

VARIATION OF THE EFFECTS OF ADOPOL EVS-9279X ON THE EMULSION AND FILM PROPERTIES OF POLY (VINYL ACETATE) AND ACRYLIC RESIN WITH TIME.

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ABSTRACT

The effects of Adopol EVS-9279X on the emulsion and film properties of poly (vinyl acetate) and acrylic resin have been examined. Variation of these effects with time was investigated in this study using 5%-10% w/w sample formulations. The emulsion and film properties were measured at 4 weekly intervals. Results indicate that properties, such as solid content, drying time and water absorption were decreased by Adopol EVS-9279X. Observation within 8 weeks shows that the solid content increased while the drying time and water absorption decreased further. At 10% w/w concentration, solid content of poly (vinyl acetate) decreased from 38.2% to 33.3% in week 0, which increased to 35.0% in week 4 and 35.2% in week 8. That of acrylic resin decreased from 45.8% to 41.8% in week 0 and later increased to 43.7% in week 4 and 43.8% in week 8. Drying time of poly (vinyl acetate) at 8% w/w concentration decreased from 74.0 min to 51.0 min in week 0, which decreased further to 49.5 min in week 4 and 48.5 min in week 8. At 7% w/w concentration, drying time of acrylic resin reduced from 68.0 min to 58.0 min in week 0, which reduced further to 55.5 min in week 4 and 55.3 min in week 8. Water absorption of poly (vinyl acetate) at 5% w/w concentration was decreased from 45.8% to 38.4% in week 0, which further decreased to 32.8% in week 4 and 32.0% in week 8, while that of acrylic resin was decreased from 37.2% to 34.0% in week 0, 29.9% in week 4 and 29.2% in week 8. Surface tension of poly (vinyl acetate) was increased from 2.06×10^{-3} N/m to 3.502×10^{-2} N/m at 5% w/w concentration. This decreased to 3.294×10^{-2} N/m in week 4 and 3.163×10^{-2} N/m in week 8. That of acrylic resin was decreased from 3.988×10^{-2} N/m to 2.866×10^{-2} N/m in week 0 and then decreased further to 2.844×10^{-2} N/m in weeks 4 and 8. Specific gravity and pH were lowered at low concentration for both polymers. Their variations within the period were not significant. Finally apparent viscosities and flexibility of both polymers were unaltered by Adopol EVS-9279X.

KEY WORDS: Adopol EVS-9279X, Poly (vinyl acetate), Acrylic resin, Time.

INTRODUCTION

Adopol EVS-9279X is an emulsion viscosity stabilizer, with sodium salts of methyl ethyl cellulose and sodium benzoate as active components (Airuehia, 1992). It has found application in the stabilization of emulsion paints, cosmetic products and agro-industrial suspensions. The properties of Adopol EVS-9279X, poly (vinyl acetate) and poly (methyl methacrylate) have been reported (Otaigbe and Onyemenonu, 2004; Otaigbe and Onyemenonu, 2004; Airuehia, 1992). A number of conventional emulsifiers/surfactants have been used to stabilize poly (vinyl acetate) and poly (methyl methacrylate) - acrylic resin lattices (Vanderhoff, 1985), which are film forming materials in the formulation of emulsion paints (Challa, 1993). These surfactants are essential for the stabilization of these lattices during post polymerization processes, such as, formulation, storage, shipping and application (Candau and Ottewill, 1990). The stabilization of liquid (solid)/liquid dispersions in polymerization reactors has been reported (Chatzi et al, 1998). Steric stabilization in emulsion polymerization using non-ionic surfactants has also been reported (Lazarides et al, 1999).

Studies on the effect of the surfactant type and concentration on drop stabilization in high holdup fraction suspension polymerization reactors have been

investigated (Chatzi et al, 1999). The differential film formation in Adopol Standard Defoamer, Adopol EVS-9279X and poly (vinyl acetate) - their characterization and application have been reported (Ebosie, 1996). The effects of Adopol EVS-9279X on the emulsion and film properties of emulsion paint, poly (vinyl acetate) and acrylic resin have also been investigated and reported (Otaigbe and Onyemenonu, 2004; Otaigbe and Onyemenonu, 2004). In continuation of the study on the effects of Adopol EVS-9279X on the emulsion and film properties of poly (vinyl acetate) and acrylic resin, the variation of these effects with time is reported here. This is essential in determining their stability and suitability for various applications after a storage period of 8 weeks.

EXPERIMENTAL

Materials

Poly (vinyl acetate) and acrylic resin poly (methyl methacrylate) were obtained from Chemlap Industries Limited, Aba. Adopol EVS-9279X was obtained from Gamor chemical and Allied Limited, Port Harcourt.

Sample Preparation

This was accomplished according to an earlier

reported procedure (Otaigbe and Onyemenonu, 2004).

Measurement of Emulsion and Film Properties

The emulsion and film properties of the poly (vinyl acetate) and acrylic resin samples such as viscosity, surface tension, specific gravity, solid content, pH, flexibility, water resistance and drying time were measured immediately after formulation as time zero and subsequently after every 4 weeks (for 8 weeks) according to earlier reported procedures (Otaigbe and Onyemenonu, 2004; Ainuehia, 1992; ASTM, 1960; Raju and Yaseen, 1983; ASTM, 1960; Raymond, 1977).

RESULTS AND DISCUSSION

Results in Tables 1 and 4 show the effects of Adopol EVS-9279X on poly (vinyl acetate) and acrylic resin respectively, which are in conformity with the earlier report (Otaigbe and Onyemenonu, 2004). The variation of these effects with time is shown in Tables 2 and 3 for poly (vinyl acetate), and in Tables 5 and 6 for acrylic resin respectively. Results show that the apparent viscosities of both poly (vinyl acetate) and acrylic resin remained unaltered on addition of Adopol EVS-9279X within the concentration range studied. The viscosity values of 3.5 cp for poly (vinyl acetate) and 2.0 cp for acrylic resin remained constant within the period under investigation. This shows that Adopol EVS-9279X is compatible with both polymers. This observation also agrees with the fact that Adopol EVS-9279X is an additive of low solid content (2.2%), since high solid content values are essential for increasing the viscosities of polymer suspensions or solutions. Therefore, Adopol EVS-9279X stabilizes effectively the viscosities of poly (vinyl acetate) and acrylic resin solutions.

The specific gravities of both polymers were lowered by Adopol EVS-9279X. For instance, at 6% w/w sample formulation, specific gravity of poly (vinyl acetate) was lowered from 1.05 to 0.91 in week 0 while that of acrylic resin was lowered from 1.09 to 1.08. This is because the addition of Adopol EVS-9279X increases volume more than mass of the sample resulting in a decrease in densities and therefore specific gravities. These specific gravity values remained fairly stable within the period of study. The specific gravity of poly (vinyl acetate) in weeks 4 and 8 remained constant at 0.91 for 6% w/w while that of acrylic resin remained at 1.08 for the same concentration. This is probably due to no significant variation in volume due to evaporation, expansion or contraction during the period of study. This reduction in specific gravity is advantageous in film formation because more area is covered when the specific gravity of the sample is lowered.

The pH of poly (vinyl acetate) and acrylic resin were found to be lowered by Adopol EVS-9279X at low concentration and increased at high concentration. Factors responsible for this trend have been reported (Otaigbe and Onyemenonu, 2004). The pH values showed very slight variation during the period of investigation due to slight variations in room temperature. At 5% w/w sample formulation, pH of poly (vinyl acetate) was reduced from 4.70 to 4.52 in week 0, which remained constant at 4.52 in week 8. pH of acrylic resin was reduced from 8.86 to 8.76 in week 0 and the value remained the same in weeks 4 and 8. Greater pH stability was obtained at low formulation concentration than at higher concentrations. The generally lower pH values at low formulation concentrations show that the polymers have a greater tendency of deteriorating during storage at low Adopol EVS-9279X concentration since polymers deteriorate faster at high temperatures and low pH values.

Table 1: Results of Emulsion and Film Properties of poly (vinyl acetate) Measured in Week 0

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	PH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
A1	2.060×10^{-3}	1.05	3.5	4.70	38.2	45.8	74.0
A2	3.502×10^{-2}	1.02	3.5	4.52	36.7	38.4	61.0
A3	3.579×10^{-2}	0.91	3.5	4.49	36.2	38.6	57.0
A4	5.627×10^{-2}	0.94	3.5	4.57	35.3	49.5	53.0
A5	7.562×10^{-2}	0.96	3.5	4.85	34.6	52.6	51.0
A6	8.996×10^{-2}	0.96	3.5	5.47	34.0	53.6	60.0
A7	8.951×10^{-2}	0.97	3.5	4.70	33.3	68.4	66.0

Where A1=poly (vinyl acetate) without Adopol EVS-9279X (control), A2=5% w/w, A3=6% w/w, A4=7% w/w, A5=8% w/w, A6=9% w/w and A7=10% w/w sample formulations.

Table 2: Results of Emulsion and Film Properties of Poly (vinyl acetate) Measured in Week 4.

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	PH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
A1	0.201×10^{-2}	1.05	3.5	4.72	38.4	44.5	73.0
A2	3.294×10^{-2}	1.01	3.5	4.51	39.0	32.8	61.0
A3	3.329×10^{-2}	0.91	3.5	4.49	38.3	32.9	55.5
A4	5.285×10^{-2}	0.94	3.5	4.55	37.4	46.8	52.0
A5	7.316×10^{-2}	0.94	3.5	4.88	36.2	50.7	49.5
A6	8.667×10^{-2}	0.95	3.5	5.40	36.0	51.3	57.1
A7	8.594×10^{-2}	0.96	3.5	4.67	35.0	66.2	65.0

Table 3: Results of Emulsion and Film Properties of Poly (vinyl acetate) Measured in week 8

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	pH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
A1	0.204×10^{-2}	1.06	3.5	4.72	38.4	44.9	72.5
A2	3.163×10^{-2}	1.01	3.5	4.52	39.1	32.0	60.0
A3	3.322×10^{-2}	0.91	3.5	4.50	38.7	32.1	55.1
A4	5.095×10^{-2}	0.93	3.5	4.56	37.5	46.7	52.0
A5	7.113×10^{-2}	0.95	3.5	4.87	36.7	50.0	48.5
A6	8.436×10^{-2}	0.96	3.5	5.44	36.0	50.0	57.0
A7	8.431×10^{-2}	0.96	3.5	4.69	35.2	65.0	64.3

Table 4: Results of Emulsion and Film Properties of Acrylic Resin Measured in Week 0

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	pH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
B1	3.988×10^{-2}	1.09	2.0	8.86	45.8	37.2	68.0
B2	2.866×10^{-2}	1.08	2.0	8.76	43.9	34.0	66.5
B3	2.702×10^{-2}	1.08	2.0	8.83	43.8	36.1	59.0
B4	2.702×10^{-2}	1.08	2.0	8.75	43.4	41.6	58.0
B5	2.771×10^{-2}	1.08	2.0	8.70	42.5	44.5	60.0
B6	3.167×10^{-2}	1.08	2.0	8.50	42.0	51.1	63.0
B7	3.173×10^{-2}	1.08	2.0	8.86	41.8	51.7	65.0

Where B1=acrylic resin without Adopol EVS-9279X (control), B2=5% w/w, B3=6% w/w, B4=7% w/w, B5=8% w/w, B6=9% w/w and B7=10% w/w sample formulations.

Water absorption was measured and used as an index for determining water resistance of the polymers. Water resistance has an inverse relationship with water absorption. It was observed that Adopol EVS-9279X reduced water absorption of both poly (vinyl acetate) and acrylic resin, with highest reduction obtained at 5% w/w concentration. At high Adopol EVS-9279X concentration, especially above 7% w/w concentration, water absorption of both polymers was increased. At low concentration, particles of Adopol EVS-9279X adsorb on the polymer films and overlap themselves thereby preventing easy penetration of the water molecules. This orientation is lost at high concentrations. However, it was observed that water absorption got slightly reduced within 8 weeks for all the sample concentration. For instance, at 5% w/w concentration, water absorption of poly (vinyl acetate) decreased from 45.8% to 38.4% in week 0, 32.8% in week 4 and 32.0% in week 8 while that of acrylic resin decreased from 37.2% to 34.0% in week 0, 29.9% in week 4 and 29.2% in week 8. At 10% w/w concentration (high formulation concentration), water absorption of poly (vinyl acetate) increased from 45.8% to 68.4% in week 0, which later decreased to 66.2% in week 4 and 65.0% in week 8. Similar observation is made in the case of acrylic resin at 10% w/w concentration. Here, water absorption was increased from 37.2% to 51.7% in week 0, which later decreased to 50.0% in week 4 and 49.7% in week 8. These results show that the rate of decrease in water absorption capacities of the polymers decreases as the time increases. This variation shows that the observed increase in water resistance within the 8 week period in all the samples studied is likely due to the evaporation of some liquids from the polymer emulsions. Evaporation of some liquids in the polymer

emulsions, tends to reinforce the adsorption potential of the particles of Adopol EVS-9279X on the polymer films. Results indicate that the acrylic resin sample has a higher water resisting ability than the poly (vinyl acetate) sample.

The solid content was observed to be reduced by Adopol EVS-9279X of both polymers. This is probably due to the low solid content of Adopol EVS-9279X (2.2%). The solid content was later observed to increase with time within the period of the study. This resulted from the likely evaporation of some liquid components of the polymer emulsion sample formulation, as indicated earlier. Greatest reduction in solid content was obtained at the highest formulation concentration of 10% w/w, thus confirming the effect of Adopol EVS-9279X's low solid content on solid content of samples. At this concentration, the solid content of poly (vinyl acetate) was decreased from 38.2% to 33.3% in week 0. This increased to 35.0% in week 4 and 35.2% in week 8. Solid content of acrylic resin was decreased from 45.8% to 41.8% at 10% w/w concentration in week 0. This increased to 43.9% in week 4 and 43.8% in week 8. The rate of increase in solid content decreases with time showing that the increase is probably due to the evaporation of some volatile components of the sample formulations.

The drying time of both polymers was found to be reduced within the concentration range studied with the optimum reduction achieved at 8% w/w sample formulation for poly (vinyl acetate). It has been reported that Adopol EVS-9279X, acting like a plasticizer, lowers the glass transition temperature (T_g) of these polymers below room temperature, thus enhancing their coalescing ability to form film at room temperature (Otaigbe and Onyemenonu, 2004). The drying time was

Table 5: Results of Emulsion and Film Properties of Acrylic Resin Measured in Week 4

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	pH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
B1	3.973×10^{-2}	1.08	2.0	8.85	45.8	35.8	67.0
B2	2.844×10^{-2}	1.08	2.0	8.76	46.2	29.9	64.5
B3	2.686×10^{-2}	1.08	2.0	8.80	45.5	34.9	56.9
B4	2.681×10^{-2}	1.08	2.0	8.75	44.6	40.5	55.5
B5	2.684×10^{-2}	1.08	2.0	8.74	44.7	43.9	57.5
B6	3.150×10^{-2}	1.08	2.0	8.50	44.2	50.2	59.4
B7	3.152×10^{-2}	1.07	2.0	8.85	43.9	50.0	61.5

Table 6: Results of Emulsion and Film Properties of Acrylic Resin Measured in Week 8

Sample	Surface Tension (N/m)	Specific Gravity	Apparent Viscosity (cp)	pH	Solid Content (%)	Water Absorption (%)	Drying Time (min)
B1	3.971×10^{-2}	1.09	2.0	8.86	46.8	35.6	66.4
B2	2.844×10^{-2}	1.08	2.0	8.76	46.3	29.2	63.0
B3	2.685×10^{-2}	1.08	2.0	8.81	45.9	32.5	56.2
B4	2.683×10^{-2}	1.08	2.0	8.77	44.8	40.0	55.3
B5	2.684×10^{-2}	1.08	2.0	8.72	44.8	43.6	57.2
B6	3.150×10^{-2}	1.08	2.0	8.53	44.2	49.8	59.3
B7	3.152×10^{-2}	1.08	2.0	8.86	43.8	49.7	61.2

Table 7: Results of the Flexibility Measurement of Poly (vinyl acetate) and Acrylic Resin for Weeks 0,4 and 8

Sample		Size of Mandrels (inches)				Remark
		1	3/4	1/2	1/6	
A1	B1	1	3/4	1/2	1/6	Passed
A2	B2	1	3/4	1/2	1/6	Passed
A3	B3	1	3/4	1/2	1/6	Passed
A4	B4	1	3/4	1/2	1/6	Passed
A5	B5	1	3/4	1/2	1/6	Passed
A6	B6	1	3/4	1/2	1/6	Passed
A7	B7	1	3/4	1/2	1/6	Passed

observed to reduce further within the 8 week period. This is due to the fact that some liquid components were lost during the 8 week storage period. This is more pronounced when Adopol EVS-9279X concentration increases. Similarly, slight increase in room temperature brings about reduction in drying time as well. At 8% w/w sample formulation of both polymers, drying time of poly (vinyl acetate) was reduced from 74.9 min to 51.0 min in week 0, 49.5 min in week 4 and 48.5 min in week 8. For acrylic resin, optimum reduction was achieved at 7% w/w concentration. Here, drying time was reduced from 68.0 min to 58.0 min in week 0, 55.5 min in week 4 and 55.3 min in week 8.

Adopol EVS-9279X was found to increase the surface tension of poly (vinyl acetate) and decrease that of acrylic resin especially at low concentration. This shows that the emulsion viscosity stabilizer reduces the wettability of poly (vinyl acetate), while it improves that of acrylic resin where it exhibits surfactant characteristics at low concentration. However, the variation trend in 8 weeks shows that there was a reduction in surface tension generally. This is probably due to the combined effects of oxidation, evaporation of some liquid components and slight increase in room temperature. At 5% w/w concentration, surface tension

of poly (vinyl acetate) was increased from 2.06×10^{-3} N/m to 3.502×10^{-2} N/m in week 0. This decreased to 3.294×10^{-2} N/m in week 4 and 3.163×10^{-2} N/m in week 8. Surface tension of acrylic resin decreased from 3.988×10^{-2} N/m to 2.866×10^{-2} N/m in week 0. This further decreased to 2.844×10^{-2} N/m in weeks 4 and 8.

Poly (vinyl acetate) and acrylic resin are flexible polymers. Results shown in Table 7 indicate that addition of Adopol EVS-9279X did not alter the flexibility of these polymers. No variation in this property was observed within the 8 weeks study period.

CONCLUSION

Adopol EVS-9279X has been shown to have various effects on the emulsion and film properties of poly (vinyl acetate) and acrylic resin. This study has shown the trend of variation of these effects with time within the 8 week period investigated. It shows that solid content, drying time and water absorption, which were initially decreased by Adopol EVS-9279X especially at low formulation concentration increased, then decreased and further decreased respectively with the period while specific gravity which was decreased on addition of Adopol EVS-

9279X, remained fairly stable. Similar observation was made for pH. Surface tension of poly (vinyl acetate) was increased while that of acrylic resin was decreased especially at low concentration. This property was found to decrease slightly within the period.

Flexibility and apparent viscosity values showed no variation within the study period.

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