Investigating the interfacial interaction of different aminosilane treated nano silicas with a polyurethane coating

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1. Introduction

Nano silicas have been widely used in coating industries for the last few decades. The main properties investigated included mechanical reinforcement of polymeric films [1–3], improvement in scratch and abrasion resistance [4], enhancing the thermal and insulation properties [4,5], as well as increasing the resistance against UV radiation [6]. In all of these applications a proper interfacial interaction is needed to ensure a good dispersibility. Therefore the interface of particle and the media in which they are incorporated plays a major role. The pristine silica is inherently a hydrophilic particle. This imposes difficulties to properly wet the untreated silica into organic film formers. In other words, the applications of this filler are generally restricted to hydrophilic media. In organic polymers with less hydrophilicity various surface treated silicas have come into existence [7]. The treating compounds give more hydrophobic nature to the particle and provide an enhanced interfacial adhesion between filler and matrix [5]. Silane coupling agents have shown to be good candidates in this regard. These materials are able to chemically link to silica surface and provide reactive functional groups through which the matrix binds tightly to the surface of silica. These functional groups can possibly guarantee maximum compatibility with resin system. To this end, different silane treated silicas have recently been prepared by researchers and are well reported in the literature [8,9]. Such particles carry organofunctional groups at their surface, including amines, vinyl, epoxy, mercapto, acrylic, etc [10].

Polyurethane coatings (PU) are being extensively used for different applications. The cross-linked films have normally good adhesion and proper mechanical performance. However, it is further possible to combine the flexible urethane chemistry with the aid of nano silicas to enhance the mechanical performance. The reason to use silica in these applications is due its low refractive index (1.46) as well as to the reasonably good hardness (5.5–6.5 Mohs). These two parameters are important for obtaining particle loaded polymers with less light scattering and enhanced mechanical performance. To obtain a proper dispersion, the interfacial relation between silica and polyurethane is of great importance. Influence of surface treated nano silica with silanes on microstructure and mechanical properties of polyurethane and acrylic melamine clear coats have been reported [11–13].

In our previous work we attempted to vary the pH conditions in surface treating of a nano silica using aminopropyltrimethoxy silane [14]. At acidic and alkaline pHs various surface functionalized silicas were obtained.

The present paper aims at revealing the role of these differently treated silicas on interfacial interaction with a polyurethane matrix. The dispersibility of nano particles in films was studied by transmission haze content. DMTA and DSC analyses were used to study the