Water-Based Coatings based on Mixtures of Acrylic Dispersions and Alkyd Emulsions

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Abstract

Acrylic dispersions were mixed with alkyd emulsions to obtain coatings that lower the amount of volatile organic compounds (VOC). The advantage of this approach is that the fast drying of the acrylic is combined with the good film properties of the alkyd. Films produced with an alkyd and a soft acrylic (SA1) did not exhibit good film properties, whereas, films produced with a hard acrylic (HA2 and HA1) and an alkyd gave films with good appearance, appropriate drying times, superior hardness and acceptable gloss. VOC was calculated below 25 g/L. The novel mixtures may be applied as high gloss enamels for architectural coatings.

Introduction

Replacement of solvent borne surface coatings by their aqueous-based counterparts is in investigation for several decades[1]. The legislative pressure, has enhanced this research during the last decade. The VOC in coatings has already been reduced by the introduction of water-based emulsion systems. However, this system has some major disadvantages compared to the solvent-based systems, for example worse mechanical properties.

One way to tackle this challenge is to use mixing or hybrid formation of acrylic dispersions and alkyd emulsions to combine the fast drying of the acrylics and the good film properties of the alkyd.

Experimental

The mixing of the acrylic dispersion and the alkyd emulsion was carried out in a 500 ml 3 neck round bottom flask. The mixture was stirred by an electrical stirrer and was heated until 50°C with a heat mantel with a heat control. The alkyd emulsion was added drop wise to the acrylic dispersion at a constant speed. The blend was stirred after the addition for an additional 30 minutes. Variables changed were: acrylics and alkyds with different properties; ratio of acrylic dispersion/alkyd emulsion and addition of driers.

Results and Discussion

The acrylic dispersions used for the initial research were SA1, HA2 and HA1. SA means soft acrylic and HA hard acrylic. The difference between SA1 and HA1 is the Tg of the polymer. 1 is for all acrylic and 2 is for an styrene-acrylic emulsion. The alkyd (letter Z in opposition to A from acrylic) emulsions used were ZS, ZM and ZL. These refer to the oil length of the alkyd: S (short), M (medium) and L (long) respectively.

[1] Jowkar-Deriss, O.J.Karlsson, *Colloids and Surfaces A: Physicochem.Eng.Aspects*, 245 (2004) 115-125
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The nomenclature of the mixtures was chosen in such a way that the name of the sample indicated the contents of the mixture and the reaction conditions. For example, the initial product in the reactor was put in as first, followed by the name of the product that was added drop wise to the reaction. For example HA1ZLDR2-1 means a mixture of the HA1 acrylic with the ZL alkyd (long oil alkyd) in a ratio 2:1 acrylic/alkyd. D means that was diluted with water so that all the mixtures produced had the same solids content.

Films were cast and were evaluated according to the appearance to the naked eye. The presence of cracks, film defects and haziness were investigated. The films were rated according to transparency, crack resistance and surface smoothness. +2 was for an outstanding film, -2 for a poor film and 0 for an intermediate film. The films made with ZS all gave very poor results and in all cases bad films were formed. This may be an indication of a poor compatibility between an alkyd with a short oil length and an acrylic latex. This conclusion is supported by the fact that the latex blends of ZS phase separated after some time.

The films made with ZM showed a different behaviour for the acrylics used. All the films made of ZM and SA1 showed bad film properties, whereas almost all films made with ZM and HA2 or HA1 gave high transparency and uniform films.

After the initial screening, the choice was made to use the blends HA2ZMDR1-1, HA2ZMDR1-2, HA2ZLDR1-1, HA2ZLDR1-2, HA1ZMDR1-1, HA1ZMDR1-2 and SA1ZLR2-1. New mixtures were produced to have approximately 44 w% of solids using driers.

The film properties of the blends containing the driers are shown in Figure 1. The first row shows the films of HA2ZMDR1-1 and HA2ZMDR1-2. The second row shows the film properties of the films made of HA2ZLDR1-1 and HA2ZLDR1-2. The third row shows the film properties of HA1ZMDR1-1 AND HA1ZMDR1-2 and the last figure is of the mixture SA1ZLDR2-1.

The first observation made for the films containing the driers was that the films were not or were less sticky than the films produced without the driers. From the figure it can be remarked that the properties of the films of HA2 and ZM were more or less the same with and without driers. This also held true for the films of HA1 and ZM. HA2ZLDR1-1 also showed more or less the same film properties with or without driers. For HA2ZLDR1-2 the properties of the film were better after the addition of the drier. The transparency for this film showed the same trend as HA2ZLDR1-1 and was worse, but the cracking and the smoothness were better for HA2ZLDR1-2 after the addition of driers. An explanation can be that this film contained more alkyd and as a result the drier had more effect on the film formation of this blend. In addition ZL must be more sensitive to the driers than ZM, because this effect is not observed for the film properties of the films containing ZM. This can be explained by the higher oil length of ZL. Furthermore, this is in agreement with a hypothesis made before. Blends with ZM may be more homogeneous and the effect of driers is not that important.

For SA1ZLDR2-1 only the crack resistance was a bit better after the addition of the driers. The effect of the drier is low, because the concentration of alkyd is low.

To sum up, the films containing ZM as the alkyd showed more or less the same film properties for the blends with and without driers. Only the smoothness of the films changed a bit because of faster drying. The films made with the blends containing HA2 and ZL showed a decrease in the transparency of the films. The film that had a ratio 1-

1 did not show more noticeable changes, but the film with ratio 1-2 showed improved crack resistance and smoothness.

The Tg's of the blends are shown in Table 1. The Tg´s of HA2ZMDR1-2DRY (with driers) and HA2ZLDR1-2DRY were not detected in a temperature range of –80°C to 100°C. This was possibly because the driers and the alkyd crosslinked the system and even the acrylic part was not detected. For the ratio 1:1 this was not the case, because the amount of alkyd was not sufficient to crosslink the whole system.

The most important result was that two Tg values were found for the mixtures containing the acrylic HA1 and only one for the mixtures containing HA2 and SA1.

A second observation was that all the Tg values reported are lower than the Tg of the pure acrylic dispersions. The Tg1 values of the mixtures containing HA1 came close to the Tg values of the pure acrylic. This implies that these samples contained domains of pure acrylic, whereas the second domain was a homogeneous mixture of alkyd and acrylic.

The results for hardness are shown in Table 1. The target of the hardness was 22 oscillations. This value is reported to be a good value for Mexican customers. As it can be seen, all the films with the ratio 1:1 had a good hardness after drying time of 7 days. The films HA2ZMDR1-1DRY and HA1ZMDR1-1DRY had a very high hardness with 42 and 48 number of oscillations respectively. The hardness of the films with the ratio 1:2 was reasonable, but the hardness of the film SA1ZLDR2-1DRY still was very low. An explanation for the poor result of SA1ZLDR2-1 is that the acrylic SA1 is a soft acrylic and does not contribute to the hardness like HA2.

The gloss of the mixtures was measured after drying for 24 hours at an angle of 60° after being formulated into paint. The set value for the gloss was 85. According to the results, one mixture (HA2ZLDR1-2DRY) exceeded the target; and exhibited a very high gloss with 88.1. This may be related to a completely crosslinked system (no Tg found). The second best is HA2ZMDR1-2DRY with 81.4 and again no Tg was found by DSC. Two other samples are close to the target and may reach the desired values just by making some adjustments in the formulation of the paint. The values of the mixtures HA2ZMDR1-1DRY, HA2ZLDR1-1DRY came close to 85 with values of respectively 73.9, 76.4. For the mixtures containing HA1 the gloss were low at 47.1 and 50.4 for respectively the ratios 1:1 and 1:2. The gloss for the only sample chosen with the SA1 acrylic gave a low value of 50.6. It is remarked that the gloss improved with increasing alkyd concentration. This was also expected, because paints made from alkyds contain good gloss properties.

The formulation into a paint remains is a proprietary but it is being formulated below a VOC lower than 25 g/L as it can be seen in Table 1 for all the mixtures studied.

Conclusions

In this work mixtures of acrylic dispersions and alkyd emulsions are produced, where the alkyd is fed into the reactor containing the acrylic. The films produced with a soft acrylic dispersion (SA1) do not exhibit good film properties, whereas the properties of films produced from mixtures containing a hard acrylic dispersion (HA2 or HA1) in combination with a soft alkyd (ZM) do contain good film properties.

After the initial screening, seven mixtures were selected and driers were added to these mixtures. For the hardness it is concluded that it increases with increasing Tg.

The gloss of the final films of the paints depends on the degree of crosslinking of the system. In fact, a high compatibility of the components in the mixture will result in a homogenous mixture, and in a effective crosslinking carried out by the driers which improves significantly gloss.

Tables and Figures

Product	König Hardness, 7 days		Gloss	VOC	Tg1 (DSC)	Tg2 (DSC)
	Oscill(s)	*Time (s)*	*60°*	(g/L)	°C	°C
HA2ZMDR1-1DRY	29	42.5	73.9	20	10.0	x
HA2ZMDR1-2DRY	20	30	81.4	20	x	x
HA2ZLDR1-1DRY	25.5	38	76.4	21	12.1	x
HA2ZLDR1-2DRY	17.5	26	88.1	21	x	x
HA1ZMDR1-1DRY	33.5	48.5	47.1	20	48.3	16.6
HA1ZMDR1-2DRY	18.5	28	50.4	20	51.6	2.3
SA1ZLDR2-1DRY	4.5	8.5	50.6	19	6.5	x

Table 1. Results of Gloss Measurements of the Selected Mixtures

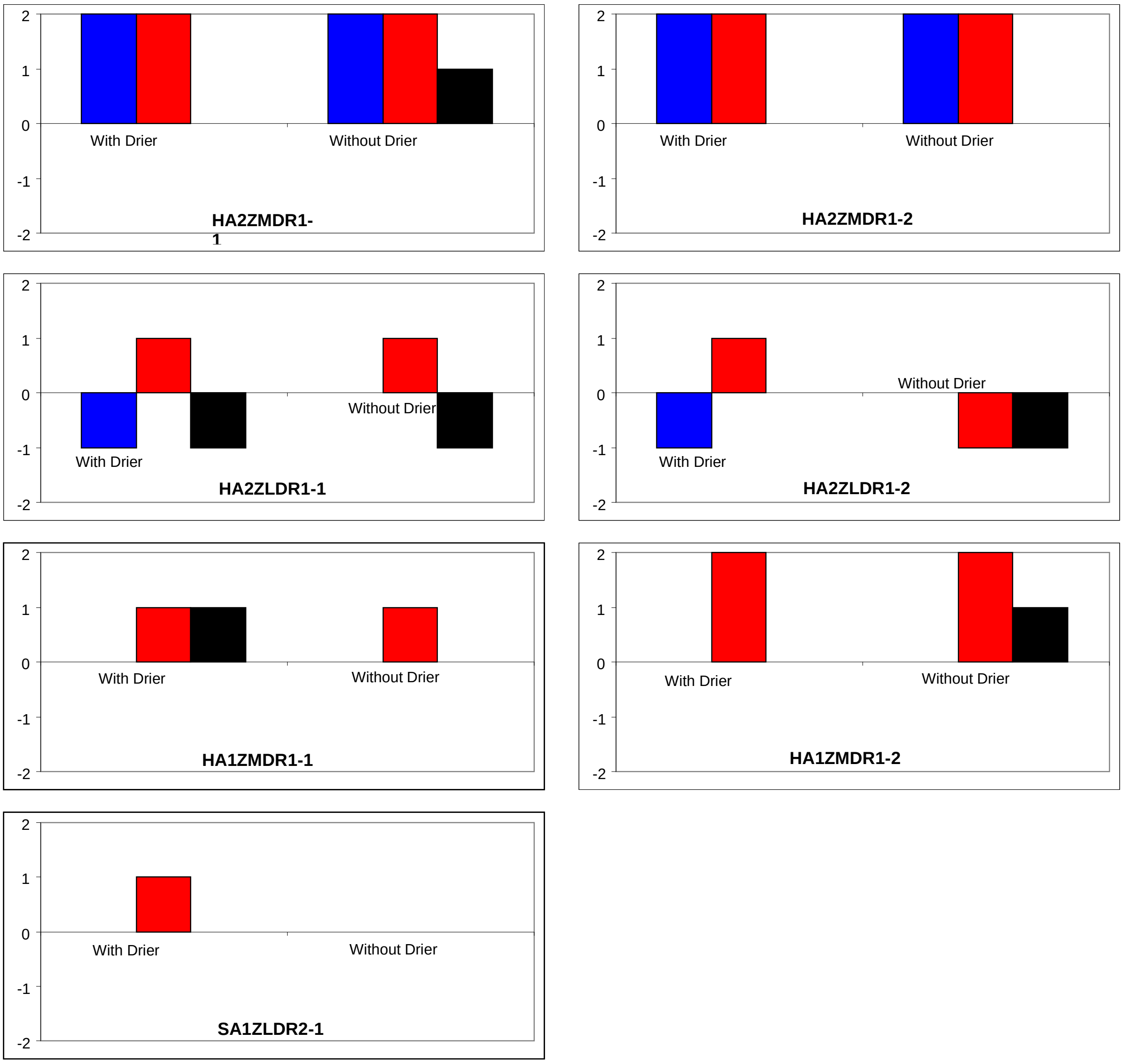

Figure 1. Film Properties of the Selected Films With and Without Driers.
Transparency; Crack Resistance; Smoothness