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# Corrosion inhibition potential of methyl-5-benzoyl-2-benzimidazole carbamate (mebendazole) for mild steel in 1.0m sulphuric acid

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## Abstract

In this research, an assessment of the influence of varying concentrations of Methyl-5-benzoyl-2-benzimidazole Carbamate (mebendazole) as an organic corrosion inhibitor for mild steel in 1.0M sulphuric acid solution was investigated. Weight loss, corrosion penetration rate, inhibition efficiency and degree of surface coverage were measured and calculated for various inhibitor concentrations and immersion time intervals. From the analysis of the results obtained, the lowest corrosion penetration rate of 4.059mm/yr with a corresponding maximum inhibition efficiency of 88.42% was achieved by the 2.0g/100mL $H_2SO_4$ after 120h (5 days) of the experiment. The results indicated that mebendazole is an effective corrosion inhibitor for mild steel in sulphuric acid medium.



*Keywords:* Mild Steel, Methyl-5-benzoyl-2-benzimidazole carbamate, corrosion inhibitor, mebendazole, inhibition efficiency.

## 1. Introduction

Mild steel is a ferrous alloy with less than 0.25% carbon content. It is unique among other metallic materials because it is readily available and has very wide range of application for domestic, services, construction, marine, industrial and engineering purposes. This grade of steel is very reactive and will readily revert to iron oxide (rust) in the presence of corrosion agents such as water ($H_2O$), oxygen ($O_2$) and ions such as chloride ions ($Cl^-$) [1]. All of these corrosion agents exist freely in the atmosphere and most service environment [2-4]. The readiness of mild steel to oxidize when its surface is exposed means that it must be adequately protected from the elements in order to meet and exceed its design life.

The mitigation of metallic corrosion using chemical inhibitors is a very active field of research. Chemical inhibitors are organic and inorganic chemical compounds that are adsorbed in the metal surfaces to control, prevent and/or minimize the destructive corrosion reactions without significant reaction with the components of the environment [2, 5]. Inhibitors find major use in closed environmental systems that have good circulation, so that an adequate and controlled concentration of inhibitor is ensured. Such conditions can be met, for instance, in cooling water recirculating systems, oil production, oil refining, and acid pickling of steel components. Corrosion inhibiting chemical compounds are extensively applied industrially to minimize the deterioration rate of metals and alloys used in corrosive environments. However, most corrosion inhibitors are costly, toxic and environmentally unfriendly [1, 6]. Most common inhibiting organic compounds evaluated as effective corrosion inhibitors for ferrous alloys are heterocyclic compounds with oxygen (O), nitrogen (N) and/or sulphur (S) as hetero atoms [6-11].

The corrosion of metals remains a worldwide scientific problem as it affects the metallurgical, chemical, construction and oil industries. The increasing interest in the manufacture and use of sulphuric acid in applications involving the extensive use of mild steel has created the need for obtaining information on the corrosion resistance of mild steel to sulphuric acid attack [12]. Sulphuric acid is widely used in industries such as acid pickling, cleaning and descaling, industrial cleaning agent, production of chemicals, etc. Mild steel is used in these environments due to its availability, low cost and excellent physical properties, but its use and lifespan is restricted in these conditions due to its susceptibility towards

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corrosion. To complement its low cost and economic value, the most effective means of addressing the corrosion of mild steel is with the use of inhibitors, especially chemical compounds of organic origin. Though many compounds show good anticorrosive activity, most of them are costly and highly toxic to both human beings and the environment. These toxic effects and ecological problems associated with the discharge of such materials have resulted in the development of other efficient and environmentally acceptable inhibitors. In this work, methyl-5-benzoyl-2-benzimidazole Carbamate with the generic name Mebendazole is used as the chemical corrosion inhibitor for mild steel in 1.0M solution of sulphuric acid ($H_2SO_4$). This chemical is a synthetic benzimidazole derivative and is an off whitish to yellowish powder, insoluble in water and common organic solvents, but freely soluble in formic acid and other inorganic acids [13]. It has the molecular formula and molecular weight of $C_{16}H_{13}N_3O_3$ and 295.30g/mol respectively [13, 14]. Among its major uses is in therapeutic treatments as anthelmintic drug. Being a less expensive, non-toxic, biodegradable and environmentally friendly compound with the O and N hetero atoms in the ring structure, this research tends to find an economically suitable secondary and technological application for mebendazole as a corrosion inhibitor for mild steel in acidic service environments.

## 2. Materials and Method

The following experimental techniques and procedures would be adopted in carrying out this research in order to achieve the stated objectives:

### *2.1 Test media*

All the experiments were carried out at ambient temperature, in 1 M dilute $H_2SO_4$, prepared with double distilled deionized water. The test medium used for the investigation consists of 100 ml of 1 M dilute $H_2SO_4$ with or without the addition of specified concentrations of mebendazole inhibitor.

### *2.2 Preparation of test specimens*

Commercially available cylindrical mild steel rod of nominal composition (Fe = 98.224%, C = 0.288%, Mn = 0.624, Cu = 0.268, Cr = 0.182, S = 0.052, P = 0.051, Ni = 0.090, Al = 0.021,) with a diameter of 12 mm was carefully machined and cut into a number of test specimens of average dimensions of 3 mm thickness. A 3-mm hole was drilled at the centre for suspension. These mild steel specimens were polished with series of emery paper grade and were then thoroughly rinsed with distilled water and cleansed with acetone before each analysis.

### *2.3 Weight-loss experiments*

Weighed test pieces were totally immersed in each of the various prepared test media contained in a 100-ml plastic container for different contact times (24hrs, 48hrs, 72hrs, 96hrs and 120hrs) with and without inhibitor addition. They were taken out after the required exposure time, washed with distilled water, rinsed with acetone, dried and re-weighed. The results of weight loss measurement are recorded in table 1. The tests without inhibitors were also carried out for comparison with the tests in inhibited environments to observe the corrosion reactions behaviour of the tested specimens. Curves of weight loss versus time of immersion and weight loss versus inhibitor concentration were also plotted. The corrosion rate (CR) in millimetres per year was calculated from Eq.1 below;

$$CR = \frac{87.6 \times WL \times 1000mg}{D \times A \times T} \quad (1)$$

Where WL is the weight loss in grams, D is the density in g/cm$^2$, A is the area in cm$^2$, and T is the time of exposure in hours. Curves of corrosion rate (calculated) versus time of immersion and corrosion rate versus inhibitor concentration were also plotted.

The % inhibitor efficiency, η, was calculated from the relationship:

$$\eta = \frac{\mathrm{CRc} - \mathrm{CRi}}{\mathrm{CRc}} \times 100 \quad (2a)$$

Where $CR_C$ and $CR_i$ are the corrosion rates in the absence and the presence, respectively, of a predetermined concentration of inhibitor. The percentage inhibitor efficiency was calculated for all the inhibitors throughout the exposure period.

The degree of surface coverage (ϕ) is calculated from Eq. 2b

$$\phi = \frac{\mathrm{CRc} - \mathrm{CRi}}{\mathrm{CRc}} \quad (2b)$$

Curves of % inhibitor efficiency (calculated) versus time of immersion, % inhibitor efficiency versus inhibitor concentration and degree of surface coverage (calculated) versus exposure time were also plotted.

## 3. Results and Discussion

### *3.1 Weight-loss measurements*

The values of weight-loss (WL), corrosion rate (CR) and the percentage inhibition efficiency (η) are presented in Tables (1-3)

*Table 1: Data obtained from weight loss (g) measurement of Mebendazole in 1.0M H2SO4 for Various inhibitor concentrations and exposure time*

| Exposure Time (hrs) | Weight Loss (g) with Respect to Inhibitor Concentration and Contact Time | | | | | |
|---|---|---|---|---|---|---|
| | Control | 0.5g | 1.0g | 1.5g | 2.0g | 2.5g |
| 24 | 0.176 | 0.063 | 0.077 | 0.080 | 0.062 | 0.060 |
| 48 | 0.448 | 0.19 | 0.198 | 0.119 | 0.111 | 0.079 |
| 72 | 0.628 | 0.366 | 0.20 | 0.245 | 0.173 | 0.162 |
| 96 | 0.964 | 0.355 | 0.366 | 0.259 | 0.311 | 0.128 |
| 120 | 1.166 | 0.467 | 0.408 | 0.290 | 0.135 | 0.299 |

*Table 2: Data obtained from Corrosion Rate (mm/yr) Calculation of Mebendazole in 1.0M $H_2SO_4$ For various inhibitor concentrations and Exposure Time*

| Exposure Time (hrs) | Corrosion Rate (mm/yr) with Respect to Inhibitor Concentration and Contact Time | | | | | |
|---|---|---|---|---|---|---|
| | Control | 0.5g | 1.0g | 1.5g | 2.0g | 2.5g |
| 24 | 26.458 | 9.471 | 11.575 | 12.026 | 9.273 | 9.020 |
| 48 | 33.674 | 14.281 | 14.883 | 8.945 | 8.342 | 5.938 |
| 72 | 31.469 | 18.34 | 10.022 | 12.277 | 8.669 | 8.118 |
| 96 | 37.44 | 13.342 | 13.755 | 9.734 | 11.688 | 4.811 |
| 120 | 35.057 | 14.041 | 12.267 | 8.719 | 4.059 | 8.99 |

*Table 3: Inhibition efficiency (%) of Mbendazole in 1M $H_2SO_4$ for various Inhibitor concentrations and time intervals*

| Exposure Time (hrs) | Inhibitor Efficiency (%) with Respect to Inhibitor Concentration and Contact Time | | | | |
|---|---|---|---|---|---|
| | 0.5g | 1.0g | 1.5g | 2.0g | 2.5g |
| 24 | 64.20 | 56.25 | 54.55 | 64.95 | 65.91 |
| 48 | 57.57 | 55.80 | 73.44 | 75.22 | 82.37 |
| 72 | 41.72 | 68.15 | 60.99 | 72.45 | 74.20 |
| 96 | 64.36 | 63.26 | 74.00 | 68.78 | 87.15 |
| 120 | 59.95 | 65.01 | 75.13 | 88.42 | 74.36 |

The corrosion rate of mild steel in 1.0M $H_2SO_4$ with different concentrations of methyl-5-benzoyl-2-benzimidazole carbamate inhibitor and immersion time showed that corrosion rate values decreased drastically with increase in the concentration of inhibitor and exposure time as a result of interaction of inhibitor molecules with the mild steel surface. The lowest corrosion rate value of 4.059 mm/yr was achieved by the 2.0g/100 mL $H_2SO_4$ after 120hrs (5 days) of immersion; after which the 2.5g/100 mL $H_2SO_4$ concentration exhibited slightly higher corrosion rate and weight loss for the same maximum immersion duration. The 2.5g/100 mL $H_2SO_4$ concentration achieved a very low corrosion rate and weight loss values of 4.811 mm/yr and 0.128g respectively after 96hrs (4days) of the experiment. In general, the mebendazole inhibitor could be adjudged to be effective for the corrosion inhibition of mild steel in 1.0M dilute sulphuric acid, as it is evident that the corrosion rate and weight loss of mild steel in the inhibited solution were considerably lower than in the uninhibited test medium.

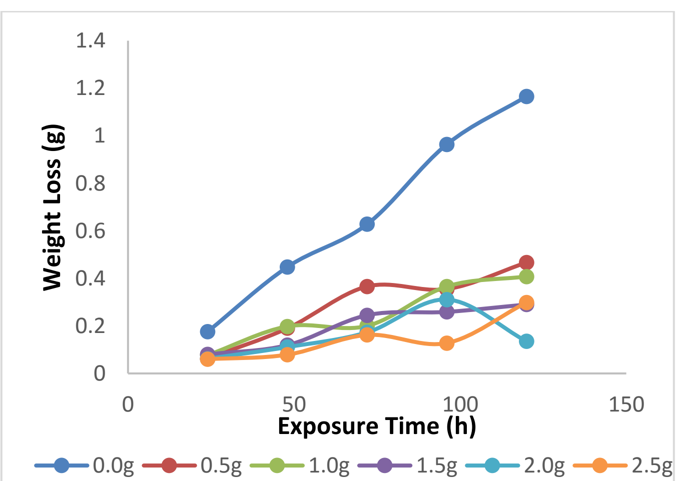


*Figure 1: Effect of immersion period on weight loss.*

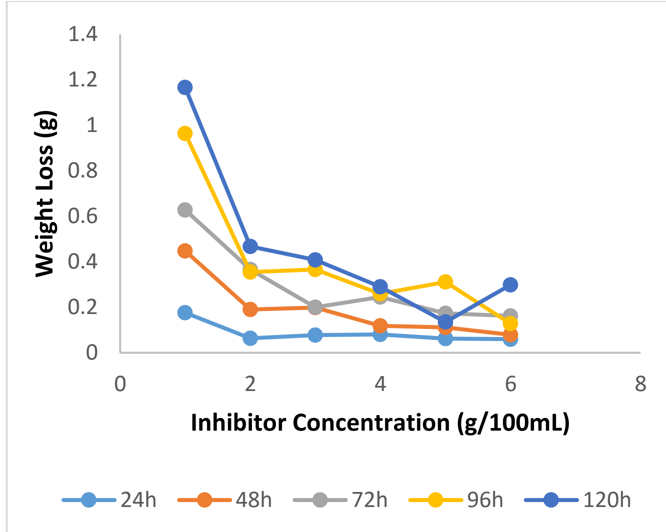


*Figure 2: Effect of inhibitor concentration on weight loss*

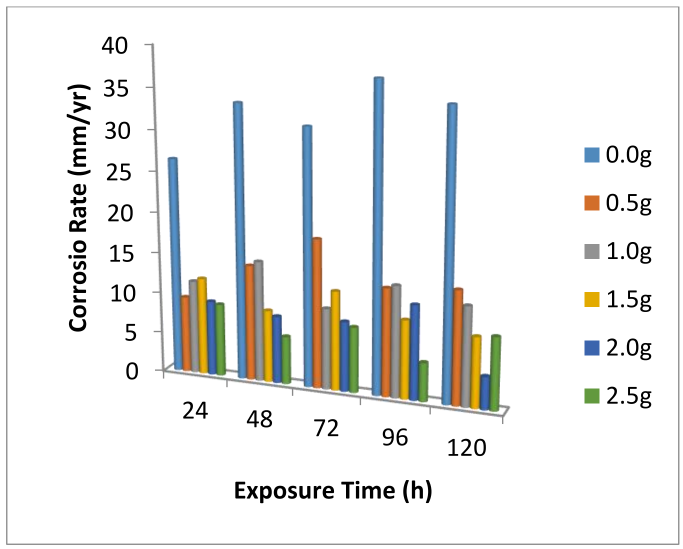


*Figure 3: Effect of immersion period on corrosion rate*

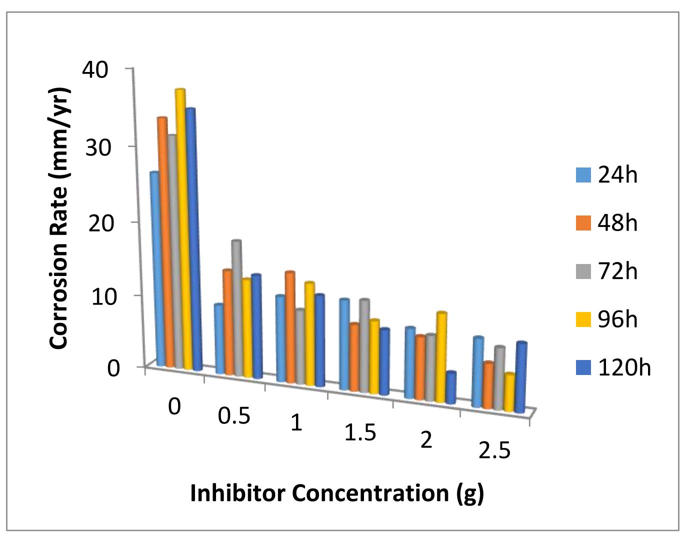


*Figure 4: Effect of inhibitor concentration on corrosion rate.*

Figures 1, 3, 5 and 7 show the variation of weight-loss, corrosion rate, %IE and degree of surface coverage with exposure time at the various inhibitor concentrations, while Figures 2, 4 and 6 show the variation of weight loss, corrosion rate and %IE with inhibitor concentration respectively. Observation of Table 1 shows the influence of the inhibitor to be dependent on the amount inhibitor concentration and immersion period as the results of the electrochemical kinetics of the inhibitor solution and mild steel surface. The weight-loss measurements, corrosion rate, percentage inhibitor efficiency and degree of surface coverage were not linearly proportional to the value of inhibitor concentration and exposure time most probably due to formation of a protective film which prevents the diffusion of the harmful anions onto the mild steel surface irrespective of its concentration and exposure duration.

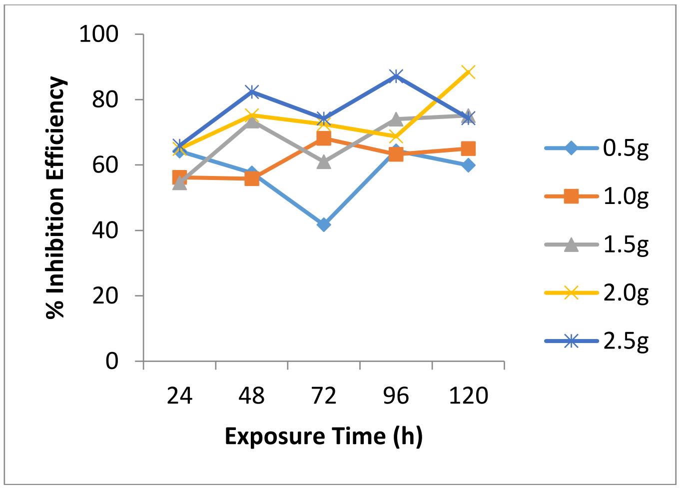


*Figure 5: Effect of immersion period on inhibition efficiency.*

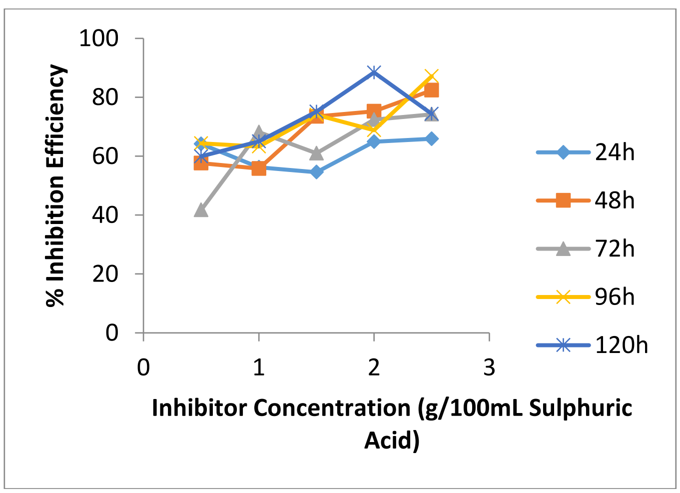


*Figure 6: Effect of inhibitor concentration on inhibition efficiency.*

As shown from Table 3, there is a strong inhibition effect of the mebendazole at higher concentrations and exposure times longer than 24hrs (1day). The highest inhibitor efficiency of 88.42% was obtained for the 2.0g/100 mL $H_2SO_4$ after 120hrs (5 days) of immersion in sulphuric acid. The 2.5g mebendazole in 100 mL $H_2SO_4$ gave a comparable good performance, achieving inhibition efficiencies of 82.37% and 87.15% after 48hrs (2days) and 96hrs (4days) respectively.

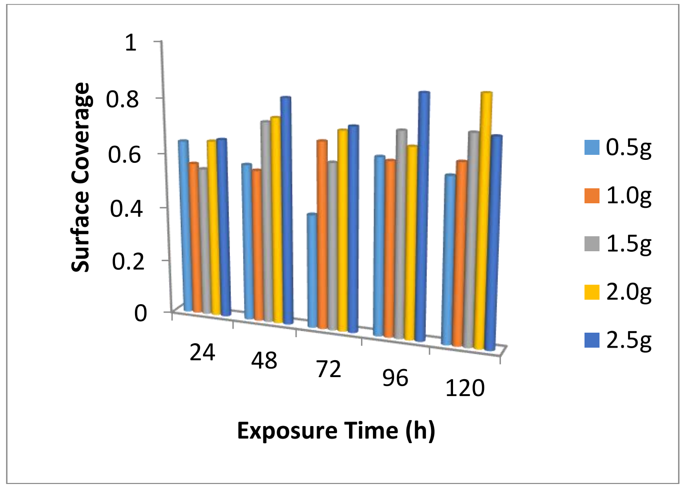


*Figure 7: Effect of immersion period on surface coverage*

As shown in figure 7, higher coverage of the inhibitor on the surface of the mild steel specimens were obtained in solutions with 2.0g and 2.5g concentrations of inhibitor from 48hrs (2days) to the end of the experiment. Thus, the formation of surface inhibitor film on the mild steel surface provides considerable protection to the mild steel against corrosion. The surface film reduces the active surface area of the specimen exposed to the corrosive medium and delays the rate of hydrogen evolution and iron dissolution.

## 4. Conclusion

The results from weight loss technique clearly indicate that methyl-5-benzoyl-2-benzimidazole carbamate (Mebendazole) is an effective corrosion inhibitor of mild steel in dilute sulphuric acid medium.

The inhibition efficiency increases with the increase in the concentration of the inhibitor, with maximum corrosion inhibition of 88.42% at 2.0g/100mL after 120hrs (5days) of immersion.

## References

[1] Abdulrahman, A.S., Kobe, I.H., Aigbodion, V.S., Ganiya, K.A., and Awe, I.C. (2014).Thermodynamic Behaviour of Mild Steel Corrosion in an Environment of Bilberry Cactus Plant Extracts in Hydrochloric Acid. Journal of Metallurgy and Materials Engineering, Vol. 9(2): 1-14.

[2] ASM (2000) Corrosion: Understanding the Basics. Edited by J.R. Davies.

[3] Osarolube, E., Owate, I.O., and Oforka, N.C. (2008). Corrosion Behaviour of Mild and High Carbon Steels in Various Acidic Media. Scientific Research and Essays, Vol.3(6):224- 228.

[4] Finsgar, M., and Jackson, J. (2014). Application of Corrosion Inhibitors for Steels in Acidic Media for the Oil and Gas Industry: A Review. Corrosion Science, vol.86:17-41.

[5] Loto, C.A., and Loto, R.T. (2016). Corrosion Inhibition Effect of Allium Cepa Exytracts on Mild Steel in $H_2SO_4$. Der Pharma Chemica, vol.8(20): 63-73.

[6] Loto, R.T., and Loto, C.A. (2016). Corrosion Inhibition Properties of the Combined Admixture of Thiocarbanilide and Hexadecyltrimethylammoniumbromide on Mild Steel in Dilute Acid Solutions. Cogent Chemistry, vol.2: 1268377.

[7] Fang, J. And Li, J. (2002). Quantum Chemistry Study on the Relationship between Molecular Structure and Corrosion Inhibition Efficiency of Amides. Journal of Molecular: THEOCHEM, 593: 179-185

[8] Murthy, Z.V.P, and Vijayaragavan, K. (2014). Mild Steel Corrosion Inhibition by Acid Extracts of Leaves of Hibiscus Sabdariffa as a Green Corrosion Inhibitor and Sorption Behaviour. Green Chemistry Letters and Reviews, vol.7(3): 209-219.

[9] Subir, P. And Ishita, K. (2016). Corrosion Inhibition of Carbon Steel in Acidic Environment by Papaya Seed as Green Inhibitor. J. Bio Tribo Corros, vol.2: 6.

[10] Loto, C.A., Loto, R.T., and Joseph, O.O. (2017). Effect of Benzamide on the Corrosion Inhibition of Mild Steel in Sulphuric Acid. South African Journal of Chemistry, Vol.70: 38-43.

[11] Loto, C.A., Loto, R.T.,Osugbunu, O., and Popoola, A.P. (2016). Corrosion Inhibition Effect of Allium Cepa Extracts on Mild Steel in HCl. Der Pharma Chemica, 2016, vol.8(20): 20- 30

[12] Loto, R.T. (2013). Corrosion Inhibition of Mild Steel in Acidic Media by Butyl Alcohol. Research on Chemical Intermediates, DOI:10.1007/S11164-013-1088-1

[13] Cadila Wormin ® Mebendazole (2005). Information for Health Professionals- Data Sheet, Cadila Pharmaceutical Ltd, India.

[14] Al-Kurdi, Z., Al-Jallad, I., Badwan, A., and Jaber, A.M.Y. (1999). High Performance Liquid Chromatography Method for Determination of Methyl-5-Benzoyl-2-Benzimidazole Carbamate (Mebendazole) and its Main Degradation in Pharmaceutical Dosage Forms. Talanta, vol.50: 1089-1097.