

# Vapro 812-Removing Rust & Corrosion through MRST

## (Molecular Reaction Surface Technology)

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### Abstract

Most rust removal treatments involve leaving the rusted metals in an acidic cleaning agent, which burns the rust off along with a loss of a proportionate amount of metal.

This article will introduce Vapro 812-MRST (Molecular Reaction Surface Technology) for removing rust and corrosion from surfaces without etching the metal.

Conventional rust removal processes involve the use of corrosive inorganic acids such as Hydrochloric (Muriatic), Hydrofluoric, Phosphoric, etc. Such acids cause hydrogen embrittlement to metals, affecting the tensile strength and reoccurrence of flash rust almost immediately after the rust removal process. This involves tedious reworking processes of rust removal, which can affect productivity. Besides posing potential hazards to users, the fumes generated also cause corrosion to the surrounding structures.

In view of the above, Magna International Pte Ltd and the Autonomous University of Baja California have jointly developed a safer and better approach of rust removal using MRST without etching the metal surfaces, thereby retarding metal loss during rust removal process.

### Introduction

According to NACE International, it is estimated that the global cost of corrosion to be US\$2.5 trillion, equivalent to roughly

3.4 percent of the global Gross Domestic Product (GDP). The two-year global study released at the CORROSION 2016 conference in Vancouver, B.C., examined

the economics of corrosion and the role of corrosion management in establishing industry best practices. The study found that implementing corrosion prevention best practices could result in global savings of between 15-35 percent of the cost of damage, or between \$375-875 billion (USD).<sup>1</sup>

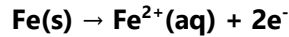
Besides the global cost for corrosion, reoccurrence of flash rust, metal loss affecting the tensile strength after rust removal is a cause of concern for all industries including automotive, aviation, marine, oil & gas manufacturing and metalworking industries, aggravating more loss to the current dire problem.

MRST was coined due to its molecular reaction of removing the rust on the surface of the metal through a process of bonding of ions and molecules to metal ions without etching of the metal, thereby minimizing metal loss during rust removal on metal surfaces.

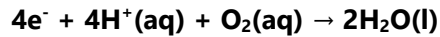
## The Mechanism of Rust

Rusting of iron consists of the formation of hydrated oxide, Fe(OH)<sub>3</sub>, FeO(OH), or even Fe<sub>2</sub>O<sub>3</sub>.H<sub>2</sub>O. It is an electrochemical process which requires the presence of water, oxygen and an electrolyte. In the absence of any one of these, rusting does not occur to any significant extent. In the air, a relative humidity of over 50% provides the necessary amount of water and at 80% or above corrosion of bare steel is worse.

When a droplet of water containing dissolved oxygen falls on a steel pipe, the solid iron or Fe(s) under the droplet oxidizes:



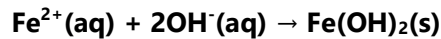
The electrons are quickly consumed by hydrogen ions from water (H<sub>2</sub>O) and dissolved oxygen or O<sub>2</sub> (aq) at the edge of the droplet to produce water:



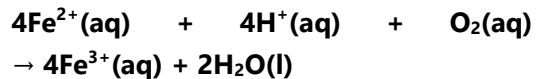
More acidic water increases corrosion. If the pH is very low the hydrogen ions will consume the electrons anyway, making hydrogen gas instead of water:



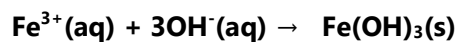
The equations above tell only a small part of the story. Hydrogen ions are being consumed by the process. As the iron corrodes, the pH in the droplet rises. Hydroxide ions (OH<sup>-</sup>) appear in water as the hydrogen ion concentration falls. They react with the iron (II) ions to produce insoluble iron (II) hydroxides or green rust:



The iron (II) ions also react with hydrogen ions and oxygen to produce iron (III) ions:



The iron (III) ions react with hydroxide ions to produce hydrated iron (III) oxides (also known as iron(III) hydroxides):



The loose porous rust or Fe (OH)<sub>3</sub> can slowly transform into a crystallized form

written as  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ , the familiar red-brown substance known as rust. Since these processes involve hydrogen ions or hydroxide ions, they will be affected by changes in pH with limited  $\text{O}_2$ , magnetite is formed ( $\text{Fe}_3\text{O}_4$ ).

## What is Vapro 812 MRST

Vapro 812 is a revolutionary organic neutral pH rust remover, a flash rust inhibitor that effectively removes rust and tarnish from both ferrous and nonferrous metals by chelating the ferrous ions from the surface of the metal. Unlike conventional rust removers, which are corrosive and dangerous to handle and store, Vapro 812 is biodegradable and is safe for humans, environment, metals and does not cause hydrogen embrittlement.

Vapro 812 is 100% organic and is an excellent replacement for conventional rust removers where chemical waste disposal has to be observed. It does not require rinsing with water or neutralization after application, and effectively cleans and removes rust from both ferrous and non-ferrous metals. Besides being non-polluting, it does not harm skin, is non-flammable and is fortified with corrosion inhibitor to prevent flash rusting. No rinsing required or neutralization is required. It effectively loosens rust and corrosion on the automotive chassis and spare parts, and is biodegradable, odourless and colourless. Listed on NATO MCRL (Master Cross Reference List).

## Mechanism Behind Vapro 812 MRST

The mechanism behind MRST is chelation, which involves the bonding of ions and molecules to metal ions. It involves the formation or presence of more separate coordinate bonds between a polydentate (multiple bonded) ligands and a single central atom see figure 1.

These ligands are organic compounds and are called chelants, chelators, chelating agents or sequestering agent.

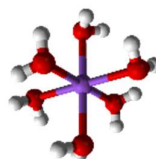
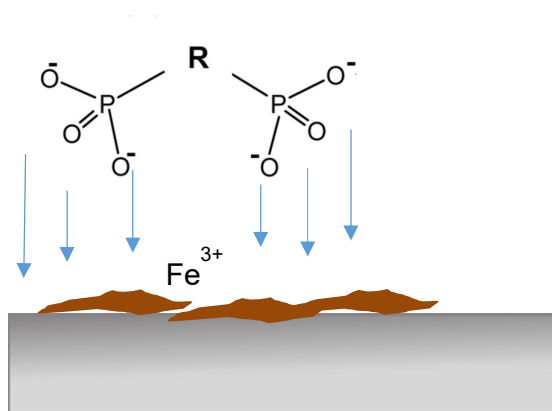


Figure 1, Atom with a monodentate ligand

**Denticity** refers to the number of donor groups in a single ligand that bind to a central atom in a coordination complex. In many cases, only one atom in the ligand binds to the metal, so the denticity equals one, and the ligand is said to be monodentate (sometimes called unidentate).

Ligands with more than one bonded atom are called **polydentate** or **multidentate**. The word denticity is derived from dentis, the Latin word for tooth. The ligand is thought of as biting the metal at one or more linkage points. The denticity of a ligand is described with the Greek letter  $\kappa$  ('kappa'). For example,  $\kappa^6$ -Vapro 812 describes the ligand of Vapro 812 that coordinates through 6 non-contiguous atoms or hexadentate ligands see figure 2.

### Hexadentate ligands of Vapro 812



Rusted Metal

### Metal Complex Compound

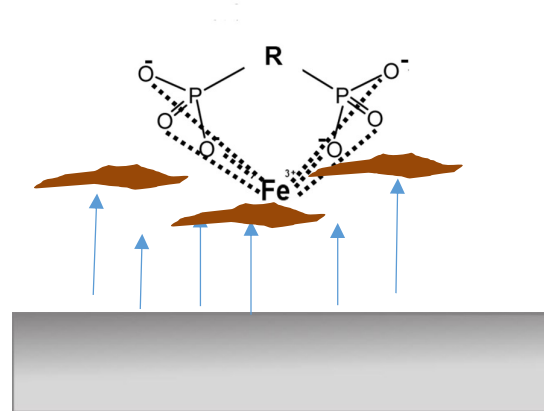


Figure 2

Rust Chelated through MRST

The above diagrams showed how rust has been chelated by the hexadentate ligands of Vapro 812, forming a metal complex compound.

The effectiveness of Vapro 812 arises from its role as a hexadentate ("six-toothed") ligand and its ability to sequester metal ions such as Fe<sup>3+</sup> and Ca<sup>2+</sup>. After being bound by the ligands of Vapro 812 into a metal complex, the said metal ions remain in solution but exhibit diminished reactivity.

### Conclusion:

In general, the stability of a metal complex correlates with the denticity of the ligands. The stability of a complex is represented quantitatively in the form of stability constants.

Hexadentate ligands tend to bind metal ions more strongly than ligands of lower denticity.

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