Insulating Varnish of Motor for Hybrid Vehicle and Electric Vehicle

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1 Abstract

In recent years, the demand for fuel-efficient hybrid vehicle (HEV) and electric vehicles (EV) is increasing. Automotive motor is mounted adjacent to engine where is always in high temperature environment compared with temperature in which usual general motors are used. The temperature could be higher when the motor is running in high output.

Therefore, it is necessary to cool the motor down with immersing directly in Automatic Transmission Fluid (ATF). Since it causes direct contact between ATF and the cured varnish which adheres several motor parts together, both heat resistance and ATF resistance are required for insulating varnish.

Furthermore, the conventional insulating varnish contains volatile organic solvents that should be reduced to meet increasing requirement for reduction of gas ignition risk and environmental impact with low volatile organic compounds (VOC). To fill this demand, we has developed a new HEV/ EV motor insulating varnish, "WP-2008", which has outstanding resistance to both heat and ATF, and possesses low VOC that cannot be achieved with conventional products.

2 Characteristics

- Heat resistance of 200°C/1000 h.
- ATF resistance of 150°C/1000 h.
- Low VOC (volatilization volume at curing $\leqq$ 1 wt%) containing no solvent.

3 Background of the Development

Insulating varnishes are sold in the market since 1912 as an establishment product of our company and have been used in various fields.

This product is typically applied to automotive motors and required properties are high heat resistance and ATF resistance evaluated based on adhesion strength.

Therefore, an improvement in heat resistance and ATF resistance was performed by examining the compositions of base resin. Since a reduction in the environmental load is essential as the market trend in recent years, a reduction in the VOC is also required.

However, it was difficult to realize a reduction in VOC in conventional varnish because the diluent uses volatile organic solvent. Therefore, we established technology for manufacturing insulating varnishes with a small amount of VOC and heat and ATF resistance by optimizing resin compositions and substituting low volatile materials having reactivity for solvents.

Figure 1 Insulating Varnishes provided by Hitachi Chemical

4 Technical Details

1. Development Concept of WP-2008

Increasing the molecular weight of the base resin is generally an effective method for improving heat- and ATF-resistance to maintain adhesion. However, because the method causes the solvent compatibility to deteriorate, it is not effective in reducing VOCs.

In order to realize coexistence of these trade-off characteristics, optimization of the base resin structure using our unique resin denaturation technology improved compatibility, enabling the adoption of special acryl base monomers with low volatility as the diluent.

2. Heat and ATF resistances

Heat and ATF resistance was evaluated based on the adhesion shear force (ϕ = 0.82 KMK-22A) using the Stracker method.

Figure 2 and **3** show the results of evaluation of the adhesion shear force after the heat and ATF resistance tests.

The adhesion shear force of the general conventional varnish WP-2763 (LF) was 20 (N) after the heat resistance test (200°C/1000 h) and was significantly lower at 13 (N) after the ATF resistance test (150°C/1000 h in ATF). On the other hand, the adhesion shear force of WP-2008 was 113 (N) after the heat resistance test (200°C/1000 h) and 110 (N) after the ATF resistance test (150°C/1000 h in ATF). That is to say, the high adhesion force required for electric automobiles is held.

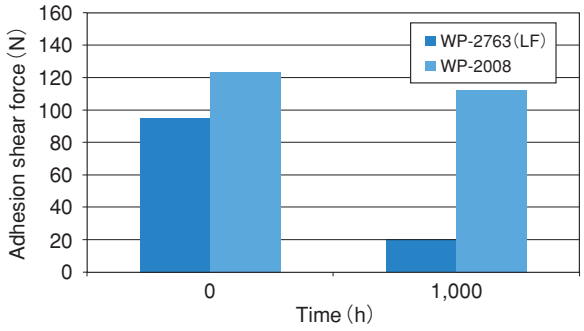

Figure 2 Adhesive after Heat resistance

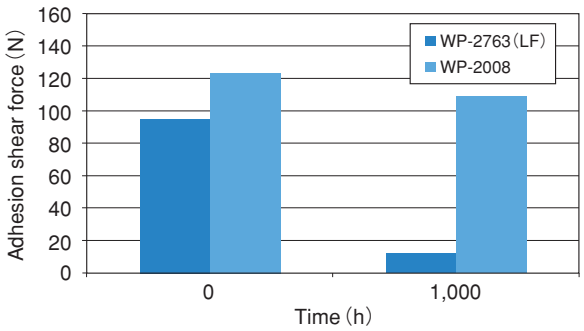

Figure 3 Adhesive after ATF resistance

3. General Characteristics of WP-2008

Table 1 shows general properties of WP-2008.

The VOC content of WP-2008 is about 1/25 of the general conventional varnish WP-2763 (LF), which was a far lower value. This property enabled to reduce the environmental load.

In addition, the flash point as high as 176°C allowed a reduction in the risk of ignition.

Table 1 General properties of WP-2008

Item	Unit	Developed product WP-2008	Conventional product WP-2763(LF)
Advantage	—	Low VOC and high heat resistance	—
Viscosity(25℃)	Pa・s	1.7	0.1
VOC content*1	%	1	25
Flash point	℃	176	31
Gelation time(120℃)	Minutes	6.5	12
Pot life(40℃)	Days	30	30
Adhesion shear force(23℃)	N	123	95
Curing condition	℃/h	130/1	130/1

*1 Sample varnish of 5.0 g was put into a metal petri dish (ϕ = 60) to measure the rate at which the weight decreased after curing.

5 Future Business Development

・Development of materials for the next generation electric vehicles

・Exploration of application to other fields