Performance Chemicals

Successful Performance Chemicals of Sanyo Chemical Group 132

Rust Inhibitor

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Metals, which are essential to our daily lives, are produced by reducing (refining) metal oxides, sulfides, and carbonates, which originally exist in the natural world in an energetically stable state, to a metastable state by application of energy. These metals are highly ductile, machinable, lustrous solids (except mercury) at room temperature, and are used in a wide range of applications essential for comfortable living, such as transportation equipment, buildings (buildings, bridges, roads), and electrical appliances, due to their ability to conduct electricity and heat.
On the other hand, these metals, which are in a metastable state, have a fate of rusting (oxidizing) as they try to return to their original stable state. When metals rust, it is not only a safety and functional problem, but also an aesthetic one. The economic loss caused by corrosion is enormous especially in humid areas, and it is important to take measures to prevent rust for the effective use and durability of these resources.

What is rust?

Rust, which we usually see, is a type of corrosion in which water and oxygen act on metals and change them into oxides and hydroxides. Metals are characterized by strong bonding strength and high electrical and thermal conductivities due to the movement of free electrons between the regularly arranged metal atoms. On the other hand, the energy state is high due to the free electrons moving around, and it tries to return to a stable state by losing its energy. For this reason, it is easy for electrons to be exchanged (potential difference is easily generated), and the potential difference generated by some trigger, such as contact with water and partial ionization, can easily be oxidized to return to the stable oxidized state (where the free electrons are trapped by oxygen and do not move freely). This is called "rust. **Figure 1** shows the mechanism of rust formation in air, using iron (Fe) as an example, which accounts for about 95% of the metal materials used today and is the most familiar metal to us. Rust is formed by the formation of a microscopic ventilation cell with positive and negative poles (a minute potential difference generated by the difference in concentration of dissolved oxygen and ions) in the thin water film formed on the metal surface. The rust then spreads over a wide area due to the phenomenon of "rust calls for rust".

Prevent rust

In order to prevent rust, there are methods of protecting the metal from a corrosive environment other than selecting a metal material such as gold that is hard to corrode. Surface coatings such as painting, plating, lining, etc., and the use of rust inhibitors are effective methods of rust prevention.
Since rust is electrochemically generated, a method of applying a weak electric current to the metal surface to eliminate the corrosion potential and prevent corrosion is also an effective rust prevention method. The period of time for which rust prevention is required varies from temporary rust prevention during a specific process, to decades, to semi-permanent rust prevention. It is necessary to select a method that does not affect the main requirements of each application.

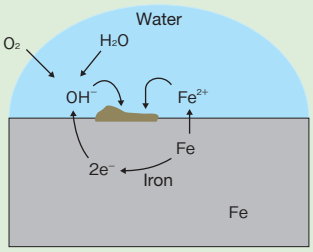

Fig. 1 Mechanism of rust formation

Rust prevention with rust inhibitor

Rust prevention using rust inhibitors is a method of preventing rust by forming a rust-proof film on the surface of the metal by applying the rust inhibitor or adding it to a solution. Compared to other corrosion prevention methods, this method requires less special equipment and can be used regardless of the shape of the metal to be protected, so it is used in a wide variety of fields.
Rust inhibitors can be divided into water-soluble, oil-soluble, and vaporizable. Oil-soluble rust inhibitors can be applied as rust preventive oil as it is, and water-soluble rust inhibitors can

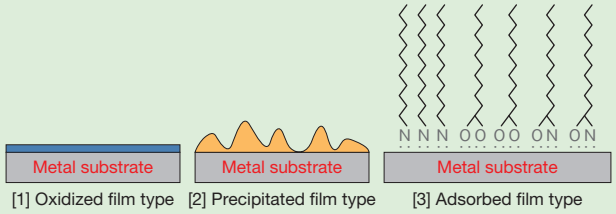

Fig. 2 The film types of water-soluble rust inhibitors

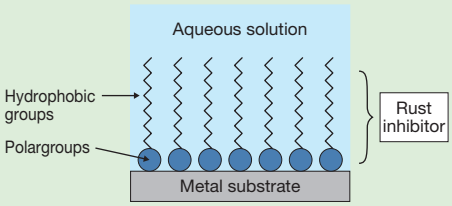

Fig. 3 Adsorbed film of water-soluble rust inhibitors

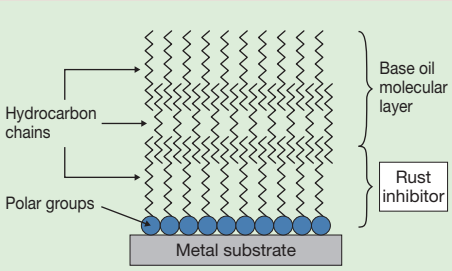

Fig. 4 Adsorbed film of oil-soluble rust inhibitors

be added to a solution. The vaporizable rust inhibitor forms a film on the metal surface and fills the air, preventing the moisture in the air from reacting with the metal.

There are two types of water-soluble rust inhibitors, inorganic and organic, and they can be classified into three types based on the formation mechanism of the rust inhibiting film: oxidized film type, precipitated film type, and adsorbed film type. **Table 1** classifies the types of rust inhibitors and the characteristics of the films formed on metal surfaces[1)] , and **Figure 2** shows the images of the three film types of water-soluble rust inhibitors. Of these, the organic rust inhibitors mainly consist of surfactants that form adsorbent films, and they form good films in solution.

The surfactant-based rust inhibitors have both hydrophobic (lipophilic) and polar groups (hydrophilic) in their molecules, and in the case of the water-soluble rust inhibitors, as shown in **Figure 3**, the polar groups adsorb onto the metal substrate to form a film, while the hydrophobic groups block water and oxygen to prevent corrosion of the metal.

On the other hand, in the case of oil-soluble rust inhibitors, they have lipophilic groups that are large enough to dissolve in oil, and the polar group is adsorbed on the metal substrate in the base oil. The base oil molecules penetrate into the adsorbed molecules, and as shown in **Fig. 4**, mixed adsorption occurs and the function is expressed.

These adsorption film-type rust inhibitors repeatedly adsorb and desorb from the metal substrate. The denser and stronger adsorbed film exhibits a better anti-corrosion effect.

Application example of rust preventive

There are a wide variety of site and process conditions where corrosion inhibitors are required, such as target metal, exposed atmosphere and temperature, required durability and target level, other effects of mixtures and potentially contaminated substances during use, cost, etc., and it is required to select an appropriate rust inhibitors and use it under

Table 1 Types of rust inhibitors and their characteristics

Type of rust inhibitors	Rust-proof film		Reoresentative rust inhibitors	Characteristics of rust-proof film
Water-soluble rust inhibitors	Oxidized film type		Chromate, molybdate, tungstate, nitrite	Forming a dense and thin film (30-200 Å) Good adhesion to metal substrate Good rust prevention
	Precipitated film type	Salt type	Polymerized phosphate, zinc salt	Forming a porous and thick film Adhesion with the metal substrate is slightly poor
		Metal ion type	Mercaptobenzothiazole, benzothiazole	Forming a relatively dense and thin film
	Adsorbed film type		Alkanolamines, fatty acid salts, Alkylate amine ethylene oxide adduct, alkyl phosphate ester salt	Forming a good film in acid solution and aqueous solution Poor adsorption on non-clean surfaces
Oil-soluble rust inhibitors (Adsorbed film type)			Petroleum sulfonate, sorbitan ester, Alkenyl succinic anhydride, alkylnaphthalene sulfonate	Forming a good film in mineral oil
Vaporizable rust inhibitor			Diisopropylammonium nitrate, Dicyclohexylammonium nitrate	Vaporized rust inhibitor fills the air Forming an extremely thin film on the metal surface

appropriate conditions.
The following is a brief description of the four processes to which rust inhibitors are applied in the process flow **(Fig. 5)** from iron ore through steel sheets to processing, mainly in applications such as automobile bodies, electrical appliances, and buildings.
[1] Pickling
After iron ore is reduced with coke to make an iron slab, the surface of the hot-rolled steel sheet will have a mill scale, a type of rust. To remove this mill scale, the steel sheet is immersed in an aqueous solution of acid such as hydrochloric acid or sulfuric acid. To prevent the surface from being roughened by dissolving the iron base too much, a rust inhibitor is added. Rust inhibitors which contain nitrogen or sulfur atoms or both and have relatively large molecular weights have strong anticorrosive effect, such as hexadecylamine, rosin amine and their ethylene oxide adducts, hexadecylammonium chloride, dodecylammonium chloride, and oleylimidazoline. These components are usually used in combination with two or more other components.
[2] Cold rolling
In the cold rolling process of processing a steel sheet into a thin sheet, rolling oil is used in order to prevent friction of the work roll and improve the finished surface of the steel sheet. The rolling oil used is palm oil, mineral oil, etc. emulsified in water with an emulsifier, and rust inhibitor also added. Fatty acid esters and alkenyl succinic acid, which have good lubricity, are used for rust inhibitors.
[3] Transportation and storage
The finished steel sheet is shipped after being coated with rust preventive oil so that rust does not occur during transportation and storage. Most of the rust inhibitors added to rust preventive oil are oil-soluble, such as oxide paraffin, fatty acid, naphthenic acid, abietic acid, dimer acid, alkenyl succinic acid and its salts, petroleum sulfonic acid and alkyl naphthalene sulfonic acid and their salts, esters such as sorbitan monooleate are used.
[4] Processing
In metal processing oil such as press oil, cutting oil, and quenching oil, rust inhibitors are added to prevent rusting of the products and the machines used in the processing. Rust is especially likely to occur with water-soluble processing oils, which is a major problem. The rust inhibitors used in the past had good rust preventive ability, but due to concerns that they may affect the environment and the human body, several types of specific alkanolamines are currently used in combination with organic aromatic carboxylic acids and salts of fatty acids. In general, since water-soluble processing oils are used for a long time, they are gradually placed in an environment where they are susceptible to rust due to deterioration and decomposition or contamination with inorganic decomposing ions. Therefore, rust inhibitors are also required to be resistant to deterioration. The rust inhibitor is also required to have low foaming properties because it is discharged and circulated from pumps.

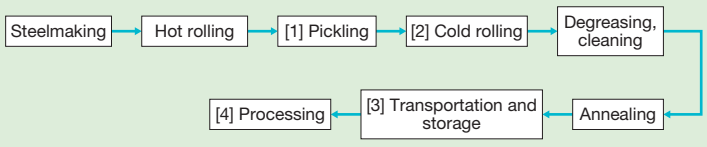

Fig. 5 Process flow from iron ore through steel sheets to processing

Sanyo Chemical's rust inhibitors

Finally, **Table 2** lists the types and features of our rust inhibitors. We have both water-soluble and oil-soluble organic rust inhibitors that are adsorbed and oriented on the metal surface to form a rust preventive film and prevent the generation of rust. Water-soluble rust inhibitors are used for primary rust prevention of metal parts, and are added to cooling water, water-soluble metal processing oils, etc.. Our oil-soluble rust inhibitor is added to lubricating oil, fuel oil, oil-soluble metal processing oil, etc., and is used to suppress corrosion of metal parts that come into contact with these liquids.
The following is an example of the evaluation results of the rust preventive property of our rust inhibitors against iron.
Table 3 shows the evaluation results of the rust-preventive effect of the water-soluble rust inhibitor on iron, and **Table 4** shows the evaluation results of the rust-preventive effect of the oil-soluble rust inhibitors on iron. As shown in **Tables 3** and **4**, our rust inhibitors have excellent rust-preventive effects on iron.

Future Issues

There are a wide range of applications and targets that require anti-corrosion performance, and the requirements are becoming more and more stringent, while environmental friendliness and safety must also be emphasized. We will make best effort to provide products that meet customer needs and develop new products.

References

1) Takashi Suzuki: Inhibitor. Material, 23, [254] 24 (1974)

Table 2 Our rust inhibitors

	Product name	Main component	Features	Specially effective metals				
				Iron	Cupper	Brass	Alumi-nium	Zinc alloy
Water-soluble	SANHIBITOR No.2-1*	Calboxylic acid type anionic surfactant	Excellent rust prevention in the air. Also effective for non-ferrous metals. Low foaming property.	○	○	○	○	○
	SANHIBITOR No.50	Amine-based ionic surfactant	Easy to wash with water. It is an amine type and has excellent adsorption power. Extremely low foaming property (almost no foaming). It also dissolves in mineral oil with an aniline point of 70 or less and acidic water.	○				
	SANHIBITOR OMA-10	Succinic acid type anionic surfactant	Effective for iron and aluminum. Also suitable as a rust inhibitor for metal processing.	○			○	
Oil-soluble	SANHIBITOR No.2-1*	Calboxylic acid type anionic surfactant	Excellent rust prevention in the air. Also effective for non-ferrous metals. Low foaming property.	○	○	○	○	○
	SANHIBITOR 102	Alkenyl succinic acid	A small amount to lubricating oil such as turbine oil and fuel oil demonstrates excellent rust prevention. Also ideal for metal processing.	○			○	○
	SANHIBITOR 150	Alkenyl succinate	It has excellent anti-emulsifying properties and is ideal for turbine oil. It can also be used for rust preventive lubricating oil.	○			○	
	IONET S-80S IONET S-800 IONET S-85	Sorbitan ester	Good rust prevention in the atmosphere. In addition to rust prevention, it also has lubricity and emulsification. Excellent. Ideal for rust preventive oils and metalworking oils.	○			○	
	DSA PDSA-DA	Alkenyl succinic anhydride	It has excellent anti-emulsifying properties and is ideal for turbine oil. It easily dissolves in mineral oil and has excellent adsorptive power.	○				

*SANHIBITOR No.2-1 can be used for both water-soluble and oil-soluble.

Please contact the sales representative of our company when handling our company's products. It is also necessary to read the "Safety Data Sheet" (SDS) in advance. It is the responsibility of the user to determine the suitability and safety for the intended use.

Table 3 Anti-corrosion property of water-soluble rust inhibitor against iron

Product Name	Concentration (mass %)	Rust inhibitor property
SANHIBITOR No.2-1	0.2	A to B
	0.5	A
SANHIBITOR No.50	0.2	A to B
	0.5	A to B
SANHIBITOR OMA-10	0.2	A
	0.5	A
No added (tap water)	–	E

Soaked the test piece of iron (SPCC-SB, 1.3 x 80 x 60 mm) in a sample solution of water-soluble rust inhibitor (0.2 and 0.5% by mass) added tap water (Kyoto City) for 1 minute (25°C). Took out and observed the changes in appearance after standing in a constant temperature and humidity machine (40°C, 80% R.H.) for 20 days. 0% rust occurrence is A grade, 1-10% is B grade, 11-25% is C grade, 26-50% is D grade, 51- It was rated based on the criteria that 100% is grade E.

Table 4 Anti-corrosion property of oil-soluble rust inhibitor against iron

Product Name	Concentration (mass %)	Rust inhibitor property
SANHIBITOR 102	1	A
	3	A
SANHIBITOR 150	1	A
	3	A
IONET S-80S	1	B
	3	A
Petroleum sulfonate (Other company)	1	D
	3	C
No added (spindle oil)	–	E

Soaked the test piece of iron (SPCC-SB, 1.3 x 80 x 60 mm) in a sample solution of a oil-soluble rust inhibitor (1 and 3% by mass) added No. 1 spindle oil (# 60) for 1 minute (25°C). Took out and observed the changes in appearance after standing in a constant temperature and humidity machine (50°C, 95% R.H.) for 20 days. 0% rust occurrence is A grade, 1-10% is B grade, 11-25% is C grade, 26-50% is D grade, It was rated based on the criteria that 51-100% is grade E.

[Contact (about the product)]
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