Study on preparation and Properties of Epoxy Fire-proof Coatings

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Abstract. In this paper, the purpose of improving the fire resistance of epoxy type fire retardant coating, the use of control variables of research methods. Eight formulations were prepared with ammonium pyrophosphate, melamine and pentaerythritol as the invariants, and were prepared with flame retardant including retardant aluminum hydroxide, zinc borate and expanded graphite as the variants. One of them was a comparative blank sample and analyzed by cone calorimeter. The results show that the performance of formula 2 with aluminum hydroxide as flame retardant is the best, and the whole experiment has achieved the expected effect. Through my research, I explored a cost-effective epoxy type fire retardant coating formula.

1. Purpose of research
Epoxy fire resistant coating, With excellent chemical corrosion resistance, heat resistance, acid and alkaline resistance, good electrical insulation and resistance to hydrocarbon fire [1]. Secondly, the epoxy flame retardant coating has excellent sealing ability, and the flame retardant component will not migrate to the coating surface, so its fire resistance is less affected by time and environment[2]. At present, the domestic understanding of epoxy fire-proof coatings is not enough, and the products introduced are far from the international leading level[3]. With the accelerating pace of construction, navigation and offshore oil exploitation in China, the demand for epoxy fire resistant coatings for outdoor use will be increasing[4]. Therefore, study on preparation and properties of epoxy fire resistant coatings is of great significance[5].

2. Experiment part
2.1. Laboratory apparatus
According to the actual situation of the laboratory, the following instruments were selected for the experiment: high-speed mixer; conical calorimeter; thermostatic bath; beaker (50ml, 100ml, 250ml);
glass rod; wood board (10cm * 10cm); paint brush; electronic balance; electric saw; vacuum dryer; ruler; weighing paper; spoon; rubber dropper; measuring cylinder; grinding rod.

2.2. **Experimental drug**
BPA epoxy resin, curing agent, ammonium polyphosphate, melamine, pentaerythritol, aluminum hydroxide, zinc borate, expanded graphite.

2.3. **Empirical method**

2.3.1 **Contrast experiment and formula.**
Here are the raw materials and dosage data for four sets of formulations including blank sample 1.

| raw material                  | sample 1 | sample 2 | sample 3 | sample 4 |
|-------------------------------|----------|----------|----------|----------|
| 1-butanediol                  | 8        |          |          |          |
| glycerol                      |          | 4        |          |          |
| epoxy resin                   |          |          | 8        |          |
| curing agent                  |          |          |          | 3        |
| ammonium polyphosphate        |          |          |          | 6        |
| melamine                      |          |          |          | 2        |
| pentaerythritol               |          |          |          | 2        |
| calmogastrin                  | 0        |          |          | 0        |
| zinc borate                   | 0        |          | 0        | 0        |
| expanded graphite             | 0        | 0        |          | 7        |

2.4. **Experimental procedure**

1) Preparation material. prepare 4 planks of 10 cm in size, equal in weight and all medicines needed in the formula.

2) Weigh, 72g 1-butanediol, 36g glycerol, 72g epoxy resin, 27g curing agent, 54g ammonium polyphosphate, 18g melamine, 18g pentaerythritol.

3) Mix. add the weighing materials to the beaker in the order of the first liquid and then the powder, stir them evenly with the glass rod, ensure that the paint slurry has the fluidity needed for the next operation, and then divide them into 4 equal shares with a small beaker. Add the prescribed ingredients to different small beakers.

4) Daub, after each beaker is fully mixed, paint from each beaker is evenly coated on different prefabricated boards.

5) Dry, put the coated wood in the sunlight to air for 1-2 days, then take it to the vacuum dryer to dry 0.5h-1h.
6) After drying, take out and cover the bottom and around the wood board with aluminum foil. Only leave the side of the fire retardant coating, put it in the cone calorimeter, and draw the form according to the data recorded by the calorimeter.

7) The experimental data are analyzed by drawing tables, and the conclusion is drawn.

| Sample | Test time(s) | Sampling interval(s) | Sample ignition time(s) | Flame duration(s) | 180s Average heat release rate(kW/㎡) | 300s Average heat release rate(kW/㎡) | Heat release rate peak(kW/㎡) | Sample residual mass(g) | Total mass loss(g) | Average mass loss rate(g/s) |
|--------|-------------|----------------------|-------------------------|-------------------|--------------------------------------|--------------------------------------|--------------------------|----------------------|----------------------|--------------------------|
| 1      | 1114        | 5                    | 16                      | 912               | 185.5475                             | 138.5756                             | 308.288                  | 583.945              | 70.3604              | 0.08                    |
| 2      | 963         | 5                    | 24                      | 586               | 193.1366                             | 119.1384                             | 228.5758                 | 618.722              | 50.1912              | 0.051                   |
| 3      | 1127        | 5                    | 20                      | 891               | 210.4901                             | 199.2211                             | 265.0186                 | 589.3759             | 80.8091              | 0.0896                  |
| 4      | 963         | 5                    | 30                      | 823               | 215.4912                             | 190.7711                             | 352.2403                 | 298.7624             | 370.9313             | 0.5678                  |

Formula No. 2 board analysis: from Table 2, we can see that the 24s of the second board ignited is much larger than that of the blank board ignited for 16s. The average heat release rate of the first 180s and the first 300s is also much smaller than that of the blank sample, which indicates that the heat release rate and the total amount of the No. 2 plank are lower, which better protects the plank from the influence of high temperature. The average mass loss rate shows that the structure of the No. 2 paint board is more stable [6], and the debris loss per unit time is smaller than that of the blank board.

Formula No. 3 board analysis: from Table 2, the fire resistance of the board of Formula No. 3 is 20 seconds before igniting, which is a little shorter than the 16 seconds of blank board. The average heat release rate of the first 180s was larger than that of the blank sample, and the average heat release rate of the first 300s was smaller than that of the blank sample. From the diagram of heat release rate in fig.4, we can see that the curve of blank sample has three peaks and that of board No. 3 has two peaks, which shows that the heat release rate of the two boards is not stable when burning. From fig.2 the total exothermic THR figure of the two samples, it can be seen that the slope and maximum value of sample 3 are higher than that of
(a) sample 1                                       (b) sample 2

(c) sample 3                                       (d) sample 4

Fig. 1 comparison of Test Diagram between 4 samples Plate conical Calorimeter

the blank sample, which indicates that the sample 3 emits more and more heat in the experiment
process.

Then look at the total mass residual diagram of the two samples and the average mass loss rate in
fig. 3. The difference is not obvious, even the average mass loss rate of sample 3 is faster than that of
blank sample . so, the fire resistance of blank sample and sample 3 is basically the same in general.

Formula 4 board analysis: according to the comparison of table 2, the ignition time of blank
sample is 16 s, and the ignition time of sample 4 is 30 s, which indicates that sample 4 has certain fire
resistance, but from heat release rate, heat release peak value, the total mass loss, mass loss rate,
sample 4 is much greater than the blank sample. From fig. 4, it can be seen that the heat release rate
diagram of sample 4 is more gentle and approximate to only one wave peak. Referring to comparison
of Test Diagram between 4 samples Plate conical Calorimeter in fig. 1, it is shown that the combustion
of sample 4 is more uniform. In the total heat release diagram, the figure span and slope of sample No.
4 are larger, which proves that the thermal release rate is much larger than that of blank sample.
Fig. 2 Comparison of four THR changes

Fig. 3 Comparison of four MASS changes

Fig. 4 Comparison of four HRR changes
3. Conclusion

1) The flame duration, heat release rate, total heat release amount, total mass loss and average mass loss rate of formula 2 plank are all the best in four samples. The sample ignition time is 24 s, which is only worse than formula 4, but better than all other formulations. Under comprehensive consideration, the fire resistance of formula 2 is undoubtedly the best, its formula material selection and proportion is the most appropriate.

2) In the comparison of four formulations, it was found that aluminum hydroxide was the main factor affecting the epoxy fire resistant coating.

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