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Studying on Infrared Stealth Property of Polyurethane Coatings†

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In general, polyurethane coatings, acrylic polyurethane coatings and organosilicon coatings are all high infrared emittance. But they have excellent chemical resistance, weather-proof and better mechanical property, such as good metal adhesive. In this paper we studied infrared property, physical and chemical properties by contrast with polyurethane coatings, acrylic polyurethane coatings and organosilicon coatings. From the experiment we selected polyurethane coatings as infrared stealth adhesive. By the method of adding fillers to polyurethane coatings and changing coatings techniques, low infrared emittance can be gained. Using polyurethane coatings as adhesive and sheet aluminium, SiO_2 powder and so on as fillers, we got aqua coat and its infrared emissivity is 0.33. At the same time we found conductance and reluctivity are high effect on infrared emissivity of coating.

Key Words: Polyurethane coatings, Emittance, Infrared.

INTRODUCTION

Infrared stealth dope possesses important position in research on infrared stealth for its unique merit[1,2]. Usually, doping low infrared emittance coat can decrease radiation of heat greatly. As most conditions resins possess high infrared emittance in infrared band, study on low infrared emittance dope is difficulty and technical key. Simultaneity, they must possess definite mechanical and chemical properties[3]. When we study adhesives, fillers and pigments, it should be reinforced that study on mechanical and chemical properties.

EXPERIMENTAL

Dopes: Polyurethane coatings, acrylic polyurethane coatings and organosilicon coatings are commercial products.

Fillers: Sheet Al powder, Al_2O_3 powder, Ni powder, SiO_2 powder, Cu powder, Cr_2O_3 powder.

Measurement: The mechanical and chemical properties of coating are measured in accordance with the state standards in China. They include adhesive, hardness, impact and flexibility. Their respective state standards are GB1720-79, GB/T1730-1993, GB/T1732-1993 and GB/T1731-1993. The coating is prepared according to GB/T 1727-1992, which is the state standards in China. The instrument of infrared emittance is IR-1, which made in Shanghai Institute of Applied Physics.

RESULTS AND DISCUSSION

In normal temperature, the coating is prepared on the tin according to GB/T 1727-1992. Then the mechanical and chemical properties and infrared emittance were done. The thickness of coating is about 30-35 μm. The fillers are made of 40 % SiO_2 powder, 40 % sheet Al powder, 5 % Ni powder, 5 % Cu powder, 10 % Cr_2O_3 powder.

As the Tables 1-3 showed, the conclusions are drawn that the mechanical and chemical properties of coating decrease sharply when fillers content are increased. Especially, adhesive falls clearly. On the contrary, infrared emittance of coating reduces when fillers content are increased, because the infrared emittance of fillers is lower than it of resins. By comprehensive contrast, selecting polyurethane as adhesive and fillers content 30 % are better than others[4-7].

In normal temperature: The different rough coating surfaces are prepared on the tin according to GB/T 1727-1992, the graphs are showed as follows. The thickness of coating is about 30-35 . Then infrared emittances were tested.

Figs. 1 and 2 are ten times pictures. It is obvious that the surface of Fig. 1 is smoother than Fig. 2, but infrared emittance of Fig. 1 is 0.83 and Fig. 2 is 0.63. Infrared emittance of rough surface is low, the main reason is that the rough surface brings the effect of echo diffusion is better than the smooth surface. So infrared stealth coating should keep definite roughness.

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TABLE-1
CHARACTERIZATION OF MECHANICAL, CHEMICAL AND INFRARED OF ACRYLIC POLYURETHANE COATING WHEN FILLERS ARE ADDED

Acrylic	Infrared emittance	Adhesive	Punch resistance	Brine resistance	Acid resistance	Alkali resistance
No: 1	0.92	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 2	0.91	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 3	0.89	3 grade	≥ 50 cm	Intact	Intact	Intact
No: 4	0.88	3 grade	≥ 50 cm	Losing luster	Losing luster	Losing luster
No: 5	0.88	4 grade	Shedding	Losing luster	Losing luster	Losing luster

Note: No: 1 fillers content 30 %, No: 2 fillers content 35 %, No: 3 fillers content 40 %, No: 4 fillers content 45 %, No: 5 fillers content 50 %

TABLE-2
CHARACTERIZATION OF MECHANICAL, CHEMICAL AND INFRARED OF ORGANOSILICON COATINGS WHEN FILLERS ARE ADDED

	Infrared emittance	Adhesive	Punch resistance	Brine resistance	Acid resistance	Alkali resistance
No: 1	0.80	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 2	0.78	3 grade	≥ 50 cm	Intact	Intact	Intact
No: 3	0.78	3 grade	≥ 50 cm	Losing luster	Losing luster	Losing luster
No: 4	0.77	4 grade	Mar	Shedding	Shedding	Shedding
No: 5	0.75	4 grade	Mar	Shedding	Shedding	Shedding

Note: No: 1 fillers content 30 %, No: 2 fillers content 35 %, No: 3 fillers content 40 %, No: 4 fillers content 45 %, No: 5 fillers content 50%

TABLE-3
CHARACTERIZATION OF MECHANICAL, CHEMICAL AND INFRARED OF POLYURETHANE COATINGS WHEN FILLERS ARE ADDED

	Infrared emittance	Adhesive	Punch resistance	Brine resistance	Acid resistance	Alkali resistance
No: 1	0.90	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 2	0.89	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 3	0.88	2 grade	≥ 50 cm	Intact	Intact	Intact
No: 4	0.87	3 grade	≥ 50 cm	Intact	Intact	Intact
No: 5	0.85	4 grade	≥ 50 cm	Losing luster	Losing luster	Losing luster

Note: No: 1 fillers content 30 %, No: 2 fillers content 35 %, No: 3 fillers content 40 %, No: 4 fillers content 45 %, No: 5 fillers content 50 %

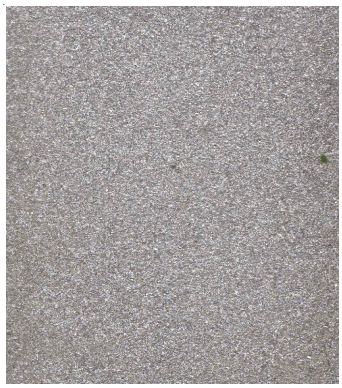

Fig. 1.

Fig. 2.

In normal temperature, the coating is prepared on the tin according to GB/T 1727-1992.Then the mechanical and chemical properties and infrared emittance were done. The thickness of coating is about 30-35 μm. The fillers are made of 5 % Ni powder, 5 % Cu powder and others as follows. The fillers content of coating is 30 %.

As Table-4 showed, the infrared emittance is on the high side. It was mainly that because the viscosity of dope is small, fillers are easy to fall on the tin owning to their gravity, which led to the surface of coating mainly made of polyurethane. it can be seen that the infrared emissivity decrease with increase of sheet Al powder also.

In normal temperature, the coating is prepared on the tin according to GB/T 1727-1992. Then the mechanical and chemical properties and infrared emittance were done. The thickness of the first coating is about 15-20 μm and the second coating is 20-25 μm. The fillers content of the first coating is 30 % and the fillers content of the second coating is 125 %. The experimental conclusions are as follows.

TABLE-4
EFFECTS OF DIFFERENT FILLERS CONTENT ON THE INFRARED CHARACTERIZATION OF POLYURETHANE COATINGS

S. No.	SiO_2 powder (%)	Sheet Al powder (%)	ITO powder (%)	Cr_2O_3 powder (%)	Infrared emittance
1	10	10	5	5	0.88
2	10	20	10	10	0.89
3	10	30	15	15	0.88
4	10	40	20	20	0.87
5	20	10	5	20	0.91
6	20	20	5	20	0.89
7	20	30	20	5	0.85
8	20	40	15	10	0.83
9	30	10	15	20	0.90
10	30	20	20	15	0.87
11	30	30	5	10	0.84
12	30	40	10	5	0.86
13	40	10	20	10	0.91
14	40	20	15	5	0.89
15	40	30	10	20	0.90
16	40	40	5	15	0.88

It can be seen from Table-5 that Cr_2O_3 powder is exchanged with phthalocyanine green and the infrared emittance decreases

TABLE-5
EFFECTS OF DIFFERENT FILLERS CONTENT OF THE SECOND COATING ON THE INFRARED CHARACTERIZATION OF POLYURETHANE COATINGS

S. No.	SiO_2 powder (%)	Sheet Al powder (%)	ITO powder (%)	Phthalocyanine green (%)	Ni powder (%)	Cu powder (%)	Infrared emittance
1	30	40	15	15	0	0	0.62
2	30	40	10	5	5	10	0.33
3	30	40	10	10	5	5	0.45
4	30	35	10	15	5	5	0.54

clearly. This certifies that Cr_2O_3 powder has much effect on the infrared emittance, in other words, the conclusion of 3.5 is right. By above methods, aqua infrared stealth coating is gained and its infrared emittance is very low.

While Ni powder and Cu powder are added into coating, the infrared emittance decreases. The reason can be explained by infrared physical optics: for opaque materials (coating is opaque commonly).

$$\varepsilon = 1-\gamma \quad (1)$$

ε-infrared emittance of material, γ- infrared transmittance of material. While a ray of no polarization ($n = 1$; $\phi = 0$) arrives at the smooth surface of dielectric materials, the part of reflectance is:

$$\gamma = \left(\frac{n-1}{n+1}\right)^3 \quad (2)$$

In the light of optical basic fundamental:

$$n^2 = \frac{\mu}{2}\left\{\sqrt{\varepsilon_j^{\,2} + \frac{4\sigma^2}{v^2}} + \varepsilon_j\right\} \quad (3)$$

n- refraction, ε_j- the dielectric constant, σ- conductance, μ- reluctivity, ν- Planck constant. According to eqns. (1), (2) and (3), it can be seen clearly that the infrared properties of materials have relation to the dielectric constant, conductance and reluctivity, *etc.* With changing the dielectric constant, conductance and reluctivity of materials, low infrared emittance can be obtained. In general, with the increase of conductance and reluctivity of materials, the infrared emittance decreases. While Cu powder and Ni powder are added to coatings, the conductance and reluctivity of coatings increase respectively. As a result, the infrared emittance of coating decreases.

Conclusion

Polyurethane coatings not only have heating resistance, acid resistance and alkali resistance but also have good adhesive and convenience construction. When it is used as infrared stealth coating, its infrared emittance is very high. In this paper, by adding fillers and changing technology of coating, the infrared emittance decreases sharply and is 0.33. At the same time, coating is aqua, it has effect of visible light stealth too. It finds that conductance and reluctivity of materials have much effect on infrared emittance of materials; this is one of the methods of lessening the infrared emittance of materials.

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