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The influence of different components on interpenetrating polymer network's (IPN's) characteristics as automotive top coats

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ABSTRACT

The aim of this study was to investigate the influence of different components of interpenetrating polymer networks (IPNs) on their behavior in dual curing automotive applications. Dual curing is one of possible ways to obtain fast curing, scratch resistant coatings for use in OEM and car refinish applications. Dual curing systems, upon hardening, represent interpenetrating networks (IPNs) [1]. IPN's were obtained using novel acrylate-terminated hyperbranched polyester with high functionality and compared to classical 2-pack polyurethane clear coat.

In our previous manuscript [1] we investigated the influence of the acrylated hyperbranched polyester (HBP(A)) content in dual curing systems. In this article we studied the influence of the reactive diluent on dual curing compositions. To this end, we have chosen IPN with 50/50 weigth ratio of polyurethane (PU) and polyacrylic (PA) component. In order to determine more clearly the role of the HBP(A) in one IPN HBP(A) was changed with hexane diol diacrylate (HDDA), keeping the same ratio with EHA.

The IPNs were characterized by dynamic-mechanical analysis (DMA), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The mechanical properties of the IPNs were also investigated. The IPN with HDDA as reactive diluent, had the best performance. IPN with HBP(A) had the highest glass transition temperature Tg and the highest crosslink density, but it did not have the highest hardness.

1. Introduction

An interpenetrating polymer network (IPN) is an intimate combination of two polymers both in network form [2]. Materials known as IPNs involve the preparation of crosslinked polymer I, subsequent swelling in a network of monomer II plus crosslinker, and the *in situ* polymerization of monomer II [3,4]. Because they combine the properties of the components forming the networks, IPNs have become the subject of extensive studies [5–8].

The main interest of UV-radiation lies in high polymerization rate, together with the advantage that it can be considered an environmental friendly technique due to the solvent free processes carried out at room temperature [9].

Hyperbranched polymers (HBP) are built from monomers of AB_x-type, i.e. monomers, containing two different functional groups. In order to control molecular weight and polydispersity, AB_x monomers are usually reacted with B_y-type molecules (core). These polymers are characterized by highly branched, tree-like structure and large number of end groups, which affects their overall properties [10,11].

Urethane-acrylates as resins for UV-curable coatings have the best mechanical and chemical properties among all UV-curable resins, but suffer from the high viscosities [11,12].

Previously we studied IPNs with different amount of acrylated HBP as a part of acrylic component of IPN [1]. This time we have chosen one IPN from the last study (the one with 50/50 ratio of acrylic and urethane component (IPN-1)) and we compared it to three different IPNs in which we just varied one component, keeping the others the same as in IPN-1.

The properties of IPNs were investigated by dynamic-mechanical analysis (DMA), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The film properties were also investigated with respect to hardness and flexibility.

The aim was to explore the influence of different components on properties of IPNs in order to get superior properties with respect to scratch resistance.

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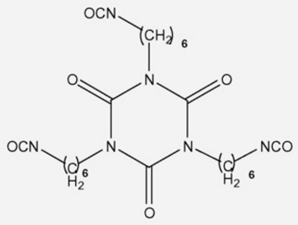
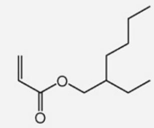
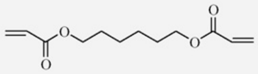
Table 1
Structure of monomers employed.



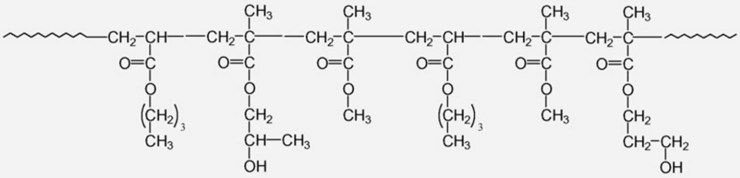
Desmodur N3390



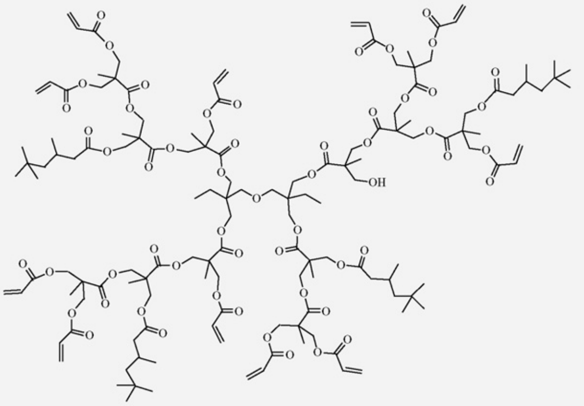
Acrylic acid 2-ethyl-hexyl ester EHA



1,6 –hexanediol diacrylate



Hydroxyl functional acrylate copolymer HA



HBP (A)

2. Experimental

2.1. Materials

Desmodur® N3390 (19.4×10^{-3} of NCO for 1 g of Desmodur), BAYER, Germany, used as 90% solution in butyl acetate, MERCK, USA Methyl methacrylate (MMA), BASF, Germany, (purity ≥ 99.9%), butyl acrylate (BuA), BASF, Germany, (purity ≥ 99.5%) and 2-hydroxypropyl methacrylate (HPMA) Cognis, were used with no further purification. 2,2′-Azobis(2-methylpropionitrile) (AIBN), DuPont, was used as the radical polymerization initiator.

2-Ethyl hexyl acrylate (EHA) BASF, Germany (purity ≥ 99.6%) and hexane diol diacrylate (HDDA), were used as reactive diluents, while acrylated hyperbranched polyester HBP(A) was used as acrylated oligomer in UV component of IPNs. 1-Hydroxy-cyclohexyl-phenyl-ketone (Irgacure 184), CIBA, USA, was used as the photoinitiator.

The structures of the employed monomers are presented in Table 1.

2.2. Synthesis of hydroxyl functional acrylate copolymer HA

A four-necked round bottom flask, equipped with an inert gas (nitrogen) inlet, a temperature regulation lug for the contact thermometer, a mechanical impeller lug with a condenser and dropping funnel, was loaded with 1.76 mol MMA, 0.98 mol HPMA and 0.64 mol BuA and 2.3 mol butyl acetate (BuAc). AIBN was used as the radical polymerization initiator (8.00 wt% diluted in monomer) and tertiary dodecylmercaptan (tert DDM) as the molar mass regulator (0.08 mol). The reaction went on for 9 h, and was followed by determination of the solid material content (% SM) (the theoretical value of % SM was 60% in BuAc). An unusually high amount of initiator and molar mass regulator was used to obtain polymer with as low molar mass as possible.