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LICHENS GROWING ON PAINTED METAL PLATES

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ABSTRACT

This study was based on the description of different species of lichens which were growing on metal plates exposed to the weather conditions in La Plata, Buenos Aires Province, Argentina. Among the six species observed, *Caloplaca cinnabarina* was the most common. Lichen species were identified by observation under optical microscope and chemical reactions. The chemical composition of the paint was analyzed by IRS and the metal composition of the plates by SEM and EDS. SEM analysis also revealed paint cracking around the lichen and paint particles trapped in the thallus.

Keywords: Argentina; *Caloplaca cinnabarina*; SEM; EDS.

1. INTRODUCTION

Lichens are able to colonize a wide range of substrates [1], this is limited only by the surface texture and microtopography for the successful attachment and survival of propagules [2, 4,3,5,6].This allows them to grow not only on natural surfaces (rocks, soil, bark, decorticated wood, leaves, and animal carapaces), but also industrial materials (plastic, paint, concrete, ceramic, glass and metal).

In the case of lichens growing on metal, the species most commonly found on iron show no particular preference for naturally occurring iron-containing rocks. In general, the observed species aresaxicolous and are known ones that generally grow on other man-made materials [7, 8, 9, 10].

Brightmanand Seaward [7] make a classification of three apparently distinct types of iron substrate: exfoliated iron, rusted iron and painted iron.

-The exfoliate iron substrate usually originates from wrought iron which has become so extensively rusted that layers of iron oxide have flaked off in sheets.

-Rusted iron is often, more strictly, steel, which has acquired a firmly adhering thin and coherent coat of

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oxide. The surface is smooth but more or less finely pitted. The horizontal members of steel bridges and the horizontal supports of iron railings from which the original paint has long since flaked away may rust in this manner and often support crustose species.

-Painted iron will support lichens when the paint coating is sufficiently weathered. They do not grow on loose flaky paint, but on pitted paint surface with a texture similar to that of rusted iron.

After colonization lichens modify their environment because of the growth of the thallus. This deterioration is performed in the interface between lichen and substrate, this is a place of considerable physical and chemical activity, presenting a complicated heterogeneity in which primary and secondary minerals, organic acids and compounds, and all kind of organisms including the myco- and photobionts of lichens, free-living algae and fungi, and bacteria, are involved [11, 12, 13, 14]. This process is performed on any type of substrate, natural and man-made, in the case of metal, can directly affect or affect this antirust paint, contributing to the oxidation process.

In our case, lichens were found on nine metal plates used to test the protective action of anti-rust paints; they were exposed to weather conditions in the terrace of LEMIT.

The objective of this study was the identification of lichens present on nine metal plates painted, and identification of possible effects of installation on the substrate.

2. MATERIALS AND METHODS

The metal plates were exposed for 15 years at ambient environmental conditions, in the city of La Plata (34°56′00″S 57°57′00″O) Argentina. The area is characterized by moderate climate, warm summers (minimum temperatures about 21ºC and maximum up to 40ºC), and mild sunny winters (mean temperatures 9.9 ºC) with rainfalls mainly concentrated in autumn, around 1040 mm/ year[15].

Lichens were observed under stereomicroscope. Handmade sections and squash preparations were obtained and observed under optical microscope. The spot test reactions in thalli and apothecia were performed with K (KOH) and C (NaClO) also the reaction under UV light. Thin-Layer Chromatograph was not performed due to the small size and low number of thalli. For the identification of the lichens species the following papers and keys were consulted: De La Rosa et. al.[16], Elix [17], Sliwa [18], Mccune[19], and Nash et. al. [20].Because of the low number of iron substrates and thalli is not possible to perform a statistical analysis of the existence of the location preferences of lichens.

All plates have a size of 15.5 x 8 cm, they were made of metal commonly used in construction, commercially known as “1015 carbon steel” (Table 1). The exact composition of the anti-rust paint was not known, but SEM shows the major components (Fig 1). In all the plates an IRS studies was performed. A strong band at 980 nm was found, corresponding to basic phosphates, a component of anti-rust paints. No records remain of the exact composition of the paint, because was characterized for semi-quantitative elemental compositions obtained by EDS -Electron Dispersive Spectrometry- (SDD Apollo 40).

For practical reasons it was decided to study the interface lichen-sustrate most abundant, this was performed by SEM -Scanning Electron Microscope- (FEI, Quanta 200).

3. RESULTS

The substrate occupied was not uniform, it was a combination of rusted and coated iron [7]. The frequency, percentage of plate covered and type of substrate on which each species was found are listed in Table 2.

Six species were found, these were:

3.1 *Caloplacacinna barina* (Ach.) Zahlbr. (Fig. 2)

Thallus crustose cracked-areolate in the center, marginal areoles slightly elongated reddish orange similar to the apothecia or somewhat lighter, epruinose. Apothecia reddish orange to orange, to 0.4 mm diam; spores ca. 8.5-11 x 4 µm; septum 2-3 µm; apothecia immersed in the areoles or finally raised; in natural environment grow on exposed acidic rocks. This species was the most frequent and occupied most of the surface of the plates.

Table 1. Chemical composition of the metal plates

	Fe	C	Si	Mn	P	S	Cr	Ni	Mo
%	98,88	0,12	0,22	0,77	0,02	0,006	0,04	0,04	0,01

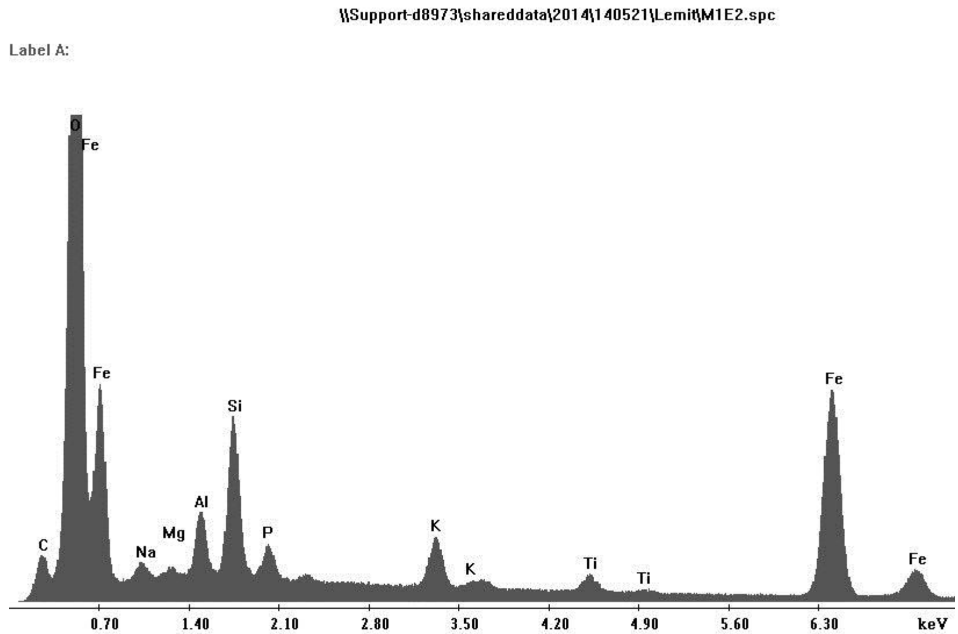

Fig. 1. semi-quantitative elemental compositions obtained by EDS of the anti-rust paint

Table 2. Frequency, percentage of covered space and type of substrate where species were found

Species	Frequency	% covered space	Substrate
C. cinnabarina	9	60	rusted iron, painted iron
S. monosporoides	9	10	rusted iron, painted iron
C. aurella	3	5	rusted iron, painted iron
R. peloleuca	3	5	rusted iron, painted iron
L. dispersa	2	5	rusted iron, painted iron
Buellia sp	1	5	painted iron

3.2 *Candelariella aurella* (Hoffm.) Zahlbr. (Fig. 2)

Thallus inapparent. Apothecia: abundant, lecanorine, 0.25-0.6 mm wide, the disc is darker yellow, round, flat or more often sligthly convex, sometimes strongly convex, the margin is thin to thick, yellow, entire and even to very uneven and often partly excluded and remaining as a few granules. 8-spored, ascospores are hyaline, simple to 1-septate, ±narrowly ellipsoid, 12- 17 x 4-5 µm. Spot tests: K- mostly on calcium-rich rocks, sometimes on bark or wood. It was also found in the walls around the metal plates.

3.3 *Rinodina peloleuca* (Nyl.) Müll. Arg

Thallus crustose, epilithic, to rimose-areolate; prothallus black or absent. Upper surface dirty white to pale grey. Apothecia 1.0-1.3 mm wide, common, usually lecanorine, immersed to adnate, contiguous; thalline margin entire, concolorous with the thallus, persistent or becoming excluded; proper margin usually visible as a thin brown line; disc dark brown to black, plane to weakly convex, epruinose. Asci 8-spored.AscosporesPhysconia-type, 1-septate, brown, ellipsoidal, 12-27 × 8-15 µm. Thallus K–, C–, P–, UV–; medulla K+ red-violet, C–.

3.4 *Staurothele monosporoides* R. Sant. (Fig. 2)

Thallus crustose, epruinose, brown, aerolateand lobes at the margin, presence of immersed perithecia with an apical pore, hymenium with algaealgae ovoid between perífisis; Asci 1-spored. Ascospore dark brown, ovoid-ellipsoid and muriform 30-50 × 15-25 µm. It is a saxicolous species and found on nearby walls. Thallus K–, C–,UV–; medulla K–, C–.

3.5 *Buellia* sp. (Fig. 2)

Thallus crustose aerolate greyish, a little pruinose apothecia biatorine, sessile, flat, 0.30.3-0,5 mm diam.,disc black, thalline margin entire, concolorousentir with the disc, proper margin not apparent, ascospores brown 1-septate ellipsoidal, 18-27 × 8- µm..Thallus-14 K–, C–,UV–; apothecia K–, C–.

3.6 *Lecanora dispersa* (Pers.) Röhl. (Fig 2)

Thallus, immersed and not apparent, mostly endolithic, or superficial but indistinct, very thin. Apothecia occurring singly, or clustered in groups, sessile, or constricted at the base, concave, flat when mature, or soon convex, 0.3-0.9 mm diam.; disc plane,0.9 smooth, pale brown, epruinose; margin prominent, or level with the disc, smooth, entire, epruinose, white. Asci clavate, 8-spored; ascospores hyaline, simple,spored; ellipsoid (broadly ellipsoid to narrowly ellipsoid), 88-12 × 4.5-6 µm. It was also found on the walls near to6 the samples.

The area of contact between the thallus of *C. cinnabarina cinnabarina* and the surface was observed by scanning electron microscopy, in this area cracks around the surface layer of paint were noted. Small pieces of material with an angular structure were observed trapped between the frames of the thallus. EDS analysis found that these structures correspond to small pieces of the paint layer (Fig. 3).

4. DISCUSSION AND CONCLUSION

The metal plates had all the types of substrates proposed by Brightman & Seaward [7], of these only rusted and painted iron were occupied by lichens, is likely to exfoliate iron is too unstable for these species [1]. Over rusted iron and painted iron are found growing the same species, in some cases the thallus extends from a surface to the other, so it is not strange to think that for these lichens there is no difference between these types of substrates and their presence is only conditioned by the arrival at the surface. With the exception of *Buellia* sp. that was found in painted iron with very low frequency and coverage, because of this is not clear whether this is an ecological choice. The metal, with or without the presence of paint, proved to be a suitable surface for the growth of saxicolous lichens, as noted by other authors [7,10, 9].

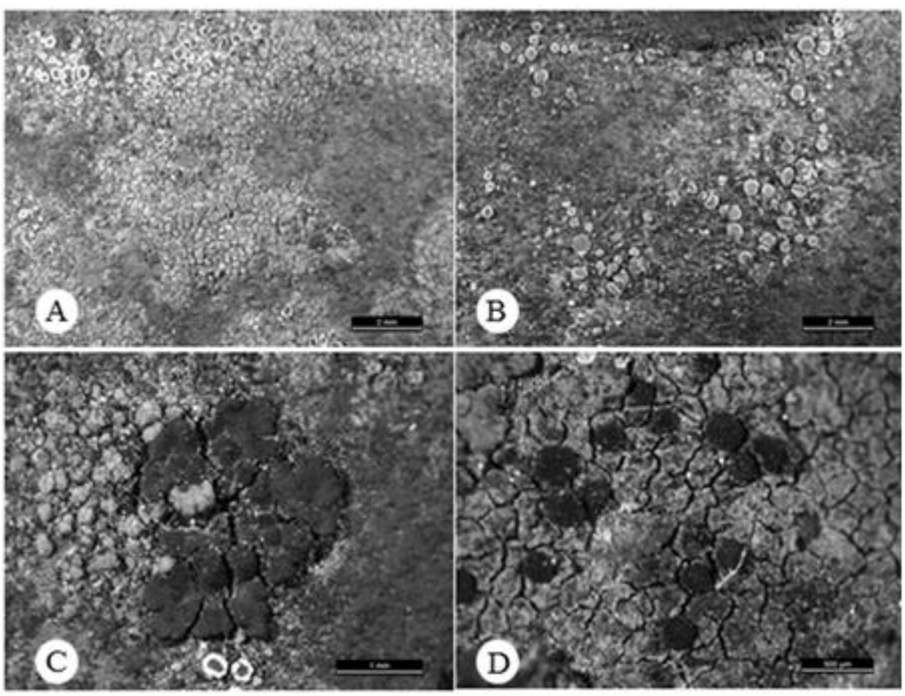

Fig. 2. Lichens on metal. A, *C. cinnabarina* and *L. dispersa*; B, *C. aurella*; C, *S. monosporoides*; D, *Buellia* sp., *C. cinnabarina*, *S. monosporoides.*

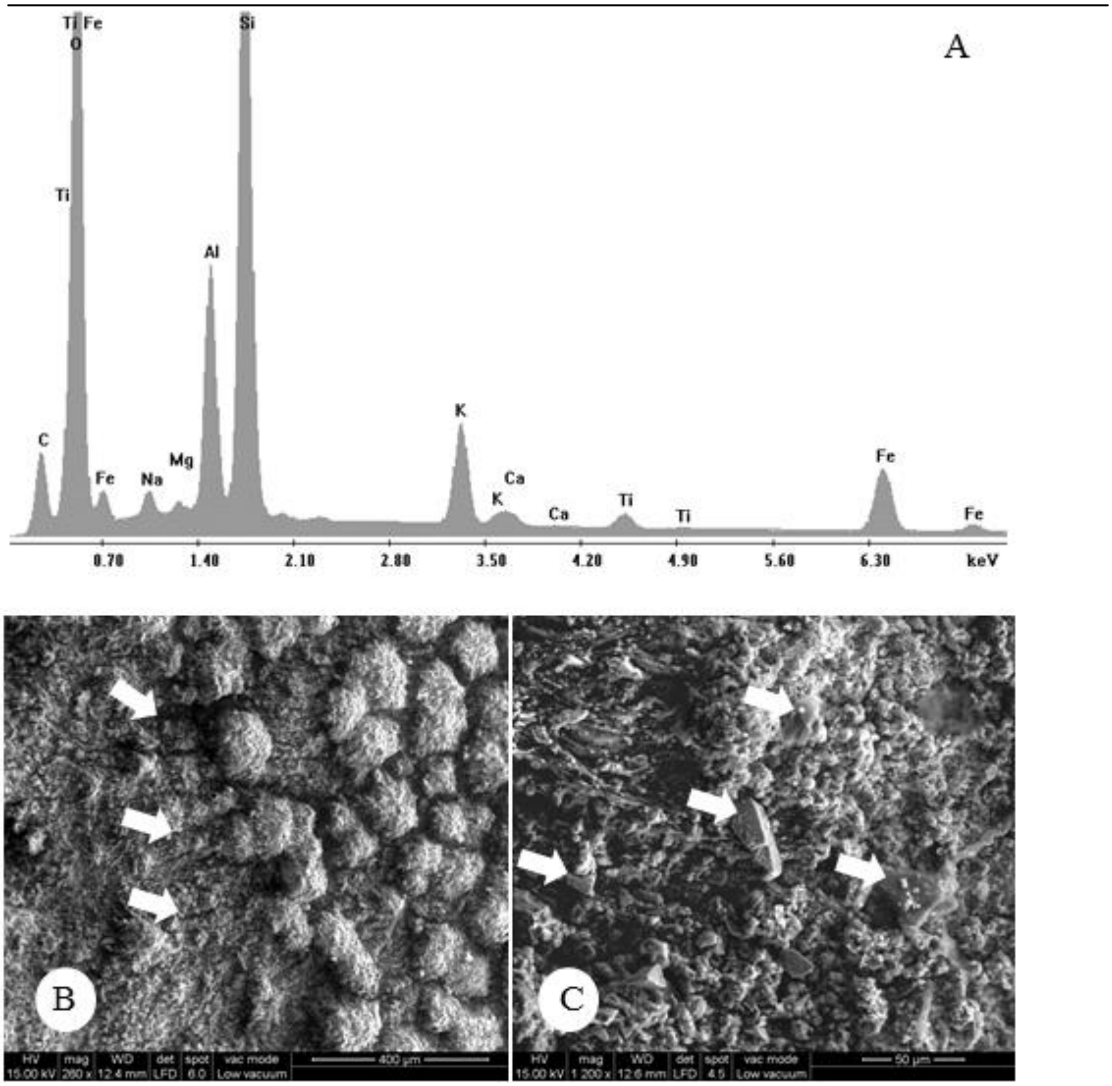

Fig. 3. A, semi-quantitative elemental compositions obtained by EDS; B, cracked surface layer of paint quantitative around *C. cinnabarina* C, pieces of paint trapped by lichen thallus cinnabarina;

As already observed by Brightman & Seaward [7] the species found are not associated with iron rich rocks, the most are cosmopolitan able to grow on other substrates, in this case the nearby walls. However *C. cinnabarina* and *S. monosporoide* have been able to grow in all plates, but only *C. cinnabarina* cover nearly all the surfaces, suggesting the species' eco-physiological characteristics allow a much better growth of the species on this unusual substrate than those of the others. In contrast *S. monosporoides* presents a small thallus that does not cover much of the surface, this species may have a development time slower than *C. cinnabarina.*

The most of the paint deterioration was caused by environmental conditions, although SEM analysis revealed cracking of the paint surface around the lichen thallus; this could be caused by the expansion and contraction of the thallus [21, 22] and by chemical compounds [11], possibly leading to loss of protection and contributing to metal oxidation. The paint particles are enveloped by the thallus of *C. cinnabarina*. A similar strategy has been described in saxicolous lichens, where the rock particles are included within the thallus [23, 24, 25].We can conclude that *C. cinnabarina* is able to deteriorate the painted surface, as well as incorporate small pieces of material removed from it. In the remremaining species this could not be observed, since data were limited by their low presence, but are likely to have the same strategy. It seems important to study species which can colonize this material because it is necessary to learn more about lichen-material interaction.

In this study we observed that metal plates protected against corrosion can be an excellent substrate for colonization and growth of lichens. Corrosion protection generates a new substrate for other damaging agent, in this case, lichens described above.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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