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硝酸鹽和亞硝酸鹽對碳鋼抗蝕性之影響

The Effects of Nitrate and Nitrite on Corrosion Resistance of Carbon Steel

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一、中文摘要

（關鍵詞：硝酸鈉、亞硝酸鈉、碳鋼腐蝕、抑制效應、酸鹼度、鉻酸鈉、異丙醇）

本計畫分為兩部份：(1)硝酸鹽對碳鋼抗蝕性之影響；(2)亞硝酸鹽對鋼抗蝕性之影響。動電位極化法將用以研究之，另以重量損失（改變）法作為核對之用。實驗參數計有：(1)硝酸鹽或亞硝酸鹽之濃度；(2)氯化鈉或鉻酸鈉之濃度；(3)溶劑（水或異丙醇）之種類；溶液之酸鹼度；(4)溶液之酸鹼度。

由動電位極化腐蝕所得數據，使用本實驗室所發展之REDIF微電腦程式以計算腐蝕電流密度，極化電阻，和鐵弗爾常數。有關金屬腐蝕型態或鈍化膜之觀察可使用立體顯微鏡為之。由實驗所得之結果，我們提出(1)硝酸鹽或亞硝酸鹽的抗蝕機理。(2)異丙醇所扮演之角色。(3)腐蝕速率異常之解釋。

英文摘要

(Keyowrds: sodium nitrate, sodium nitrite, inhibitive effect, carbon steel corrosion, effect of pH, sodium chromate, isopropyl alcohol)

The project includes two parts: (1) the effect of nitrate on the corrosion resistance of carbon steel and (2) the effect of nitrite on the corrosion resistance of carbon steel. The potentiodynamic polarization technique along with weight loss method are used in this study. The experimental parameters include: (1) the concentraions of nitrate or nitrite; (2) the concentrations of sodium chloride or sodium chromate, (3) the type of solvents (water or isopropyl alcohol); and (4)the pH of the solution.

The corrosion data obtained from potentiodynamic polarization are input into the REDIF microcomputer program developed in this laboratory to calculate the corrosion current densities, polarization resistance, and Tafel constants. The corrosion patterns of metal or the passive film were observed by stereo-microscope. From the experimental results, we would (1) suggest the anticorrosion mechanisms of nitrate or nitrite; (2) determine the role of isopropyl alcohol, and (3) suggest the causes of the abnormal pattern of the corrosion .

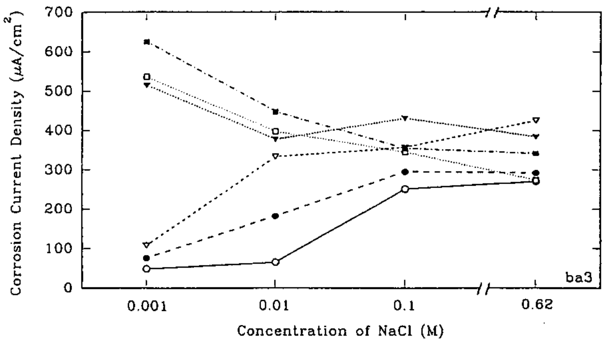

Fig. 1 Corrosion current densities for carbon steel in solutions containing various [NaCl] and [$NaNO_3$] at pH=3 [$NaNO_3$]: ○ 0; ● 0.001; ▽0.01; ▼ 0.1; □ 0.2; ■ 0.5M.

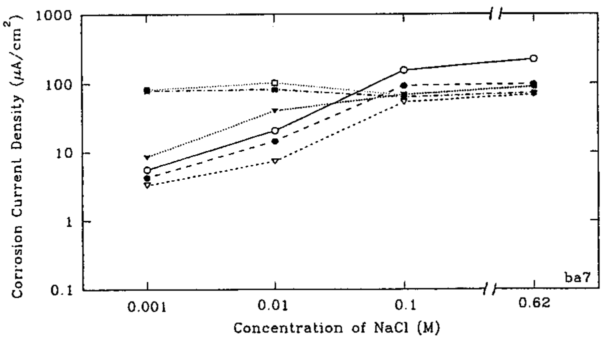

Fig. 2 Corrosion current densities for carbon steel in solutions containing various [NaCl] and [$NaNO_3$] at pH=7 [$NaNO_3$]: ○ 0; ● 0.001; ▽0.01; ▼ 0.1; □ 0.2; ■ 0.5M.

二、計畫緣由與目的

雖然硝酸鹽和亞硝酸鹽對鋼材之腐蝕性和抗蝕性為腐蝕專家們所熟知，然而，它們之腐蝕性與抗蝕性在pH之分野卻未有實驗數據以供分辨，並且在廣大之pH範圍（3至11）之電化數據（腐蝕電流密度、鐵弗爾常數、極化電阻等），在文獻中亦十分缺乏。其腐蝕及抗蝕機理亦未完全被瞭解。

由於大氣中之氮氧化物可能造成硝酸或亞硝酸（或鹽類）存在於酸雨中，加上，硝酸應用於酸洗工業，硝酸使用於防銹底漆，亞硝酸鹽應用於石油或有機溶劑（如異丙醇）中之抑制劑。本

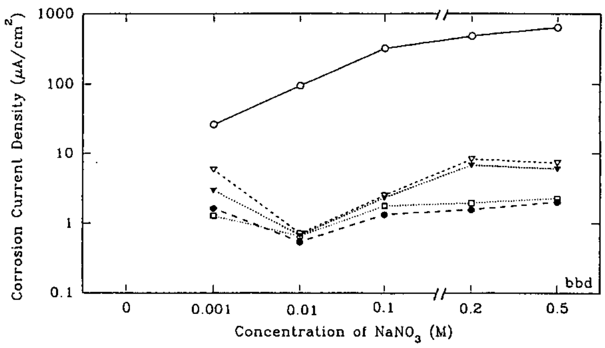

Fig. 3 Corrosion current densities for carbon steel in nitrate solutions without chloride at various pHs.
○ pH=3; ● pH=5; ▽ pH=7; ▼ pH=9; □ pH=11

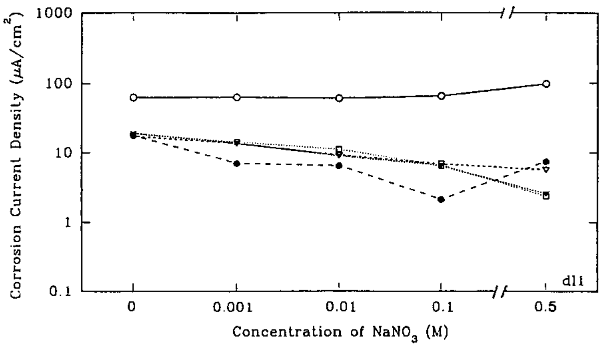

Fig. 4 Corrosion current densities for carbon steel in IPA* and water combined solutions of [NaCl]=0.01M and various [$NaNO_3$] at various pHs.
○ pH=3; ● pH=5; ▽ pH=7; ▼ pH=9; □ pH=11
*IPA stands for isopropyl alcohol

計劃之研究結果及提出之機理可供學術及工業上之參改。

三、研究方法及成果

本研究使用中或低碳鋼為材料，浸於各種溶液組合中，以動電位掃瞄之方法，測得極化曲線，利用本實驗室所發展之Redif微電腦程式以計算腐蝕電流密度、鐵弗常數和極化電阻，並提出腐蝕和抗蝕之機理，有關成果請見結論和討論。

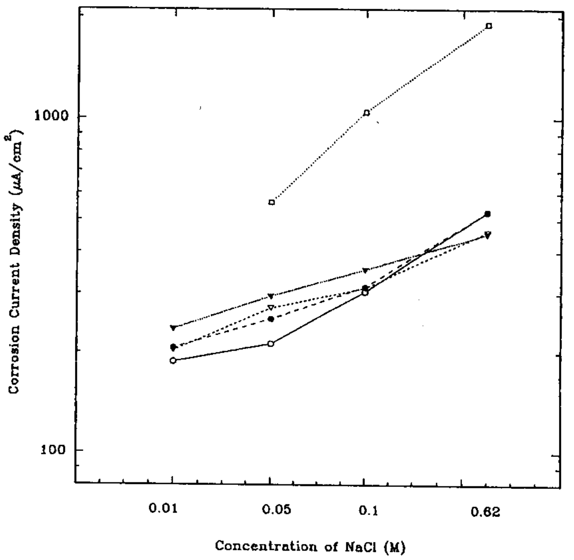

Fig. 5　Corrosion current densities for carbon steel in solutions containing various [NaCl] and [NaNO₂] at pH = 3.
[NaNO₂]: ○ 0; ● 0.0001; ▽ 0.001; ▼ 0.01; □ 0.1M

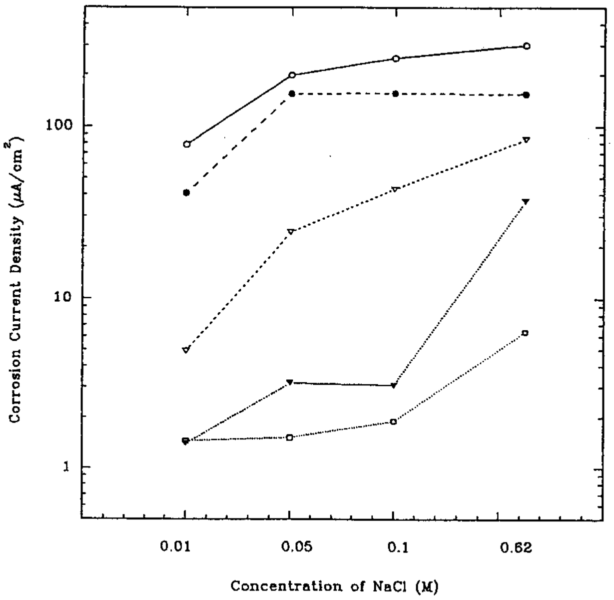

Fig. 6　Corrosion current densities for carbon steel in solutions containing various [NaCl] and [NaNO₂] at pH = 7.
[NaNO₂]: ○ 0; ● 0.0001; ▽ 0.001; ▼ 0.01; □ 0.1M

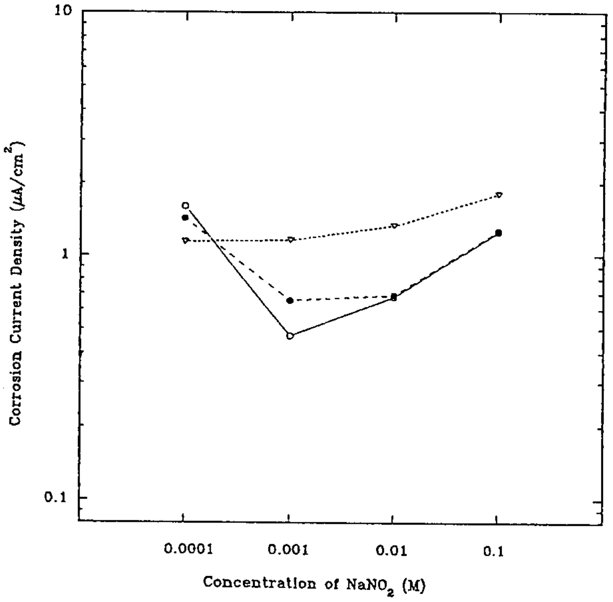

Fig. 7　Corrosion current densities for carbon steel in nitrite solutions without chloride at various pHs.
○ pH = 7; ● pH = 9; ▽ pH = 11

四、結果與討論

實驗之結果歸納於下，並示於若干代表性之圖中（圖1～圖8）。

(1)腐蝕速率一般依氯化鈉溶液之濃度而增加和依pH之增加而減少，除非後者在孔蝕或間隙腐蝕發生之情況；(2)在低pH（如3）腐蝕速率依NO_3^-或NO_2^-濃度之增加而增加，在其他pH大抵腐蝕速率依此等離子之增加而減少。(3)腐蝕速率因鉻酸鹽或異丙醇之添加而減少，抑制效應亦因異丙醇之存在而減少。

硝酸鈉或亞硝酸鈉之腐蝕和抑制之雙重性可解釋如下：NO_3^-或NO_2^-爲強氧化劑（前者較強）能在金屬表面上形成氧化層以保護金屬，然而其保護性會受H^+或Cl^-腐蝕性所影響；若氧化膜受破壞而形成孔蝕或間隙腐蝕，則腐蝕電流會顯得異常大。鉻酸根離子爲強氧化劑可形成氧化保護而減低腐蝕速率。異丙醇有減低電導度氧濃度及鐵表面NO_3^-、NO_2^-或Cl^-濃度之作用。

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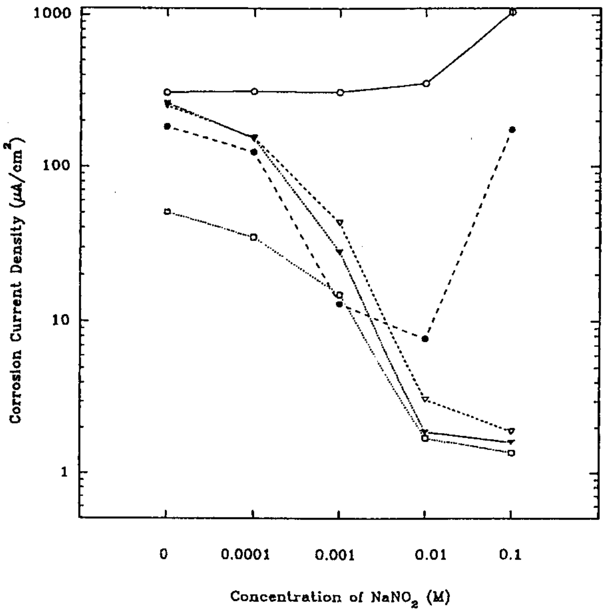

Fig. 8 Corrosion current densities for carbon steel in water solutions of [NaCl] = 0.1M and various [$NaNO_2$] at various pHs.
○ pH = 3; ● pH = 5; ▽ pH = 7; ▼ pH = 9; □ pH = 11a

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