm foam concrete surface distance still has good catalytic effect of titanium dioxide.

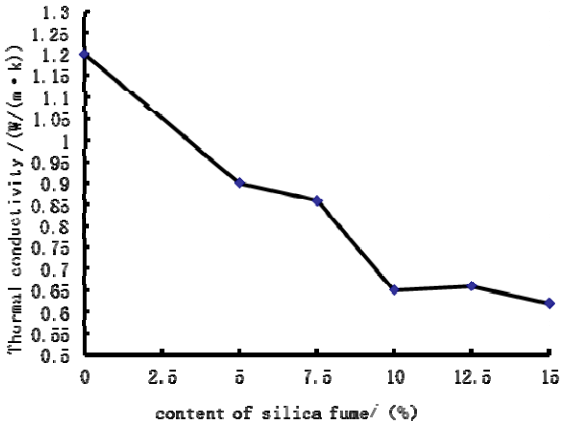

Fig.11 Different Change of Thermal conductivity of different content of silica fume

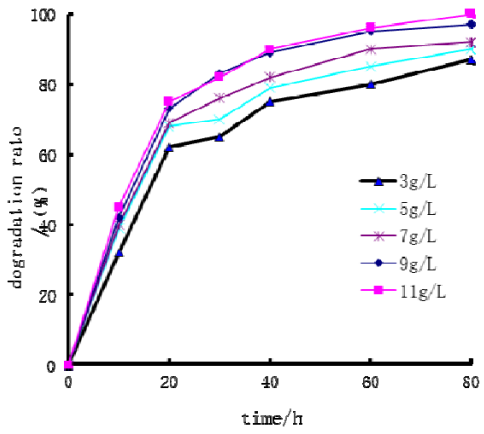

Fig.12 Effect of different concentration of titanium dioxide solution on Catalytic Performance

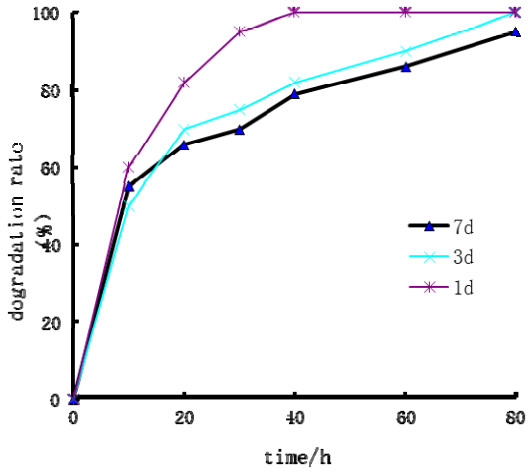

Fig.13 Effect of spraying time on catalytic performance of different solution

2.6 The influence of spraying time light catalytic efficiency

From figure 13, at the time of specimen maintenance 1 day, in the specimen surface spraying, nano titanium dioxide solution in 40 hours when the degradation rate basically reached 100%, far higher than in 3 days, 7 days when the effect of spraying, spraying, the shorter the age, coating on titanium dioxide particles on the

surface of the specimen, the stronger, the more uniformly distributed in the surface of specimen, the degradation efficiency is higher [6-7].

3 Conclusion

(1) Conclusion 1: under the same density, with the increase of the dosage of fly ash as 28 days compressive strength is on the rise, and in the design of bulk density, the greater the strength under the condition of the less affected by the water cement ratio. And in the design of unit weight is 700 kg, at 3 m - intensity were similar under different water-binder ratio, fly ash content was 30% the highest compressive strength, can be as high as 5.58 MPa.

(2) Conclusion 2: foam concrete bibulous rate is increased with the increase of dosage of fly ash as a whole tend to be lower, and in the design of unit weight is 600 kg, m - 3, water cement ratio of 0.42, was 30%, the dosage of fly ash foamed concrete bibulous rate is low, at just 18%.

(3) Conclusion 3: when the small dosage of fly ash, fly ash had no significant effect coefficient of thermal conductivity of concrete; When the dosage of 30% fly ash can obviously reduce the coefficient of thermal conductivity of concrete, the minimum of only 0.55 w. (m • K) - 1.

(4) Conclusion 4 photocatalytic effect with the improvement of the added amount of nano titanium dioxide, continue to improve, at the time of 9 g · L 1, basic saturated mortar of titanium dioxide.

(5) Conclusion 5: at the time of specimen maintenance 1 day, in the specimen surface spraying nano titanium dioxide solution, the degradation rate in 40 hours when basically reached 100%, the shorter the spraying of age, the degradation efficiency is higher.

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