Degradation and stabilization of an aromatic polyurethane coating during an artificial aging test via FTIR spectroscopy
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In this investigation nanozinc oxide-containing polyurethane-based coatings were prepared by incorporating 3 wt% nano-ZnO in the electrocoating composition. The paint films were deposited on phosphated steel panels through electrodeposition. The films were then rinsed by DI water and baked for 20 min at 165 °C in an electrical laboratory oven. The cured films were exposed to ultraviolet (UV) radiation under humid condition. Variation of chemical nature, color, surface roughness, gloss, and corrosion resistance of the coatings were investigated as a function of UV exposure period. It was found that in presence of nano-ZnO particles, photodegradation reactions of the aromatic polyurethane network are delayed for a longer time. Specular gloss and surface roughness values of the exposed films are in accordance to this observation too. It was found that deep cracks are formed in the films in which no nano-ZnO is present. The higher electrical resistance value of the nano-ZnO stabilized films was found to be due to the protective effect of the particles against photodegradation of the polyurethane binder.

1 Introduction

One of the degradation mechanisms of polymeric coatings is the chemical breakdown of their organic matrix. This breakdown occurs often as a result of photo-oxidation of the polymer by ultraviolet (UV) radiation [1–3]. The atmospheric degradation of a coating results in loss of its mechanical properties. Physical properties such as color, gloss, adhesion, corrosion resistance, etc. are also affected negatively. Coating becomes brittle and cracks and holes are formed at the surface and then penetrate into the bulk of the film [4].

Polyurethane coatings are used extensively in various environments such as chemically polluted atmospheres, humid atmospheres, and environments with relatively high temperature. Their excellent adhesion and water resistance, good resistance to acids and solvents, relatively better alkali resistance than most of other binder chemistries, good abrasion resistance and in general, good mechanical properties such as high flexibility makes them suitable for such applications. However, the aromatic types are very sensitive against exposure to light [5, 6].

Among the polyurethanes, aromatic polyurethanes made from aromatic isocyanates are more susceptible to UV degradation than aliphatic polyurethanes. They also cure faster due to inherently higher chemical reactivity of the aromatic polyiso-
cyanates and exhibit more chemical and solvent resistance while being less expensive [6]. They are mostly used therefore, as primers or intermediate coats in conjunction with non-aromatic topcoats that provide UV resistance. Since aromatic polyurethanes are very prone to UV-induced degradation the coatings based on this chemistry have to be recoated after a short time. Exposing these coatings to outdoor conditions before overcoating results in intense photodegradation [7]. To extend the overcoating time, one can use light stabilizers in the coating formulation. These compounds protect the backbone resin against photodegradation reactions.

The main classes of light stabilizers are namely UV absorbers (UVAs) and hindered amine light stabilizers (HALS). UV absorbers protect against photodegradation by competing with the polymer for absorbing UV light. An ideal UVA should be very light stable, and should have high extinction coefficient over the entire UV range from 290 to 400 nm. Some of the more common UV absorbers are organic materials which due to their relatively low molecular weight, can migrate out of the applied coatings, either to the coating surface or into the substrate. On the other hand, because of their organic nature, they are susceptible to a number of degradation mechanisms [8]. Many metal oxides also are known to absorb UV radiation the most common of which are zinc oxide (ZnO), titanium dioxide (TiO2), cerium oxide (CeO2), and iron oxide (Fe2O3). Some of the nanoparticles like nano-ZnO have the ability to offer UV protection while also being transparent and colorless. Particles with diameters less than 100 nm can be incorporated into a polymer matrix (e.g., coatings) to yield visibly transparent materials. The transparency is obtained because the particles are considerably smaller than...