Effect of MF and UF/MF on pressure sensitive adhesives based on copoly(butyl acrylate/acrylic acid)

Hadi Babaei[1], Gholamhossein Zohuri[1*], Mehran Gholami[2], and Mohsen Shahidi[2]

1. Department of Chemistry, Faculty of Science, Ferdowsi University of Mashhad, P.O. Box 91775-1436, Mashhad, Iran
2. Samed Manufacturing & Industrial Co. (Mashad Adhesive), Mashhad, Iran
Zohuri@um.ac.ir

Abstract

Three useful properties for describing pressure sensitive adhesives (PSAs) are including: tack, peel and shear strength. Cross-linking of PSA is one of the key techniques to control balance between cohesive and adhesive strength of the obtained polymer. Effect of the concentration of cross-linkers such as melamine formaldehyde (MF) and MF/UF (urea formaldehyde) mixture on the adhesive was investigated. Increasing MF concentration from 0.00 w% to 2.65 w% decreased peel strength and shear strength from 0.23 N/mm to 0.16 N/mm and from 230 kPa to 155 kPa, respectively, however, tack of the latex increased from 1 cm to 3.8 cm. However, using mixture of MF/UF improved all of the three investigated parameters. The mixed cross-linker significantly increased shear strength from 230 kPa to 550 kPa, and peel strength represented a maximum value at 0.6 w% of the mixture and its tack increased from 3.18 cm into 1.6 cm.

Keywords: pressure sensitive adhesives, semi-batch emulsion polymerization¬, cross-linking agent, adhesive, acrylate latex

Introduction

In the last fifty years, acrylic PSAs have made a great deal of effort from almost a simple art to a complex science [1]. Synthesis of acrylate PSAs latex is usually accomplished through out of a semi-continuous emulsion polymerization using butyl acrylate (BA) and acrylic acid (AA) and so on monomers [2, 3]. PSAs are commonly used to cover labels, PSA tapes, decorative films, and etc. PSAs require special properties: in addition to good surface adhesion, PSAs should have good stability over light, oxygen, moisture and the adhesion properties should be very wide within a wide range of temperatures [4]. Three useful properties for describing PSA include: tack, peel strength (adhesion) and shear strength (cohesion). To a large extent, these properties are controlled via nature of the solvent, the type of monomers, concentration and type of initiator, polymerization method, molecular weight of the acrylic polymer, and in particular by the type and concentration of cross-linking agent added to the PSA resin [5]. Cross-linking of PSA is one of the key techniques to control balance between cohesive and adhesive strength of the obtained polymer [3]. Use of UF resin, cross-linking agent, to control the adhesive properties of the copolymer was shown that with increasing its concentration, shear and peel strengths were increased, however, the tack of the latex was reduced [6]. In this research, MF and UF/MF were used as cross-linking agents for PSA adhesive based on copoly(butyl acrylate/acrylic acid)

Experimental/ Theoretical

UF and MF were prepared from Samed Chemical Industries Co., (Mashad Adhesive), Mashhad, Iran. Butyl acrylate and acrylic acid were purchased from Petro Chem., Dubai, UAE. Commercial ammonium persulfates, the initiator, was bought from Merck Co. Dioctyl sulfosuccinate sodium (DOSS) was obtained from Sigma Aldrich Co. St. Louis, USA. Stabilizer, nonylphenol ethoxylate (k30), was purchased from Kimiagran Emroz Co. Tehran, Iran. Sodium bicarbonate, the buffer, was prepared from Merck Co. Germany. Semi-batch emulsion polymerization

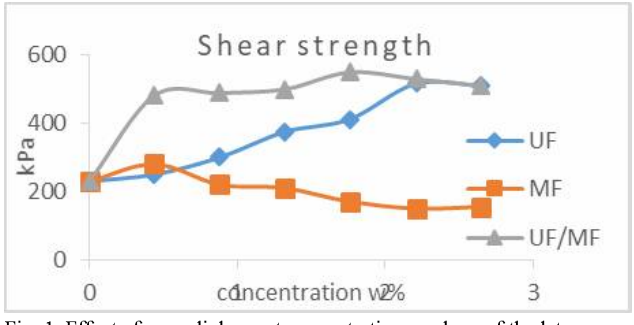

Fig. 1. Effect of cross-link agent concentration on shear of the latex

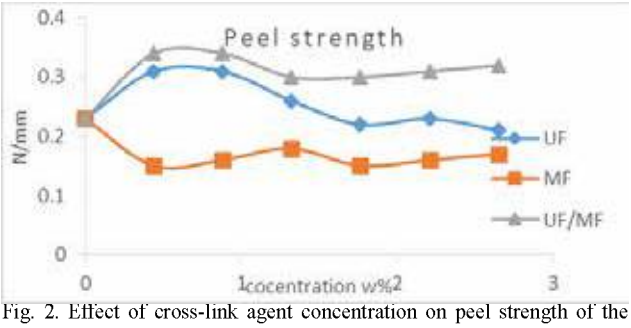

Fig. 2. Effect of cross-link agent concentration on peel strength of the latex

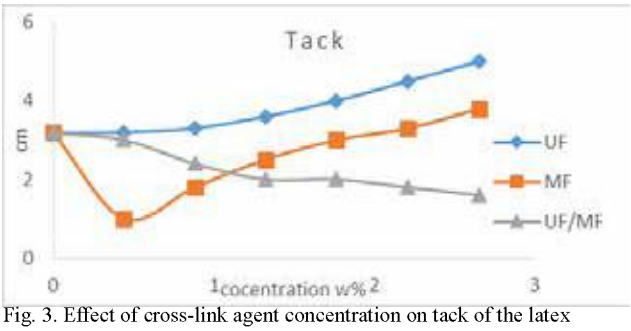

Fig. 3. Effect of cross-link agent concentration on tack of the latex

technique was considered to prepare the copolymer of BA and AA. The polymerization was performed at 76 °C in a four-inlet one-liter glass reactor equipped with temperature controller, thermostat, mechanical stirrer and injection funnel. Pre-emulsion was obtained using BA (354 g), surfactant (DOSS, 9.5 g), AA (4 g), k30 (3.75 g), initiator (APS, 0.6 g), water (314 mL) and sodium bicarbonate (0.7 g). The pre-emulsion (15 w%) was added into the reactor at the beginning of the polymerization. The rest of the pre-emulsion, however, was gradually injected into the reactor for about 5 h. MF, the cross-linker, (concentration from 0.00 w% up to 2.65 w% of the monomers) was added into the polymerization reactor after 2:30 h from started of the reaction. However, for mixture of UF and MF, concentration of UF was kept constant (1 w%) while concentration of MF was varied (from 0.00 up to 3.09 w% of the monomers).

Results and Discussion

Addition of MF (0.00 w% up to 2.65 w% of the monomers), the cross-linker, to the polymerization, reduced shear strength of the latex, while, using mixture of MF/UF (0.44 w% MF, 0.00 w% up to 2.65 w% UF of the monomers) sharply increased its shear strength (from 230 kPa into 550 kPa) to a limited value (Fig. 1). Use of MF into the polymerization, reduced peel strength of the latex but using MF/UF mixture caused to increase the peel strength and represented a maximum in the range of 0.44 to 0.88 concentration of the cross-linker in the monomers (Fig. 2). Tack of the latex was affected by using MF, UF and their mixture with different regularity (see Fig. 3 for the details).

Conclusion

All of the main characters of the prepared PSA are affected by type and concentration of UF, MF and UF/MF cross-linkers used in the project. The mixed UF/MF cross-linker showed better performance to the factors studied in the investigated range.

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