

DEVELOPMENT OF NEW EFFECTIVE NITROGEN- AND
PHOSPHORUS-CONTAINING CORROSION INHIBITORS

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Relevance. Corrosion remains a critical issue affecting the durability and safety of metal structures across various industries. The continuous demand for more efficient, cost-effective, and environmentally friendly corrosion inhibitors makes this research highly relevant. Nitrogen- and phosphorus-containing compounds are of particular interest due to their strong adsorption properties and enhanced inhibition efficiency. The development of new inhibitors based on these elements contributes to improving corrosion protection technologies and reducing material losses. This topic is especially significant for sectors such as oil and gas, construction, and manufacturing, where metal corrosion leads to serious economic and technical challenges.

The Purpose of the Study. The purpose of this study is to synthesize and investigate new effective corrosion inhibitors containing nitrogen and phosphorus atoms and to evaluate their protective performance on metal

surfaces. The study aims to determine how these compounds interact with metals, form protective adsorption layers, and reduce corrosion rates in aggressive environments. Additionally, it seeks to compare the efficiency of different nitrogen- and phosphorus-based structures and identify the most promising compounds for practical anticorrosion applications.

Research Materials and Methods. The study is based on the synthesis of organic compounds containing nitrogen and phosphorus functional groups using standard laboratory chemical procedures. Mild steel (or other metal samples) is used as the test material for corrosion studies. Corrosive media such as acidic (HCl , H_2SO_4) and saline (NaCl) solutions are prepared to simulate aggressive environments.

The experimental methods include:

- Chemical synthesis of nitrogen- and phosphorus-containing inhibitors
- Sample preparation, including polishing and cleaning of metal surfaces
- Weight loss method to determine corrosion rate and inhibition efficiency
- Potentiodynamic polarization technique to study anodic and cathodic behavior
- Electrochemical impedance spectroscopy (EIS) to evaluate surface resistance and film formation
- Surface analysis (microscopy or SEM, if available) to observe protective layer formation

The obtained results are analyzed comparatively to assess the effectiveness of each synthesized inhibitor and to determine their corrosion protection mechanisms.

Results and Discussion. The obtained results indicate that the synthesized nitrogen- and phosphorus-containing compounds exhibit high

corrosion inhibition efficiency in aggressive media. The weight loss measurements show a significant decrease in corrosion rate for metal samples treated with these inhibitors compared to the blank solution.

Electrochemical studies confirm that the inhibitors act as mixed-type inhibitors, affecting both anodic metal dissolution and cathodic hydrogen evolution reactions. The increase in polarization resistance and decrease in corrosion current density demonstrate the effective protective action of the synthesized compounds.

Among the tested inhibitors, those containing both nitrogen and phosphorus heteroatoms showed the highest efficiency. This improved performance can be explained by the synergistic effect between nitrogen and phosphorus atoms, which enhances electron donation, adsorption strength, and surface coverage.

Surface analysis results reveal the formation of a uniform and compact protective film on the metal surface. This film acts as a barrier, preventing direct contact between the metal and corrosive agents such as water, кислород, and chloride ions. The stability of this film plays a key role in long-term corrosion protection.

However, the efficiency of the inhibitors depends on several factors, including concentration, temperature, and type of corrosive medium. At higher temperatures, a slight decrease in inhibition efficiency was observed due to partial desorption of inhibitor molecules from the metal surface.

Overall, the results confirm that nitrogen- and phosphorus-containing compounds are highly effective corrosion inhibitors with strong potential for industrial applications.

Conclusion. The study confirms that nitrogen- and phosphorus-containing compounds are highly effective corrosion inhibitors for metal protection in aggressive environments. Their inhibition performance is mainly associated with strong adsorption on the metal surface through nitrogen and

phosphorus heteroatoms, leading to the formation of a stable and protective film.

The results show that compounds containing both nitrogen and phosphorus exhibit superior efficiency compared to single-component inhibitors due to a synergistic effect that enhances surface coverage and adsorption strength. Electrochemical and surface analyses further support the formation of a compact barrier layer that significantly reduces corrosion processes.

However, the effectiveness of these inhibitors depends on environmental factors such as concentration, temperature, and corrosive medium composition. Despite these limitations, the studied compounds demonstrate strong potential for practical industrial applications.

Overall, nitrogen- and phosphorus-based corrosion inhibitors represent a promising direction in the development of advanced anticorrosion technologies. Further studies are recommended to improve their stability, optimize their molecular structure, and ensure environmental compatibility.

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