Thermomechanical and Chemorheology Properties of a Thermosetting Acrylic/Melamine Clearcoat Modified with a Hyperbranched Polymer

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ABSTRACT: The work presented here aims at studying the thermomechanical and chemorheological properties of an automotive clearcoat containing an acrylic/melamine resin modified with a hyperbranched poly ester-amide (HBP) additive. Rheological experiments were conducted at ambient (25°C) and curing temperature (140°C). Dynamic mechanical thermal analysis and hardness measurements were performed to reveal the influence of HBP content on the behavior of the cured samples. It was found that the viscosity of the resin containing HBP samples considerably decreased. Although curing degree and mechanical properties were improved at low HBP loadings, a reverse effect was seen at higher contents. Dynamic rheological results during curing showed that although low amount of HBP resulted in an early gel point (GP), higher HBP loading postponed the GP. This loading-dependent behavior was explained by the influence of HBP on viscosity and reactivity of the system on which the curing performance was influenced oppositely. © 2013 Wiley Periodicals, Inc. J. Appl. Polym. Sci. 000: 000–000, 2013

INTRODUCTION

Dendritic polymers are macromolecules produced from polymerization reaction of multifunctional monomers. A poly-functional monomer acting as a core provides sites for interacting with other multifunctional monomers. “Dendritic” is originated from a Greek word “Dendron” which means “tree.” Today, synthesis, properties, and applications of dendritic polymers have been well documented.¹ ² Dendritic polymers are classified into dendrimers and hyperbranched polymers depending on their branching architecture. Although dendrimers have a perfect structure due to a precise control in their synthesis process, hyperbranched polymers have an imperfect branching structure. This makes hyperbranched polymers to be much cheaper compared with dendrimers. Accordingly, this eases the mass production of hyperbranched polymers and develops their applications in different industrial products. Hyperbranched polymers can be utilized in a diverse range of applications such as catalysis, sensors, delivery systems, polymeric blends, and especially coatings.² Low melt viscosity, high solubility in organic solvents, well-defined structure, large degree of functionality, and the possibility for modification of functional groups make hyperbranched polymers highly versatile materials for coating applications.³ ⁴ Hyperbranched polymers have been used as main resin in production of powder coatings,⁵ ⁶ UV-curing resins,⁹ ¹¹ high solid coatings,⁴ water-borne coatings,¹³ and also as multifunctional crosslinkers in some thermosetting systems.¹⁴ ¹⁶ Hyperbranched polymers have also been proposed as toughening agents for thermosetting systems, especially for epoxy-based polymers.¹⁷ ²³ Hyperbranched polymers in comparison to conventional toughening agents such as rubber and thermoplastic particles, have shown to toughen the epoxy resins more effectively without any significant decrease in modulus. Despite extensive use of hyperbranched polymers as toughening agent for epoxy resins, their effects in other thermosetting systems have rarely been reported. In few attempts, vinyl-urethane hybrid resins and bis-maleimide containing thermosetting systems were toughened by various polyether and/or polyester-based hyperbranched polymers.²⁴ ²⁶

Acrylic resins cured with melamine crosslinkers are the most common types of thermosetting polymers being used as automotive clearcoats.²⁷ ²⁹ In this system, the intended reaction occurs between hydroxyl groups of acrylic resin and methoxy groups of the methoxylated melamine resin.³⁰ While they meet the need for having a high modulus, their high glass transition temperature and relatively low elongation at break make them a brittle network. This can affect the mechanical properties such as chip and scratch resistance needed for such applications.³¹ ³⁴