The impact of baking conditions on physico-chemical characteristics influencing topography and appearance aspects of polyurethane coatings

H. Yazdani Ahmadabadi a, S. Rastegar a,∗, Z. Ranjbar b, c, A. Allahdini a

a Faculty of Polymer Engineering and Color Technology, Amirkabir University of Technology, Hafez Street, Tehran, Iran
b Department of Surface Coatings and Corrosion, Institute for Color Science and Technology, No. 55, Vafamanesh Street, Hossein Abad Square, Pasdaran, Tehran, Iran
c Center of Excellence for Color Science and Technology, Tehran, Iran

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The appearance aspects of an electrodeposited polyurethane-based coating as a function of baking condition were investigated. Specular gloss and color was measured as a mean to trace the changes of the surface topography due to baking conditions. Atomic force microscopy combined with FTIR spectroscopic investigations showed that the shrinkage occurred due to the high baking temperature results in surface roughness. Films baked at higher temperature form higher $T_g$ networks. The color was changed to yellow as the baking temperature was raised.

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1. Introduction

Polyurethane coatings are used in a large variety of industrial and commercial applications (such as organic coatings, adhesives, sealant, fibers, foams and elastomeric products) due to their good flexibility, water resistance, pH stability, superior solvent resistance and good mechanical properties [1–5]. Despite all good characteristics, poor UV resistance is a big limitation for the aromatic polyurethanes which has been studied by several researchers in recent years. Introducing nano materials into the urethane structure is one of the new methods to solve this problem [4].

Also, the thermal decomposition of polyurethane coatings at high temperatures is a great concern, and furthermore the decomposition reactions and the mechanical properties of the rearranged structure have been studied by many authors [6–9]. One of the major application fields of urethane structures is in automotive cathodic electro-coatings as the first organic protective layer on the car bodies. A typical automotive coating system includes an inorganic conversion coating, the cathodic electro-coating, a primer surfacer, base coat and the clear coat, respectively. Urethane structure of a cataphoretic electro-coating is formed by the reaction of a polyl (normally epoxy-based) and a de-blocked polyisocyanate as the cross-linking agent [10].

Electrochemical deposition of materials on the metallic substrates warrants the high corrosion resistance and good adhesion of the primer for long time service life due to the high throwing power, a highly cross-linked urethane structure and an excellent saponification resistance. Basic characteristics of the adducted group (amine) catalyze the reaction of the polyl (adducted epoxy) and polyisocyanate. As the reaction proceeds, a highly cross-linked urethane network (HCUN) is formed which is responsible for the corrosion protection of the car bodies.

Electro-deposition process is a complex application method due to the combination of electrical and chemical phenomena [11]. In this process, mass transfer happens via three steps of migration, convection and diffusion [12]. In the paint bath, firstly, colloidal micelles (positively charged epoxy-amine adduct and pigment particles) move toward the cathode surface (convection step), after that the colloidal particles penetrate to the alkaline boundary layer. Establishing of the alkaline boundary layer close to the cathode surface persists just a few seconds (diffusion step) [10]. And finally a uniform compact layer is formed on the surface of the cathode and its recessed area [11].