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# Corrosion behavior of LY11 aluminum alloy in soil①

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**Abstract:** The corrosion behavior of LY11 aluminum alloy in acid, alkaline and neutral soil after burying for 1, 3 and 5 a was studied. It is shown that localized corrosion is the major behavior of LY11 aluminum alloy in soil, and corrosion of LY11 depends on the soil texture: severe corrosion occurs in the heterogeneous alkaline and acid soil, and slight corrosion occurs in homogeneous neutral and acid clay soil.

**Key words:** LY11 aluminum alloy; soil corrosion; corrosion behavior **Document code:** A

## 1 INTRODUCTION

Aluminum and its alloys, just less than steels, were widely used in communication cable, pipeline and power station and so on in soil. Soil corrosion experiments of various materials have been conducted abroad since 1920s[1~3]. In our country, the network of soil corrosion have been built since 1950s, steel and lead specimens have been buried from then on[4,5], while stainless steels and nonferrous metals since 1989[6]. In this experiment, the corrosion behavior of LY11 aluminum alloy was studied in neutral soil of Shenyang, Chengdu, acid soil of Shenzhen, Yingtan and Guangzhou, and alkaline soil of Xinjiang, Dagang after buried for 1, 3 and 5 a.

## 2 EXPERIMENTAL

### 2.1 Experimental material

LY11 aluminum alloy pipe was used for test. The specimen dimension was $d40$ mm × 3.0 mm × 200 mm. The elemental composition (mass fraction, %) of the specimens are Al-0.51Mn-1.25Mg-0.17Fe-4.30Cu.

### 2.2 Soil sites

Soil sites were selected by the principle that the soils were representative; there were no pollutant and stray current on the ground; and the sites is easily managed. The soil texture, chemical and physical properties of test sites are shown in Table 1. The soils of Yingtan, Guangzhou and Shenzhen are acid soils, those of Shenyang and Chendu are neutral soils, and those of Xinjiang and Dagang are alkaline soils.

### 2.3 Experimental method

At each test site, the specimens were buried 1.5 m deep, placed about 35 cm apart. Sufficient specimens were buried at each test site to permit recovery of a complete set at specified intervals (1, 3, 5, 8 and 12 a). Properties and bacterium of the soils were analysed by the rules of the network of soil corrosion[7].

## 3 RESULTS AND DISCUSSION

### 3.1 Corrosion behavior of LY11 aluminum alloy in soil

Mass loss and pitting depth of LY11 aluminum alloy in the soils of seven test sites after 5 a as a function of test time were shown in Figs. 1 and 2. Specimens of LY11 aluminum alloy in Chengdu neutral soil show uniform corrosion and there are only a few pitting holes less than 0.2 mm deep on the pipe, while specimens in other soils show obvious localized corrosion. Severe

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**Table 1** Chemical and physical properties of soil at test sites

| Site | Soil type | pH | Resistivity /(Ω·m) | $w$(Salt) /% | $w(Cl^{-1})$ /% | $w(SO_4^{2-})$ /% | Soil texture |
|---|---|---|---|---|---|---|---|
| Yingtan(YT) | Red soil | 4.8 | >628.0 | 0.0059 | 0.0014 | 0.0013 | Clayey soil |
| Guangzhou(GZ) | Crimson soil | 5.5 | >628.0 | 0.0091 | 0.0000 | 0.0078 | Sandy soil |
| Shenzhen(SZ) | Crimson soil | 6.1 | >628.0 | 0.0129 | 0.0010 | 0.0078 | Bouldery soil |
| Shenyang(SY) | Loam | 7.4 | 37.5 | 0.0446 | 0.0017 | 0.0139 | Meadowy soil |
| Chengdu(CD) | Clay | 8.1 | 26.9 | 0.0403 | 0.0017 | 0.0114 | Clayey soil |
| Xinjiang(XJ) | Alkaline soil | 8.7 | 39.6 | 0.6690 | 0.1322 | 0.3236 | Brow desert soil |
| Dagang(DG) | Alkaline soil | 8.6 | 0.4 | 1.9669 | 1.0945 | 0.1120 | Saline soil |

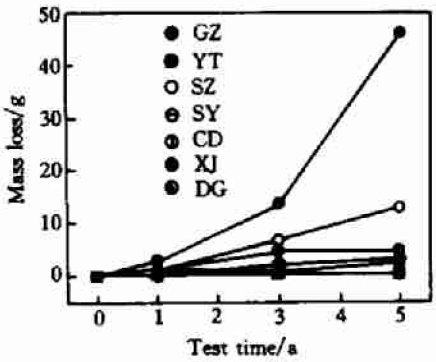


**Fig.1** Mass loss of LY11 as a function of test time

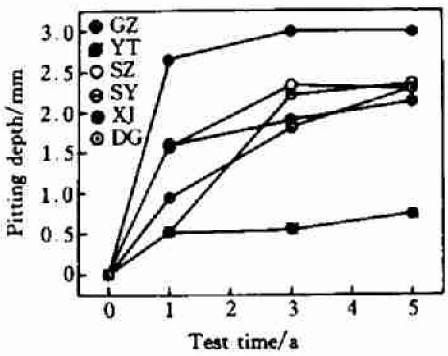


**Fig.2** Pitting depth of LY11 as a function of test time

pitting corrosion of Al alloy occurred in acid soil of Guangzhou and Shenzhen, neutral meadow soil of Shenyang and alkaline brow desert soil of Xinjiang. Moreover, specimens in the soil of Xinjiang cracked after buried for 3 a; one specimen broke into pieces after 5 a.

LY11 aluminum alloy is an aluminum-copper alloy. The X-ray diffraction analysis shows that there are $Al_2O_3$, $Al(OH)_3$ and copper in the corrosion products of the LY11 alloy. The separation of copper from LY11 aluminum alloy can decrease the corrosion-resistibility of the alloy. The SEM micrograph of LY11 aluminum alloy buried in Xinjiang soil for 5 a is shown in Fig.3. It can be found that the white parts are copper. The EDAX results show that the content of copper is more than 80% in these parts.

**Fig.3** SEM micrograph of LY11 in buried Xinjiang soil

### 3.2 Factors affecting corrosion of aluminum alloy

Severe corrosion of LY11 alloy in alkaline occurred in the desert soil of Xinjiang and acid bouldery soil of Shenzhen, while slight corrosion in acid clay of Yingtan and neutral clay soil of Chengdu, so the corrosion of LY11 aluminum alloy depends on the soil type and texture.

In three acid soils, the corrosion rate of LY11 in the soil of Yingtan is much less than those in the other two acid soils. The soils of three sites are different from each other. The soil of Shenzhen is sandy soil; there are 35% grits bigger than 1.00 mm and much semi-rottener in it.

The soil of Guangzhou is sandy soil, there are 20% grits bigger than 1.00 mm. There are no grits bigger than 1.00 mm but clayey particle smaller than 1.00 mm in clayey soil of Yingtan. Compared with the sandy soils, the clayey soil is more homogenous and it is not easy to occur macrocell corrosion in it, the permeability of the soil is poor, and the ability of holding water is good, so the corrosion behavior of LY11 aluminum alloy in the clayey soil of Yingtan is different from that of Guangzhou and Shenzhen, and the mass loss and pitting depth are much less than the others.

The corrosion of LY11 in neutral meadowy soil of Shenyang is much severer than that in the soil of Chengdu. In the soil of Shenyang, localized corrosion occurred in LY11 alloy and the pitting depth is 2.35 mm, while it showed uniform corrosion in yellow clayey soil of Chengdu, there are only a few pitting holes less than 0.20 mm on the surface of the alloy.

The influence of soil texture on the corrosion behavior of LY11 aluminum alloy can be found in alkaline soils. Compared with Xinjiang soil, the resistivity of the saline soil of Dagang is the lowest (0.42 Ω), the $Cl^-$ content of the soil (1.0945%) is much higher than that of Xinjiang (0.112%). It seems that the corrosivity of the soil of Dagang is the highest among seven soils according to the criteria of the soil resistivity and salt content. But the corrosion of LY11 alloy in the soil of Dagang is much slighter than that in the soil of Xinjiang. This maybe caused by the heterogeneous texture and good aeration of Xinjiang soil.

Generally, soil texture is the main factor affecting the corrosion of LY11 aluminum alloy, severe corrosion occurred in the heterogeneous alkaline and acid soil, and slight corrosion occurred in homogeneous neutral and acid clayey soil.

## 4 CONCLUSIONS

LY11 aluminum alloy shows localized corrosion in the soil, and corrosion was determined by the type and texture of soils. Severe corrosion occurred in the heterogeneous alkaline and acid soil, and slight corrosion occurred in homogeneous neutral and acid clayey soil. Severest corrosion occurred in the soil of Xinjiang, severer corrosion in the soil of Shenzhen, slightest corrosion in neutral clayey soil of Chengdu and acid clayey soil of Yingtan, and moderate corrosion in the other soils.

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