

“ZAMONAVIY TA’LIMDA SUN’IY INTELLEKTNI QO‘LLASHNING ISTIQBOLLARI VA MUAMMOLARI” XALQARO ILMIY-AMALIY ANJUMAN 22-23-MAY 2026-YIL

FROM SECONDARY PET WASTE TO A VALUE-ADDED CORROSION INHIBITOR: ELECTROCHEMICAL PERFORMANCE OF PPD-F-MK FOR St20 STEEL IN 1 M HCl

J.B. Normurotov^{1*}, O‘.Ch. Akhmedov²

¹Termiz davlat muhandislik va agrotexnologiyalar universiteti

²Termiz davlat universiteti

*Mas’ul muallif: jahongirnurmurotov1310@gmail.com

Abstract. Chemical upcycling of polyethylene terephthalate (PET) waste into functional corrosion-control materials offers a route to combine polymer-waste valorization with metal protection. In this study, secondary PET was used as the starting feedstock in a stepwise chemical-processing route to obtain p-phenylenediamine, which was subsequently employed with formalin and monochloroacetic acid to prepare the PPD-F-MK oligomeric corrosion inhibitor. The inhibitor was evaluated for St20 carbon steel in 1 M HCl by potentiodynamic polarization at 298 ± 1 K after 2 h exposure. Increasing the PPD-F-MK concentration from 100 to 400 mg/L decreased the corrosion current density from 0.167 ± 0.10 to 0.072 ± 0.001 mA/cm² and increased the inhibition efficiency from 81.67 to 92.10%. Surface coverage increased from 0.8167 to 0.9210, while the inhibition coefficient rose from 5.46 to 12.65. The results demonstrate that a corrosion inhibitor prepared through a PET-waste-derived p-phenylenediamine platform can effectively suppress the electrochemical corrosion of St20 steel in hydrochloric acid.

Keywords: *secondary PET waste; chemical upcycling; p-phenylenediamine; PPD-F-MK; St20 steel; corrosion inhibition.*

1. Introduction: Polyethylene terephthalate is one of the most widely used thermoplastic polyesters and generates a substantial post-consumer waste stream. Chemical recycling is particularly attractive when the objective is not merely to recover polymer feedstock but to convert PET into higher-value chemical products. Recent international literature has demonstrated that PET-derived intermediates can be transformed into functional materials, including corrosion inhibitors for carbon steel. In this context, coupling PET waste valorization with corrosion protection is consistent with circular-economy principles.

The present research follows a stepwise route in which secondary PET is chemically processed to obtain p-phenylenediamine as a functional intermediate. This intermediate is then used as a platform for the synthesis of several corrosion inhibitors. PPD-F-MK is obtained from p-phenylenediamine, formalin and monochloroacetic acid. The dissertation study established an optimal 1:2:1 molar ratio for the synthesis system, at which the gravimetrically determined protection level reached 94.31%. The aim of this conference paper is to focus on the electrochemical performance of PPD-F-MK in 1 M HCl and to connect that performance explicitly with the value-added utilization of secondary PET.

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2. Materials and Methods: Secondary PET waste served as the original polymer feedstock for the broader synthesis route. After stepwise chemical conversion to p-phenylenediamine, the PPD-F-MK inhibitor was prepared using p-phenylenediamine, formalin and monochloroacetic acid. The inhibitor-production scheme developed in the dissertation includes reagent dosing, controlled reaction, cooling, filtration, washing and drying operations. St20 carbon steel was used as the metallic substrate and 1 M HCl as the corrosive electrolyte. PPD-F-MK concentrations of 100, 200, 300 and 400 mg/L were examined. Potentiodynamic polarization measurements were carried out at 298 ± 1 K after 2 h exposure. Corrosion current density (i), inhibition coefficient (γ), surface coverage (θ) and inhibition efficiency (η) were evaluated relative to the uninhibited acid solution.

3. Results and Discussion: The electrochemical data show a monotonic concentration-dependent inhibition effect. In uninhibited 1 M HCl, the corrosion current density was 0.911 ± 0.15 mA/cm². Addition of only 100 mg/L PPD-F-MK reduced this value to 0.167 ± 0.10 mA/cm². Further increases in concentration produced progressively lower current densities, reaching 0.072 ± 0.001 mA/cm² at 400 mg/L. The increase in surface coverage from 0.8167 to 0.9210 and in inhibition efficiency from 81.67 to 92.10% indicates that the protective response strengthens as the inhibitor dosage increases. These electrochemical trends are consistent with progressive occupation of interfacial sites and restriction of direct contact between the acidic electrolyte and electrochemically active regions of the steel surface. The data support an adsorbed protective interface; however, the precise molecular adsorption mode should be established only by combining electrochemical results with adsorption-isotherm and surface-characterization evidence. From a materials-valorization perspective, the result is important because the corrosion-active product is linked to a feedstock originating from secondary PET rather than being presented solely as a conventional inhibitor synthesized from virgin aromatic intermediates. This provides a functional destination for chemically processed PET and demonstrates how waste-derived aromatic building blocks can be redirected toward corrosion-control applications.

C, mg/L	i , mA/cm ²	γ	θ	η , %
Uninhibited	0.911 ± 0.15	—	—	—
100	0.167 ± 0.10	5.46	0.8167	81.67
200	0.135 ± 0.05	6.75	0.8518	85.18
300	0.091 ± 0.005	10.01	0.9001	90.01
400	0.072 ± 0.001	12.65	0.9210	92.10

Table 1. Electrochemical parameters of St20 steel in 1 M HCl with PPD-F-MK at 298 ± 1 K ($t = 2$ h).

4. Relevance to PET Waste Valorization: Published studies have already shown that PET waste can be chemically recycled into amide-, glycol- and surfactant-type corrosion inhibitors. The present work differs in its selected transformation pathway: the dissertation route uses stepwise PET processing to obtain p-phenylenediamine, followed by synthesis of PPD-F-MK. Accordingly, the scientifically

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appropriate description is 'PET-waste-derived' or 'obtained through a PET-derived p-phenylenediamine platform', rather than implying a one-step direct conversion of PET into PPD-F-MK.

The broader dissertation also reports industrial circulating-water tests for the developed inhibitors and surface characterization by SEM and AFM, supporting their practical corrosion-protection potential. For PPD-F-MK, the industrial protection efficiency at 400 mg/L is reported as 94.93%. This provides an additional application-oriented context for the laboratory electrochemical findings.

Conclusions

Secondary PET can be incorporated into a value-added chemical route leading to a functional corrosion inhibitor through a p-phenylenediamine intermediate. PPD-F-MK exhibited a clear concentration-dependent electrochemical protection effect for St20 steel in 1 M HCl. At 400 mg/L, the corrosion current density decreased to 0.072 ± 0.001 mA/cm² and the inhibition efficiency reached 92.10%. The combined waste-valorization and corrosion-protection concept provides a technically relevant direction for converting secondary PET into functional chemical products.

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