Chapter 8
Modelling of the Surface Properties of Model Anti-Corrosion Materials by Inverse Gas Chromatography

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ABSTRACT

To reinforce the protection of the steel against corrosion, surface treatments are carried out (conversion coating, for example) followed most often by the application of an organic coating. The adhesion of the conversion layer or of the polymer to the metal oxide layer must be optimal. However, in adhesion phenomena, the dispersive interactions and acid-base type interactions between the surface sites of the two materials in contact play an important role. In order to understand and predict adhesion, it is necessary to quantify these interactions. The authors proposed in this research to study the dispersive and Lewis acid-base interactions between the oxides present on the surface of galvanized sheets and model organic molecules by using the inverse gas chromatography (IGC) at infinite dilution and the new models recently published. The obtained results proved that the dispersive surface energy of the Monogal surface is greater than that of zinc oxide surface, but much lower than the zinc hydroxide surface. It was also shown that the Monogal exhibited the lower Lewis acid-base properties.

INTRODUCTION

Corrosion was known since several thousand years after the discovery of iron and the different uses of metals in the human current life. Since longtime, people also tried to prevent the corrosion by using different techniques such as the surface paints or the metal alloys. The corrosion had several origins or causes and different terms were currently used such as corrosion by air, sea water or oxygen, soil, acids, bases or salts, by bacteria, or by severe environmental changes. Many scientific and complicated

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phenomena are implicated in corrosion, such as metallurgy, surface and interface sciences, chemical thermodynamics and kinetics, solid-state chemistry, electrochemistry and physics thus proving the pluridisciplinarity of this phenomenon which has become a real scientific discipline.

The corrosion was commonly defined as the degradation of a material under the action of the ambient environment and by a process other than mechanical. It represents a worldwide scourge, the cost of corrosion, which covers all the means of combating corrosion, the replacement of corroded parts or structures and the direct and indirect consequences of accidents due to corrosion, is estimated at 2% of the gross world product (Jacobson, 2016). The world cost of corrosion is estimated at $2.5 trillion per year. By implementing good practices to fight against corrosion, scientists and experts estimate that, depending on the sector, savings of between 15 and 35% of the cost of this corrosion could be achieved. This represents, globally, between 375 and 875 billion USD (Jacobson, 2016).

Many industrial products were used to protect the metals against the corrosion. Of these products was the commercial extragal that was used in the automobile industries. The surface of this very complex extragal is mainly composed of mixed oxides or hydroxides of zinc and aluminum. Because of their high corrosion protection capacity and surface quality, Extragal coated products are recommended for numerous automotive applications, for both exposed and non-exposed parts.

The determination of the surface properties of extragal is necessary to understand its adhesion behavior with other materials and the interaction with the environmental conditions. The monogal surface, the pure zinc oxide and hydroxide were used to model the commercial extragal. The powder composed essentially of zinc was recuperated from the monogal surface.

We supposed in this study that the surface properties of a flat surface and a powder are approximately the same.

It was proved that the inverse gas chromatography (IGC) is the best technique to determine the dispersive and non-dispersive surface properties, and the Lewis acid-base parameters of materials (James and Martin, 1952; Conder and Young, 1979; Saint-Flour and Papirer, 1982 (a), 1982 (b); Papirer et al., 1989; Hamieh et al., 1996, 1997, 1998; Feeley et al., 1998; Voelkel and Grzeskowiak, 2000; Kalantzopoulou et al. 2001; Hamieh et al, 2001(a), 2001 (b); Hamieh et al., 2002; Hamieh and Schultz, 2002; Santos and Guthrie, 2005; Yang and Yoon, 2007; Przybyszewska et al., 2009; Przybyszewska et al., 2009; Hamieh, 2011; Hamieh et al., 2011; Gamelas, 2013; Gamelas et al., 2014).

IGC is an important powerful technique for analyzing the surface dispersive and specific properties of solid materials. The Lewis acid-base properties and the London dispersive surface free energy were used to estimate the performance of metals, metallic oxides, polymers, polymers/oxides and carbon fibers to predict the adhesion properties between materials (James and Martin, 1952; Hamieh et al., 1996, 1997, 1998; Feeley et al., 1998; Voelkel and Grzeskowiak, 2000; Kalantzopoulou et al. 2001; Hamieh, 2001(a), 2001 (b); Santos and Guthrie, 2005; Yang and Yoon, 2007; Przybyszewska et al., 2009; Hamieh, 2011; Gamelas, 2013; Gamelas et al., 2014;). The phase change morphological behavior on the solid material surfaces can be easily described by IGC technique. In the IGC methods, polar solvents and n-alkanes are used at infinite dilution to quantify the surface properties between these organic model molecules and the solid filled in the chromatographic column. The dispersive component of the surface energy of solid surfaces is calculated by using the n-alkane solutes, whereas, the specific and polar properties are determined the through the Guttmann electron acceptor (*AN*) and electron donor (*DN*) parameters. The interaction between the organic solvents and the solid materials is quantified by the retention volume *Vn* of the adsorbed molecules at fixed temperature. This leads to the determination of the specific free energy of adsorption and therefore to the Lewis acidity K_A and basicity K_D constants of the studied