EDITORIAL

Effects of aluminum on cells and tissues

Effets cellulaires et tissulaires de l’aluminium

KEYWORDS
Aluminum; Tissular effects; Cellular effects; Toxicity

MOTS CLÉS
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Aluminum (Al, also written aluminium) is the most abundant metal of the earth crust (about 8.2%) although it is never found as a free element in nature. The first chemist who isolated the metal was HD. Oersted in 1825 but the most effective process was discovered in 1886–1888 by CM. Hall, PLT. Héroult and KJ. Bayer. Large amounts of the metal were extracted from bauxite, an aluminum-rich ore discovered near Les Baux de Provence, in the southern part of France. Today the Al production is about 57,889 thousand tons a year (in 2015) [1]. Al is largely used in various industries: transport (25%, i.e. airplanes, boats…), construction (25%, i.e. windows, structures…), packaging (17%; i.e., food, containers, bins, soft packages, foils…) (Fig. 1), electrical engineering (10%, i.e. cable, bus bars…); machinery and equipment (10%) and other purposes including cosmetics and food additives…

Al is a soft, light, ductile and malleable metal with a low density (about one-third of steel). It has a good resistance to corrosion due to a thin layer of aluminum oxide which spontaneously forms at the surface of the metal when exposed to air and prevents further oxidation. However, this thin layer is stable in the general pH range 4–9 but corrosion can be observed in liquids containing dissolved salts, particularly chlorides and at high and low pH [2,3]. When oxidized, Al can be highly reactive. The problem is well known in agriculture when Al increases in acidified water and soils: it can contaminate grass and other plants and secondarily cattle (85% of the Rwanda soils are acid and rich in Al) [4]. A simple experiment to make at home consists in placing a piece of Al foil in a compartment of your dishwasher and to add a detergent as usual. These products have a variable composition and usually contain phosphonates, sodium carbonate, silica chlorine or oxygen bleaching agents together with a surfactant (tension active compound). All these ingredients become very aggressive at high temperature and high pH and provoke a surface oxidation of the aluminum foil with large brownish stains with poorly defined contours. To see

Figure 1 Some of the multiple commercial uses of aluminum in the food packaging.

Quelques utilisations commerciales des multiples possibilités de l’aluminium dans l’emballage alimentaire.
what is happening at the surface of the aluminum foil after a single washing cycle, we used Vertical Scanning Interferometry (VSI or optical profilometry) to measure and image the roughness of the foil samples. This microscopy produces 3D topographical maps of the sample surface and provides classical roughness parameters. In addition, Electron Dispersive Spectrometry (EDS) coupled with a scanning electron microscope allows a quantitative analysis of the atoms of the samples. Fig. 2A shows the VSI analysis of the brilliant surface of a new Al foil. The striations produced by the rolling mill are responsible for a 154 nm roughness and EDS indicates that oxygen represents 1.57% of the atoms at the surface of the foil. After a single cycle in the dishwasher, the same analyses revealed a pitting corrosion of the foil in the brownish areas with increased roughness (Ra = 321 nm) and an increased Al2O3 layer with 51.46% of the surface atoms being represented by oxygen. Such a reactivity of the metal can induce deleterious changes in the human body because no tissue and no cell are equipped to eliminate Al from the organism.

This special issue of Morphologie provides an update of the cellular and tissular effects of Al in humans. The results of the research on aluminum are regularly presented at the Keele Symposium, the last one was held in Lille in February—March 2015. We have asked several of the participants to prepare a review on their own research:

- Christopher Exley, from Keele University, UK, will present a position paper on the general effects of Al;
- Romain Ghéardi et al. (Hôpital Henri Mondor, Paris, France) present the effects of Al oxyhydroxide (used as an adjuvant for vaccines) on the muscle and the identification of the macrophagic myofascitis;
- Cécile Vignal et al. (UMR 995, Lille, France) explore the effects of Al on the gut;
- Philippa Darbre (University of Reading, UK) reviews the effects of Al on breast cells and the suspected role of Al in oncogenesis;
- Walter Lukiw et al. (University of New-Orleans, USA) present molecular results concerning the effects of Al in the nervous system;
- our group in the University of Angers, France has studied the accumulation of Al in the bone matrix.

We hope that this special issue of our journal will interest all the morphologists and will open the mind to fruitful reflections.

Disclosure of interest

The author declares that he has no competing interest.

Acknowledgments

Thanks to Florence Pascaretti (GEROM) for the VSI, Guillaume Mabilleau (SCIAM) for EDS-SEM and Laurence Lechat for secretarial assistance.

References


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