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Full Length Research Paper

Preparation of Low VOC Hybrid Binder for Surface Coating Applications

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ABSTRACT

Studies on the Physico-chemical properties of hura crepitans seed oil and its modification have been carried out. Properties such as colour, specific gravity,% free fatty acid, acid value, saponification value and iodine value were determined. Hura Crepitan seed oil based alkyd resins were previously prepared by step-wise polymerization of the monoglycerides with phthalic anhydride. Properties of film samples prepared from the alkyd resins were evaluated as composite binders for surface coatings. The film samples were of relatively lower volatile organic compound (VOC) (between 0.2 and 0.9%) compared to their corresponding alkyd resins (about 1.3%). The composite binder exhibited excellent resistance to brine and water, and fair resistance to acid and alkali.

Key words: Hura Crepitans; Volatile organic compounds; Alkyd resin, film properties

INTRODUCTION

Alkyd resins have proven themselves both from a cost and performance point of view over a wide range of coatings applications for architectural metal, wood, industrial, agricultural and construction equipments, Patton, (1962), Ikhuoria et al, (2004). As alkyd coatings are solvent-borne, they contribute to Volatile Organic Compounds (VOC) emissions. Increasing concerns regarding ground level ozone and indoor air quality have spurred research activities to find alternative technologies to lower VOC emissions without compromising performance, Waters, (1955). This has proven to be a major challenge for the coating industry as the key issue is reformulating solvent borne coatings having lowest possible VOC while delivering expected performance benchmarks. Designing alkyd resin composite binder for surface coating and low VOCs solvent- Borne alkyds are a few concepts which can be used for a sustainable and environment friendly coatings without sacrificing their performances, Kirk, R.F and Othmer, (1947). The possibility to obtain versatile, low cost, renewable, and low VOC emission products makes alkyd films very attractive materials, Aigbodion et al (2003).VOC compliant coatings can be met through minimizing the solvent content to make high solids resins or by emulsifying the alkyd into water to make alkyd emulsions. Alkyds and acrylics can be combined by emulsification to make the so called hybrid film formers, Kent et al,(2008). In this present study, the film properties of oil-modified alkyd resin prepared with oil obtained from Hura crepitans seed oil and blends of the alkyd and poly vinyl acetate achieved using linear alkyl benzene sulphonate as emulsifier is presented.

MATERIALS AND METHODS

Materials

Technical grades phthalic anhydride, glycerol, xylene, iodine trichloride and other reagents were used in chemical processes and characterization were supplied by British Drug House (BDH), Poole, England.

Characterization of the oil and Preparation of Alkyd Resin

The characterization of the oil and alkyd resin preparation were reported in previous work, Idiaghe ,Imanah and Bakare, (2005).

Characterization of the Alkyd Resin

Physico-chemical properties of the alkyd resin were determined in comparison with the virgin Hura Crepitan seed oil. The drying schedule and the resistance of the alkyd sample in different service media were evaluated using standard methods; ASTM D1640-69 and ASTM D1308-5-57 respectively.

Preparation of the Hybrid Binder

The hybrid binder was prepared according to the method described by Aigbodion et al, (2003): A supersaturated solution of the alkyd resin in xylene was prepared and portions were taken for further reaction according to the formulation in Table. 1. Polyvinyl acetate (70%, w/w) and 1ml of x% solution of linear alkyl benzene sulphonate (surfactant) were added, while being vigorously stirred. Cobalt and calcium driers were added to the binders. Each alkyd-poly vinyl acetate hybrid binder sample was applied on a glass plate and oven-baked for about 90 min at 100^{o}C. A control sample (alkyd resin alone) was similarly treated. The chemical resistance of the films was determined following ASTM 9D1308-57 standard test method.

Table 1: Formulation for the hybrid binder preparation.

Formulation	A_1	A_2	A_3	A_4	A_5
Alkyd Resin in xylene (g)	10	9	8	7	5
PVA (g)	0	1	2	3	5
Surfactant (g)	1	1	1	1	1

RESULTS AND DISCUSSION

Characterization of the Alkyd Resin

The alkyd resin characteristics presented in Table 2, revealed that the density of the resin under the same condition of temperature is slightly higher than the raw oil. The high saponification value of the resin could be due to the

predominance of the ester linkages in the resin chemical structure, Kihlefer, (1938). The few proportion of the unsaturated fatty acid from the oil present in the resin could be the reason for the low iodine value of the resin in comparison with the oil.

The chemical resistance of the alkyd resin film in different service media is presented in Table 2. The results show that the resin is unaffected by acid, brine, and water. However, the film exhibited poor resistance to alkali which could be due to the presence of alkali hydrolysable ester groups in the film. The alkyd film dried fast on exposure, this was revealed by the touch, surface and dry through times which was found to be 6mins, 45mins and 2.28h respectively as presented in Table 3, the drying ability of resins is critical to their application as binder in surface coating.

Table 2: Physio-chemical properties alkyd resin

Properties	Alkyd Resin
Colour	Brownish Yellow
Specific Gravity (33oC)	0.932
Acid Value (mgKOH/100g)	6.56
Saponification value (mgKOH/100g)	271.96
Iodine value (gI_2/100g)	55.15
Free fatty acid (%)	-
Distilled water	Non
Alkali (0.1M KOH)	Wrinkle
Acid (0.2M H_2SO_4)	Non
Salt (5% w/v NaCl)	Non

Table 3: Drying schedule of the Alkyd film

Set to touch (min)	Surface dry (min)	Dry through (h)
6	45	2.28

The chemical resistance of the hybrid binder in different chemicals is shown in Table 4. The results show that the binders are unaffected by brine and water, but slightly affected by the acid. However, they are affected to varying degrees by alkali except sample A_1, containing high amount of polyvinyl alcohol, most resistant. The poor resistance of the binders to alkali may be explained on the basis that they are essentially consisted of hydroxyl functional groups, Aigbodion et al 2003. Table 4 shows that the VOC emission decreases with the amount of polyvinyl acetate used. Sample A_5 has the least emission, showing the effectiveness of hybrid film formers in reducing VOC emission. Results corroborate with typical properties of solvent-based hybrid binders such as good film formation, high gloss and water and chemical resistance. The emulsion stability from Table 4, show that the hybrid binder exhibits colloidal stability and better handling technique, Wicks et al, 1992.

Characterization of the hybrid binder

Table 4: Results of hybrid binder characterization

Parameter	A_1	A_2	A_3	A_4	A_5
Alkaline resistance(0.1M KOH)	Film removed	Blistering	wrinkled	Slightly wrinkled	No affect
Acid resistance(0.2M H_2SO_4)	Blistering	Wrinkled	Slightly wrinkled	No affect	No affect
Water resistance (Distilled)	Non	Non	Non	Non	Non
Brine resistance(5% w/v NaCl)	Non	Non	Non	Non	Non
VOCs emission (%)	1.333	0.588	0.938	0.571	0.256
Emulsion stability (mins)	N/A	4	6	9	11

CONCLUSION

The results of this study have shown that the oil extracted from Hura Crepitans seed can modify alkyd resin, making it suitable as binder for surface coating applications. The alkyd film showed good chemical resistance to acid, brine and water, but not to alkali. An emulsion low VOC emitting hybrid binder, comprising the oil-modified alkyd and poly vinyl acetate can be suitably prepared using linear alkyd benzene sulphonate as an emulsifier.

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