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Preparation and Properties of One-component Waterborne Acrylic Anticorrosive Coatings for Marine Applications

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Abstract: To prepare a paint that could be used for ship corrosion protection. A single-component water-based acrylic was used as the main film-forming material, and zinc phosphate and aluminum tripolyphosphate were added as rust-resistant pigments. Various additives were used as auxiliaries to obtain a single-component water-based acrylic paint for ship use. The effects of the content of single-component water-based acrylic, the amount of various additives, and the amount of pigments and fillers on the coating performance were discussed. The paint had good thermal storage stability and good corrosion resistance, and the drying time was shorter, the adhesion was stronger, and the flexibility was good. The single-component water-based acrylic paint could meet the requirements for ship corrosion protection.

Keywords: One-component; water-based acrylic; corrosion-resistant coating; ships.

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1. Introduction

The marine environment is a harsh natural environment, and the requirements for anti-corrosion performance in the marine environment have become one of the key limiting factors in the manufacturing and development process of equipment. China is a major maritime country, with more than 18,000 kilometers of coastline, over 6,500 islands along the coast, and jurisdiction over more than 3 million square kilometers of sea area. It possesses abundant marine resources and a thriving marine industry. However, the marine environment is extremely severe and highly corrosive. Therefore, marine corrosion and protection will be an urgent issue to be resolved in China's economic development.

According to the different materials of the objects to be protected and the mechanisms of corrosion, they can be divided into two major categories: one is steel structure anti-corrosion coatings, and the other is non-steel structure anti-corrosion coatings. The former mainly targets equipment and infrastructure such as ships, bridges, and subsea steel pipes that are primarily made of steel materials. The latter mainly targets equipment and infrastructure such as bridge piers and docks that are primarily made of concrete, rubber, and other materials.

With the progress of the times and the development of science and technology, the awareness of environmental protection among countries and the public is gradually increasing. Therefore, the development of environmentally friendly anti-corrosion coatings has become a hot topic among researchers. Water-based acrylic coatings have many advantages, such as low/zero VOC emissions, environmental friendliness, high fullness, excellent adhesion, strong rust prevention performance, strong weather resistance, and easy application, etc.[1-2], which makes them have a large application space[3]. Li Yong[4] and others prepared an environmentally friendly single-component water-based acrylic anticorrosion coating with self-made rust-inhibiting pigments, which can withstand salt fog for up to 192 hours. Liu Wenjie[5] and others prepared a water-based light anti-corrosion

coating for steel structures using water-based acrylic modified alkyd resin, heavy calcium powder, silica powder, mica powder, sodium nitrite, and organic chelate compounds, which can withstand salt fog for 72 hours. However, it cannot meet the anti-corrosion requirements of steel structures in the marine environment for ships, and the use of nitrites will increase the impact on the marine environment. The aqueous acrylic anti-corrosion coating developed by Liu Chengtai[2] demonstrated limited corrosion resistance in standardized testing: it exhibited a salt spray resistance (SSR) of merely 96 hours and a saltwater immersion resistance of only 24 hours. These performance metrics indicate that the current formulation was primarily suitable for short-term corrosion protection applications such as container coatings, while showing insufficient durability for long-term service in highly corrosive environments liking marine engineering or shipbuilding industries. Wang Xiu[3] had designed an environmentally friendly lightweight anti-corrosion single component acrylic anti-corrosion coating, which had good aging resistance. However, the surface drying time and actual drying time were relatively long, making it difficult to meet the needs of on-site construction. Therefore, the development of a green anti-corrosion coating suitable for ship use has significant practical significance.

This study uses a single-component water-based acrylic emulsion as the main film-forming substance, and by adding rust-inhibiting pigments such as zinc phosphate and rust-inhibiting silica powder, as well as various additives, a single-component water-based acrylic anti-rust paint applicable to ships is prepared, in order to solve the corrosion problems of ships in the marine environment.

2. Experiment

2.1. Raw Materials

Silicone PUA Emulsion, Dolphin1052T25, Solids content:(50.00 ± 2.00)%, Dolphin New Materials; Water-based Super Dispersant, Silok®7139W, Solids content:(50.00 ± 3.00)%,Sloke; Wetting Agent, WSS-713, Active ingredient content:100%, Guangyuan New Material Technology Co., Ltd.; Wetting Agent, HT-090, Content: 90%, Guangzhou Biheng Chemical Technology Co., Ltd.; Wetting Agent, ED3060, Active ingredient content: 100%, Shanghai Wangyi Chemical Co., Ltd.; Defoamer, XF-801, Effective ingredient content: 65%, Hangzhou Xianfei Chemical; Defoamer TEGO®Airex 904W, Active ingredient content: 100%, Guangyuan New Material; Defoamer DP-210, Effective ingredient content: 100%, Guangdong Tianfeng Defoamer Co., Ltd.; Anti-settling Agent, RHEOBYK-420, Active ingredients: 52%, Guangyuan New Material; Thickener, HEC33, 99% purity, Feicheng Yutian Chemical; Film-forming Aid, Ethylene Glycol Diacetate (EGDA), 99.5% purity, Propylene Glycol Diacetate (PGDA), 99.5% purity, Foshan Jinjia New Material Technology Co., Ltd.; Film-forming Aid, Dipropylene Glycol Butyl Ether (DPNB), 99% purity, Dipropylene Glycol Methyl Ether (DPM), 99% purity, Diethylene Glycol Butyl Ether (DB), 99% purity, Guangzhou Changhong Chemical Technology Co., Ltd.; Titanium Dioxide, R-566, The mass fraction of TiO_2: 94.0%, Tianjin Smait Technology Co., Ltd.; Flash Rust Inhibitor, Anticorrosion Agent 6151, Effective ingredient content: 100%, Poran New Material; Flash Rust Inhibitor, THI®F-3118, Effective ingredient content: 100%, Yantai Hengxin Chemical Technology Co., Ltd.; Rust Inhibiting Pigment, Zinc Phosphate, 98.5% purity, Changzhou Deshuo Chemical Technology Co., Ltd., Alumino Phosphate, 99.5% purity,Changzhou Akode New Material Science Co., Ltd.; Filler, 800 mesh Precipitated Barium Sulfate, 98.5% purity, Hebei Wei Cai Pigment Co., Ltd.; 800 mesh Talc, 99.5% purity, Guilin Gui Guang Talc Development Co., Ltd.; 800 mesh Calcium Carbonate, 98.5% purity, Lingshou County Hua Yao Mineral Products Processing Factory; Anhydrous Ethanol, 99.5% purity, AR, Dezhou Jinyi De Chemical Co., Ltd.; Distilled Water, Laboratory Prepared.

2.2. Apparatus and Equipment

YP1002 Electronic Balance, Shanghai Jinping Scientific Instrument Co., Ltd.; DF-101S Heating Mantle Magnetic Stirrer, Gongyi Yuhua Instrument Co., Ltd.; STM-IVB Stormer Viscometer, Jie Lai Laboratory Instruments (Shanghai) Co., Ltd.; QTX Coating Elasticity

Tester, Tianjin Shuida Laboratory Equipment Co., Ltd.; QGS Coating Drying Tester, Tianjin KeXin Testing Machine Factory; AR932 Coating Thickness Gauge, Dongguan Wan Chuang Electronic Products Co., Ltd.; CK-90A Salt Spray Chamber, Beijing Times Maker Technology Co., Ltd.; DHG-9203A Desktop Digital Display Air-Circulating Drying Oven, Longkou City Electric Furnace Factory; Elcometer 106 Adhesion Tester, Elcometer.

2.3. Preparation of the Coating

2.3.1. Basic Formulation (See Table 1)

Table 1 Basic Formula

Serial No.	Component	Percentage/%
1	Distilled Water	10-20
2	Defoamer	0.1-0.5
3	Dispersant	0.5-1.5
4	Wetting Agent	0.1-0.5
5	Flash Rust Inhibitor	0.5-1.5
6	Film-forming Aid	3-5
7	Acrylic Emulsion	20-60
8	Filler	10-15
9	Rust Inhibiting Pigment	10-15
10	Thickener	1-3

2.3.2. Preparation Process

Add components 1-6 in sequence, disperse at a speed of 600r/min for 10 minutes, then add component 7 and disperse at a speed of 1000r/min for 5 minutes. After that, add component 8 and disperse at a speed of 1500r/min for 30 minutes. Then, add component 9 and continue to disperse at a speed of 1500r/min for another 30 minutes. Finally, add component 10 and disperse to adjust the viscosity of the paint material, all at 20℃.

2.4. Coating Preparation

Select steel plates with dimensions of 150mm × 70mm × 3mm. First, use a sandblaster for surface treatment to remove rust and oxide layers from the surface. Then, use an air compressor to blow off sand powder and other attached impurities from the surface. After blowing, immerse the plates in anhydrous ethanol to dissolve any oil stains on the surface, and then wipe with degreasing cotton. Finally, place them in an oven at around 50 °C to dry, and then store them in a desiccator for later use.

Take the steel plates from the desiccator, pour the prepared coating into a spray bottle, and use an electric spray gun for application. During spraying, the distance between the spray gun and the surface to be coated should not be less than 200 mm. The spraying direction should be at an appropriate angle to the surface, with an air pressure of 0.2~0.4 Mpa, and the spray gun should move at a uniform speed. The prepared coating should be placed under constant temperature and humidity conditions for 48 hours to adjust the state. For impact resistance and drying time tests, the dry film thickness of the coating should be (23±3) μm. For salt spray resistance tests, the dry film thickness should be (90±10) μm. For all other tests, the dry film thickness should be (75±10) μm.

2.5. Coating Performance Test Methods

Thermal Storage Stability of Coating: Refer to the standard GB/T 6753.3-1986 "Test Method for the Storage Stability of Paints," take 150 g of liquid base material and place it into a reagent bottle, seal it, and store it in an oven at (50 ± 2) °C for 30 days, observing the state of the base material.

Drying Time: In accordance with GB/T 1728-2020 "Determination of Drying Time of Paint Films and Stains."

Adhesion: Measured according to GB/T 5210-2006 "Paints and Varnishes - Pull-off Test for Adhesion."

Flexibility: Measured according to GB/T 1731-2020 "Determination of Flexibility of Paint Films and Stains."

Resistance to Salt Water: Conducted in accordance with GB/T 10834-2008 "Ship Coatings - Determination of Resistance to Salt Water - Immersion in Salt Water and Hot Salt Water," with the test salt water temperature being (27±6) ℃.

Resistance to Salt Spray: Conducted in accordance with GB/T 1771-2007 "Paints and Varnishes - Determination of Resistance to Neutral Salt Spray."

Adaptability to Top Coats and Paint Workability: Conducted according to "5.12 and 5.13" in GB/T 6748-2008 "Anti-fouling Paints for Ships."

Determination of Bubble Density Reduction Ratio (BDRR): Prepare 100 g of three sets of paint containing different types of defoamers according to the preparation process in 2.3.2, then poured them into a 150 mL measuring cylinder and let it stand for 1 minute. Record the volume of bubbles as V_1 mL. Prepare another set of paint 100 g without defoamers, then pour it into a 150 mL measuring cylinder and let it stand for 1 minute. Record the volume of bubbles as V_0 mL. The bubble density reduction ratio is recorded as $(V_0-V_1)/V_0\times100\%$.

3. Results and Discussion

3.1. Selection of Defoamers

During the preparation of coatings, additives such as dispersants, wetting agents, and thickeners were used, which could generate a large amount of foam that was not easy to dissipate during stirring. The air present in the foam could hinder the dispersion of pigments and fillers, leading to surface defects in the coating due to the presence of foam, which in turn affects the coating's corrosion resistance and weatherability[6-8]. Therefore, the role of defoamers in coatings was crucial and directly related to the quality of the coating performance[9]. Common types of defoamers include polyethers, organosilicon compounds, and polyether-modified organosilicon compounds. The experiment selected three different types of defoamers and prepared single-component waterborne acrylic coatings according to the preparation process in 1.3.2. By observing the surface condition of the coating, the appropriate defoamer was selected. The physicochemical parameters of the three defoamers and the surface condition of the coatings were shown in Table 2.

Table 2 Physicochemical parameters and coating surface state of the three defoaming agents

Serial No.	Name	Type	Coating Process	Coating Surface Condition	BDRR (%)
1	DP-210	Polyether Type	Poor defoaming	Craters appeared	86
2	TEGO®Airex 904W	Polyether-Modified Organosilicon Type	Good defoaming	Surface appears normal	98
3	XF-801	Organosilicon Type	Good defoaming	Pinholes appeared	95

From Table 2, it could be observed that different types of defoamers exhibit varying performance and have distinct impacts on the resulting coatings. The organosilicon defoamer, although effective in defoaming during the initial sample preparation, resulted in a coating surface with pinholes, making it unsuitable for this system[10]. The polyether defoamer had poor defoaming capabilities in the early stages of sample preparation, leading to the formation of craters in the final coating[11]. In contrast, the polyether-modified organosilicon defoamer not only demonstrated excellent defoaming effects during the

paint-making process but also yielded a coating surface that appeared normal. Therefore, the type of defoamer used in this study is TEGO®Airex 904W.

3.2. Selection of Film-Forming Aids

The surface tension of hydroxyl acrylic dispersions in an aqueous medium is high, the latent heat of vaporization was large, and the solubility was limited. Therefore, film-forming aids were required to enhance the compatibility of the coating system during the paint preparation process[12]. The addition of film-forming aids can shorten the surface drying time of the paint film and simultaneously improve the condition of the paint film surface[13]. Different film-forming aids had different physicochemical properties, which ultimately lead to varying performance of the coatings[14]. In this experiment, five commonly used film-forming aids were selected, and paints were prepared according to the manufacturing process in 2.3.2, followed by spraying to obtain the corresponding coatings. The physicochemical properties of the five film-forming aids and the corresponding indicators of the coatings were shown in Table 3 and Table 4.

Table 3 Physicochemical properties of film forming additives[15]

Film-Forming Aid	Chemical Name	Evaporation Rate (Relative to Butyl Acetate)	Boiling Point/℃	Water Solubility	Surface Tension ($mN \cdot m^{-1}$)	Molecular Weight
EGDA	Ethylene Glycol Diacetate	0.05	187	5.3%(20℃)	33.7(20℃)	146.14
PGDA	Propylene Glycol Diacetate	0.04	191	Completely water-soluble	31.0(20℃)	160.17
DPNB	Dipropylene Glycol Butyl Ether	0.08	261.7	40%(25℃)	28.4(20℃)	190.28
DPM	Dipropylene Glycol Methyl Ether	0.02	190	Completely water-soluble	28.8(25°C)	148.20
DB	Diethylene Glycol Butyl Ether	0.003	230.4	Completely water-soluble	33.6(25°C)	162.23

Table 4 Coatings and corresponding coating indexes

Film-Forming Aid	State Before Heat Storage	State After Heat Storage	Drying time/	Coating Condition
EGDA	Milky homogeneous	Semi-transparent paste	110	Smooth and even
PGDA	Milky homogeneous	Semi-transparent paste	135	Smooth and even
DPNB	Milky homogeneous	Semi-transparent paste	60	Orange peel
DPM	Milky homogeneous	Milky homogeneous	70	Smooth and even
DB	Milky homogeneous	Semi-transparent paste	160	Smooth and even

Generally, the closer the solubility parameters of the solvent and the resin, the more effectively the resin could be dissolved, thereby increasing the viscosity of the paint[14].

From the table, it could be observed that before heat storage, the coatings prepared with the five film-forming aids all exhibited a milky homogeneous state. However, after heat storage, only the single-component waterborne acrylic coating prepared with DPM maintained a better milky homogeneous state, while the coatings prepared with the other four film-forming aids had become semi-transparent paste. This may be because the addition of DPM had a relatively smaller degree of swelling on the resin compared to the other four film-forming aids, resulting in a smaller increase in paint viscosity during the entire heat storage process, thus still presenting a milky homogeneous state after heat storage.

During the drying process of the paint film, there was evaporation of water and solvent, and the evaporation of water mainly follows two models: the three-stage evaporation model proposed by Vanderhoff and the two-stage evaporation model proposed by Croll[16]. The difference between these two models was that the three-stage evaporation model takes into account the "skinning" of the paint film surface during the evaporation of water. Since acrylic emulsions could form a dense film on the surface, it slowed down the evaporation of volatile components on the surface of the coating. Therefore, it was necessary to reasonably control the time of surface skinning to shorten the evaporation time of volatile components on the surface of the coating[13]. From Table 4, it could be seen that the surface drying time of the coatings added with EGDA, PGDA, and DB was longer. This was because the boiling points of the three are relatively high, and their degree of swelling on the waterborne acrylic dispersion particles was larger, some of which could associate with the hydrophobic groups of the waterborne acrylic resin, slowing down their evaporation in the paint film. Although DPNB had a relatively high boiling point, its evaporation rate was faster, so the surface drying time was faster, leading to the appearance of orange peel phenomenon on the coating surface. DPM, due to its moderate evaporation rate and boiling point, results in a relatively short surface drying time and a smooth and even coating surface. Based on the experiments, the best film-forming aid chosen in this study was DPM.

3.3. Selection of Flash Rust Inhibitors

In waterborne acrylic coatings, a common issue was the occurrence of flash rust, which happened during the drying process of the coating sprayed on the steel surface. Due to the potential difference formed in different areas, electrochemical corrosion could occur on the surface of the steel, and this process could happen in a very short time during the surface drying phase. Large rust spots may appear shortly before the moisture evaporates completely, leading to flash rust[17-18]. Therefore, it was necessary to add a certain amount of flash rust inhibitors to suppress the flash rust phenomenon during the drying process of single-component waterborne acrylic coatings.

In this study, two commercially available flash rust inhibitors, Anticorrosion Agent 6151 and THI®F-3118, were selected and prepared according to the process in 1.3.2. They were sprayed onto the treated steel plates, and the resulting paint films were observed for any signs of "flash rust" after drying. The experimental results were shown in Figure 1.

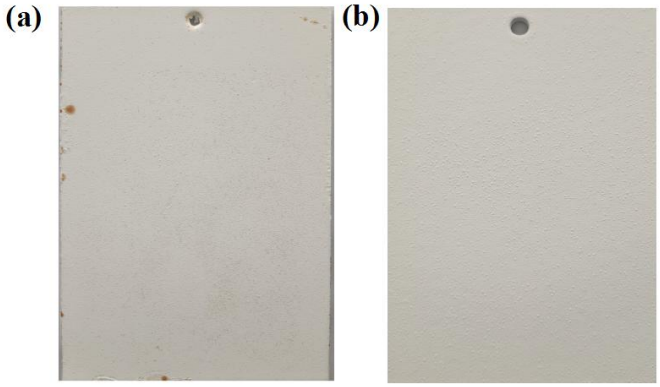

Figure 1 Coating state after adding different anti flash rust agents（a.Anticorrosion Agent 6151, b.THI®F-3118）

Figures (a) and (b) showed the drying effects of coatings with the flash rust inhibitors Anticorrosion Agent 6151 and THI®F-3118, respectively. From the figures, it could be observed that the coating with Anticorrosion Agent 6151 exhibited numerous rust spots, and flash rust appeared shortly after the coating began to dry, indicating that this flash rust inhibitor does not effectively suppress the flash rust phenomenon in this system. In contrast, the coating with THI®F-3118 did not show any signs of flash rust throughout the spraying and drying process, demonstrating that this flash rust inhibitor can effectively suppress the occurrence of flash rust in this system. Therefore, the best flash rust inhibitor chosen in this study is THI®F-3118.

3.4. Selection of Wetting Agents

In waterborne coatings, the high surface tension of water leads to a high surface tension of the coating itself[19]. The higher surface tension resulted in poor wetting of the coating on the substrate surface, leading to surface defects such as craters, edges shrinking, and uneven coating, which in turn affected the coating's corrosion resistance[20-21]. Therefore, wetting agents played a very important role in waterborne coating systems. In this study, three different types of wetting agents were selected, with a controlled addition of 0.5% each, and three batches of single-component waterborne acrylic anti-corrosive coatings were prepared according to the manufacturing process in 1.3.2. After spraying and drying, three sets of coatings were obtained, and the categories of the three wetting agents and the spraying results are shown in Table 5.

Table 5 Coating states after adding different types of wetting agents

Name	Category	Coating Condition
HT-090	Gemini ion-type surfactant	Coating shows craters
WSS-713	Organosiloxane copolymer	Coating surface normal, uniform coating
ED3060	Ethylenediamine oxide addition product	Coating shows edge shrinking

From the table, it could be observed that the coating obtained from the paint with HT-090 showed cratering, and the coating from the paint with ED3060 exhibited edge shrinking. This indicated that these two wetting agents were not effectively reducing the surface tension of the paint on the substrate surface, leading to poor wetting and resulting in surface defects. The coating obtained from the paint with WSS-713 had a better surface appearance, with a more uniform and smoother coating. This was likely because the oxygen in the organosiloxane class could form hydrogen bonds with polar atoms or molecular groups on the substrate surface, thereby reducing the overall surface tension of the paint and increasing its spread on the substrate. In conclusion, the best wetting agent selected in this study was the organosiloxane copolymer WSS-713.

3.5. Selection of Rust Inhibiting Pigments

The active components in rust inhibiting pigments reacted with the metal surface to form a dense protective layer, effectively reducing the rate of electro-chemical corrosion and enhancing the adhesion of the coating to prevent blistering, cracking, or detachment caused by corrosion[22]. Therefore, rust inhibiting pigments played a very important role in waterborne anti-corrosive coatings. In this study, zinc phosphate A-S-7, aluminum tripolyphosphate A-ATW-1, and rust inhibiting silica powder MpAdd 304 were selected as experimental subjects, with a controlled proportion of 10% in the coating. Coatings were prepared according to the process in 1.3.2, then sprayed to obtain the corresponding coatings. The adhesion, salt fog resistance, and salt water resistance of the coatings were tested, with the results shown in Table 6.

Table 6 Effects of Different Anti rust Pigments on Coating Performance

Performance	Antirust pigment						
	Zinc Phosphate	**Aluminum Tripolyphosphate**	**Rust Silica Powder**	**Zinc Phosphate + Aluminum Tripolyphosphate**	**Zinc Phosphate + Rust Silica Powder**	**Aluminum Tripolyphosphate + Rust Silica Powder**	**Zinc Phosphate + Aluminum Tripolyphosphate + Rust Silica Powder**
Adhesion/Grade	2	2	2	2	1	2	1
Salt Fog Resistance/h	168	192	216	240	336	240	240
Salt Water Resistance/h	96	144	168	192	240	192	192

From the table, it could be observed that the rust-inhibiting effects of single-component pigments showed that those containing zinc phosphate and aluminum tripolyphosphate had shorter salt fog and salt water resistance times, while rust silica powder exhibited relatively longer resistance times. This was primarily because zinc phosphate and aluminum tripolyphosphate released ions at a slower rate initially, which meaning that the passive film on the coating had not yet formed. Rust silica powder, being an ion-exchange type silica, could effectively chelate with the substrate surface at the early stages of corrosion, providing better protection.

Regarding the combined components, the combination of zinc phosphate and rust silica powder showed better salt fog resistance, salt water resistance, and adhesion compared to other combinations. This may be due to the synergistic effect of zinc phosphate and anti rust silicon powder. Anti rust silicon powder fills the coating pores, forms a dense physical barrier, and blocks the penetration of water, oxygen, and corrosive ions (Cl^-, SO_4^{2-}, etc.); Zinc phosphate inhibits local corrosion through chemical passivation. On the other hand, the surface of silica contains hydroxyl groups (-OH), which may adsorb H^+ or OH^- in the environment, adjust the pH of the coating micro area, promote the stable dissolution of zinc phosphate, and form a passivation film. Both jointly extend the protective life of the coating. Although aluminum tripolyphosphate as a single component had better salt fog and salt water resistance than zinc phosphate, the suspension of aluminum tripolyphosphate had a pH that was acidic to neutral, which could not stabilize the pH of the paint film. This results in coatings containing aluminum tripolyphosphate in combined components having slightly lower salt water and salt fog resistance.

Considering all the experimental results, the combination of zinc phosphate and rust silica powder was selected as the more suitable rust-inhibiting pigment for the system.

3.6. Comprehensive Performance of the Coating

In summary, this study selected Dolphin1052T25 emulsion as the main film-forming substance, TEGO®Airex 904W as the defoamer, DPM as the film-forming aid, THI®F-3118 as the flash rust inhibitor, WSS-713 as the wetting agent, and zinc phosphate and rust silica powder as the main rust inhibiting pigments to prepare a single-component waterborne acrylic anticorrosive coating for ship use. The main performance of this anticorrosive coating was shown in Table 7. From the table, it could be seen that the test results of the anticorrosive coating meet the standard requirements and could be used in the field of ship anticorrosion.

Table 7 Main Performance of Anti corrosion Coatings for Ships

Performance	Requirement	Test Result	Performance	Requirement	Test Result
Surface Drying Time/h	/	1	Salt Water Resistance/h	(27±6)℃，96h	240
Hard Drying Time/h	≤24	3	Salt Fog Resistance/h	168h	336
Adhesion/Mpa	≥3	3.5	Compatibility with Top Coat	No adverse phenomena	Normal
Flexibility/mm	≤2	1	Workability	Pass	Pass

4.Conclusion

This study successfully developed a single-component waterborne acrylic anticorrosive coating for ship use by selecting suitable defoamers, film-forming aids, flash rust inhibitors, wetting agents, and rust inhibiting pigments. The performance of the coating meets the requirements of the standard GB/T 6748-2008 "Anti-fouling Paints for Ships." The coating has a surface drying time of 1 hour, a hard drying time of 3 hours, salt water resistance of 240 hours, salt fog resistance of 336 hours, and exhibits good adhesion and flexibility. This research provides a reference for the development of anti-rust paints for ships and could be effectively applied in the field of ship anticorrosion.

5. Patents

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References

1. Shu S J. Research on Anticorrosive Application of Waterborne High-gloss and High-performance Acrylic Latex[J]. China Coatings, 2022, 37(3): 63-69.
2. Liu C T. Preparation and Application of Waterborne Acrylic Anti corrosion Coating[J]. Shanghai Coatings, 2021, 59 (03): 15-17.
3. Wang X. Application research on environmentally friendly water-based acrylic anti-corrosion coating[J]. Paper Equipment and Materials, 2022, 51 (05): 63-65.
4. Li Y, Jiang C C, Liao M R, et al. Preparation of a Kind of Waterborne Acrylic Anticorrosive Coatings with High Salt Spray Resistance[J]. China Coatings, 2023, 38(3): 64-67+76.
5. Liu W J, Chen M, Guan H. Preparation of a waterborne light-duty anticorrosive paint for steel structures[J]. Electroplating & Finishing, 2020, 39(16): 1119-1123.
6. Liu C T. Screening of Defoamers in Waterborne Acrylic Coatings[J]. China Coatings, 2021, 36(1): 51-60.
7. Chang X Y, Huang Y H, Gao X, et al. Brief Introduction on the Development of Waterborne-based Wood Paint[J]. China Forest Products Industry, 2016, 43(3): 11-15.
8. Hou H T, Zhang Y B, Li Y D. Selection of film-forming additives for waterborne acrylic polyurethane paint [J]. Electroplating & Finishing, 2023, 42 (12): 51-56.
9. Liu D Y, Wang P Z, Li C X, etc Development of a polyaspartic acid ester anti-corrosion coating[J]. Shanghai Coatings, 2024, 62 (05): 20-23.
10. Yu G L, Wang X K. Application of Defoamer in Waterborne Coatings and Research Progress[J]. China Coatings, 2019, 34(2): 70-74.
11. Huang X, Wang M K, Wang W J et al. Preparation and Performance Study of Organosilicon Defoamer[J]. Siliconematerial, 2015, 29(4): 296-299.

12. LIN Y S, WU Y X, HUANG Y P, et al. Preparation of waterborne acrylic amino baking varnish and characterization of its properties [J]. Electroplating &Finishing, 2018, 37 (10): 442-446.
13. HOU H T, ZHANG Y B, LI Y D. Selection of film-forming additives for waterborne acrylic polyurethane paint[J]. Electroplating & Finishing, 2023,42 (12): 51-56.
14. RONG J C, YAN L, SONG K L, et al. Study on the effects of coalescent additives on the properties of waterborne amino baking coatings[J]. Paint & CoatingsIndustry, 2021, 51 (12): 76-82.
15. CHENG N L. Solvents Handbook [M]. 5th ed. Beijing: Chemical Industry Press, 2015.
16. WANG W S. Drying process of aqueous polyurethane dispersion[J]. Coatings Technology & Abstracts, 2011, 32 (12): 7-18.
17. GU R, LI Y D. A Study on Application of Anti-flash-rust Agent in Waterborne One-component Acrylic Coatings[J]. China Coatings, 2021, 36(7): 42-46+56.
18. WANG Z K, JIAO J, HAN Y X, et al. Study on Acrylic Polymer Emulsion wit h Flash-Rust Resistance[J]. Coating and Protection, 2021, 42(1): 47-53.
19. QIU B X, LIN W Q, ZHANG Y T, et al. Application of Waterborne Coatings in Urban Railway Vehicle[J]. PAINT & COATINGS INDUSTRY, 2019, 45(11): 69-72.
20. LIU M L. Research on the Application of Substrate Wetting Agent in Water-borne Coatings[J]. PAINT & COATINGS INDUSTRY, 2023, 53(10):76-81.
21. XIONG W, ZHANG M, ZHANG S J, et al. Development of Waterborne Acrylic Polyurethane Topcoat for Rail Vehicles[J]. PAINT & COATINGS INDUSTRY, 2022, 52(1): 46-53.
22. BAI F X, WANG Y C, LI H Y, et al. Preparation and Performance of High Performance Waterborne Acrylic DTM Anticorrosive Coatings[J]. Coating and Protection, 2024, 45(9): 50-55.