Development and performance of high temperature resistant coating

Thermal protective coating is a special purpose coating, which is widely used in the aerospace, electrical and electronic, textile, construction and other fields. Since the 1960s, room temperature vulcanized silicone rubber because of its resistance to oxidation, resistance to high and low temperature alternating, cold, ozone resistance, excellent electrical insulation, physiological inertia, corrosion resistance, moisture resistance and other excellent performance, and it has been widely used and researched.

Experiment

The selection of base rubber

Thermal protective coating requirements of its film-forming material with high temperature characteristics, and should have a certain mobility. Silicone resin, modified epoxy resin, polyacrylate, organic fluoropolymer, polyphenylene sulfide, etc. are widely used. These resins are resistant to temperatures above 200℃, but curing conditions are harsh, and require specialized equipment. The main chain of dihydro-polydimethylsiloxane Si-O ensure good thermal stability, can withstand temperature -60 ~ 250℃, it can be vulcanized at room temperature, and it's cost-effective. In theory, the greater the molecular weight of the polymer, the physical and mechanical properties gradually increased more, but the mobility is poor, and unfavorable for construction. After the preliminary screening, the molecular weight of 3×10^4 of the base rubber is more appropriate.

The selection of color filler

The filler should be added into the coating appropriately, it is to improve the physical properties of the base rubber, on the other hand to strengthen the heat resistance of the base rubber, heat insulation properties. Taking inorganic - organic combination can significantly improve the mechanical properties of the coating, temperature resistance and oxidation resistance. Commonly used fillers include silica, aluminum powder, zinc powder, silica powder and so on. At the same time, the amount of flame retardants, mica powder can be added into the coating, so that the coating has thermal insulation properties. The addition of pigment can improve the temperature resistance of silicone rubber, but not more than 1%.

The selection of cross - linking agent

In this paper, the preparation of single-component room temperature vulcanized silicone rubber, there are three common types of cross - linking agent: First, acetic acid type, such as methyl triacetoxy silane crosslinking agent; Second, oxime type, such as methyl triacetone oxime Silane; third is alcohol type, such as methyl trimethoxysilane and methyltriethoxysilane. Acetic acid and oxime type are corrosive to metal, and it's smelly; alcohol type is a better choice, but organic tin and other catalysts need to be added , such as dibutyl tin dilaurate.

Formula and process

The optimum formula for thermal protection coatings is shown in Table 1. The preparation process is shown in Pic 1.

Table 1 The formula of thermal protection coatings

Name	mass fraction %
Fumed white carbon black	10~30
Al(OH)3	40~50
Antimony trioxide	15~20
Iron red	0.3~0.5
KH550	0.7~1
l.l.l.-Trichloroethane	60~80
methyltrimethoxysilane	7~8
Dibutyltin dilaurate	0.5~0.7

Note: 100 parts polydimethylsiloxane as the cardinality.

PDMS → Stirring, heating, vacuum.Inorganic filler (pretreatment) → Stirring, heating, vacuum.Inorganic filler (Coupling agent and crosslinking agent) → Stirring, heating, vacuum(Catalyst)→Finished product

Pic 1 The configuration process of thermal protective coating

Results and discussion

Effect of white carbon black on tensile strength

The data of the tensile test are shown in Table 2.

Table 2 Tensile strength for different amounts of white carbon black coating

Amounts of white carbon black/%	10	15	20	25	30
Tensile strength/MPa	0.80	0.93	1.40	0.75	0.60

It can be seen from Table 2 that the tensile strength increases with the increase of the amount of white carbon black, and when the mass fraction of white carbon black reaches 20%, the tensile strength has a maximum value of 1.4MPa, and then the tensile strength decreases sharply.

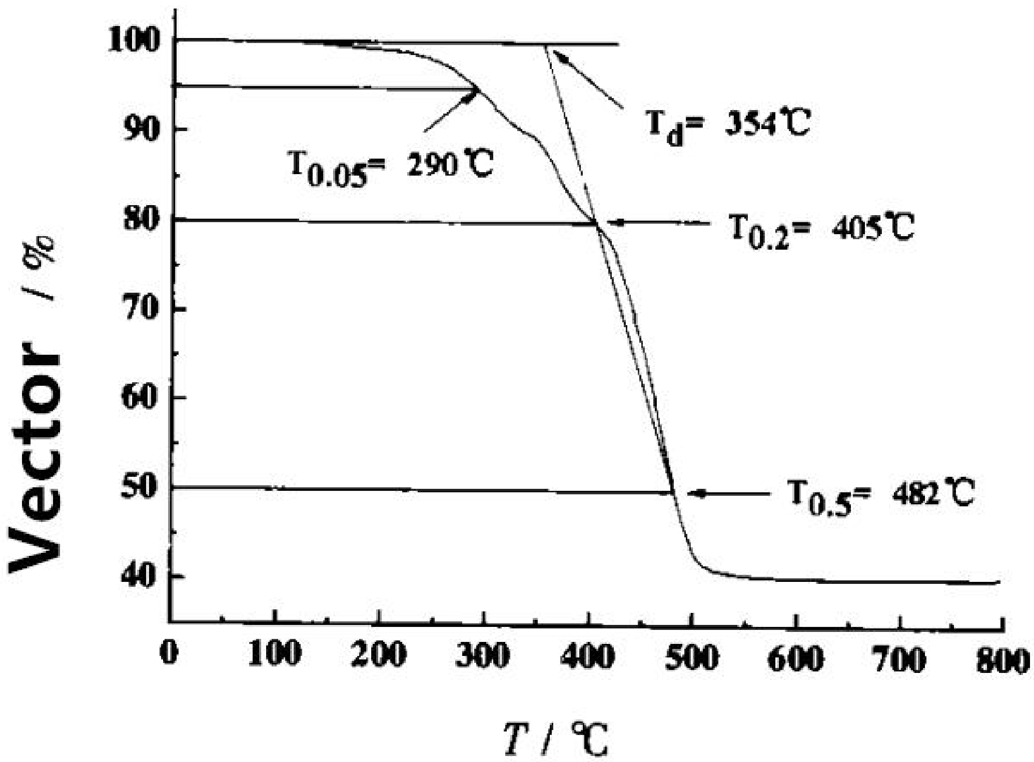
From the "structured" theory, it can be seen that the amount of silica filled has a limit value. After exceeding the limit value, the white carbon black will be combined twice to produce creep hardening, which leads to the decrease of the mechanical properties, especially the tensile strength.

Effect of Al (OH) 3 on temperature resistance

According to the mechanism of low temperature volatile heat insulation, the addition of Al $(OH)_3$ can obviously improve the heat resistance temperature of silicone rubber. Al $(OH)_3$ is heated to about 220 ℃ when the rapid decomposition of the crystal water and absorb a lot of heat, thereby reducing the temperature of the material surface.

The decomposed crystal water reacts with the free carbon produced by the decomposition of the organic material under the catalysis of Al_2O_3 to produce volatile CO and CO_2, which also consumes part of the heat. Pic 2 is the TG curve of the Al $(OH)_3$ sample with 50% mass fraction.

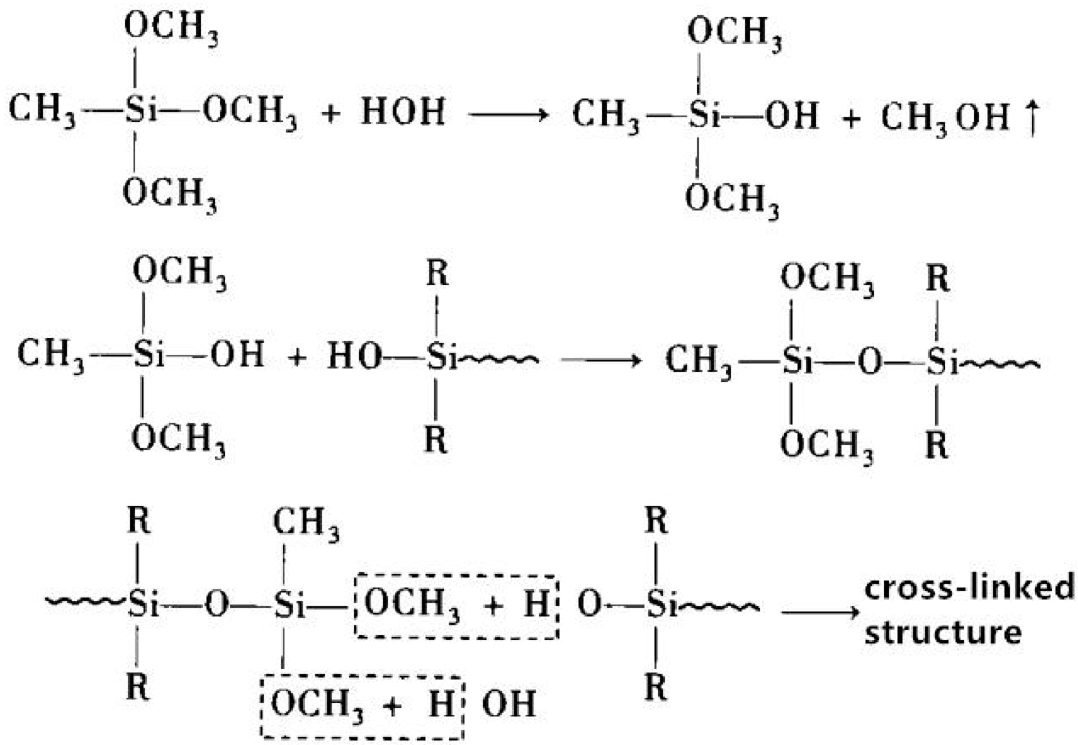
As shown in Fig. 2, the sample was raised from room temperature to 800℃, the weight loss was 40.2%, and the residue was 59.8%. Thus, the coating has a certain residual amount after thermal decomposition, and the gasification fraction is relatively high, which is helpful to improve the ejection coefficient. The thermal decomposition rate of the coating is 5%, 20% and 50% respectively. The decomposition temperature is 290℃, 405℃ and 482℃, respectively, and the thermal decomposition temperature is 354℃. Therefore, the coating can be used under the temperature 290℃ for long term working, it can also can be used at the temperature 354℃ within a short time.



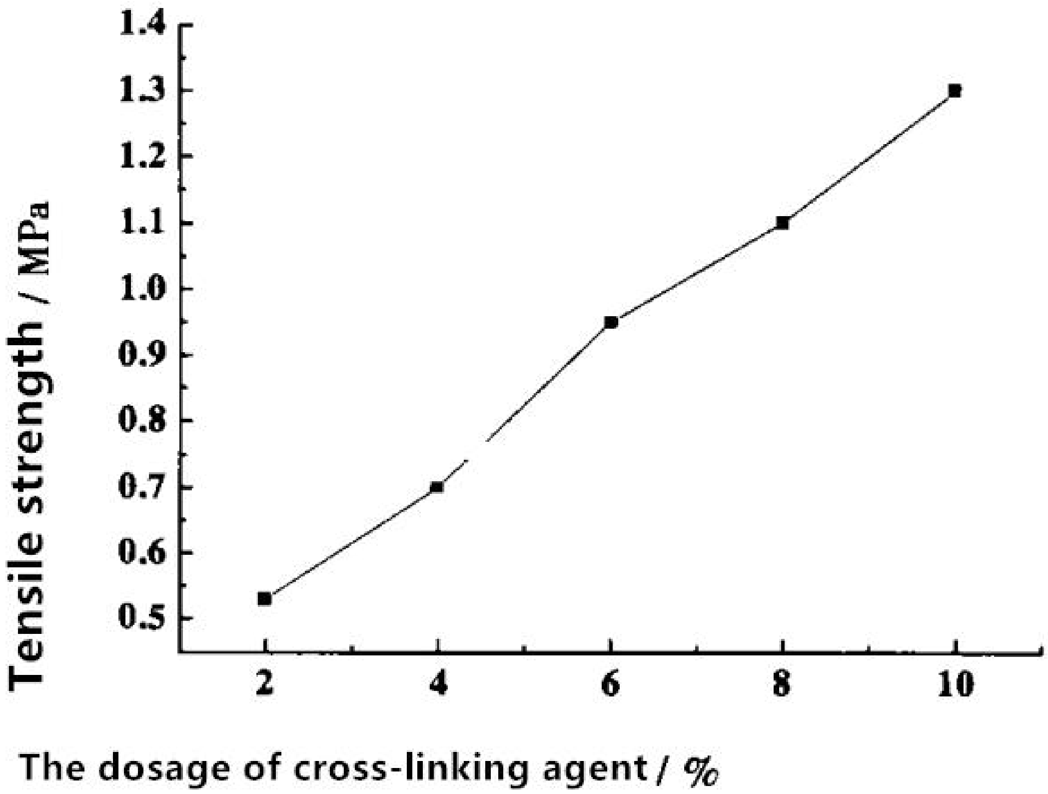
Pic 2 The TG curve of A $(lOH)_3$ samples with mass fraction of 50%

Effect of crosslinking agents on tensile properties

Methyltrimethoxysilane is a commonly used cross-linking agent, the cross-linking reaction is as follows:



Pic 3 shows the tendency of the tensile properties of methyltrimethoxylates in different amounts. It can be seen from Figure 3, with the increasing amount of crosslinking agent, the tensile strength also increases, but there is no practical value with excessive amount, because enough construction time should be left in the construction project, adding excessive cross-linking agent of the coating will lead to its rapid curing; and coating costs will increase. After a comprehensive test, 7% to 8% methyl trimethoxy is the best dosage.



Pic 3 Effect of crosslinking agent on tensile properties of coatings

Conclusion

The addition of inorganic fillers and additives improved the mechanical properties of the coating, tensile strength up to 1.4MPa. 20% silica is the best dosage, excessive dosage will lead to the coating material "structured"; the best dosage of methyl trimethoxy is 7% to 8%.

Al $(OH)_3$ improves the temperature resistance of silicone rubber. The coating material has high temperature performance, which can be used under the temperature 290 ℃ for long term working, it can also can be used at the temperature 354℃within short time, and it has extensive applications.