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Surface Coating Studies of [(Alkyd) – (Epoxy Resin Treated Castor Oil)]: [Maleated/Tetrahydrophthalated Cyclohexanone-Formaldehyde Resin[-[Epoxy Resin] condensate

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ABSTRACT

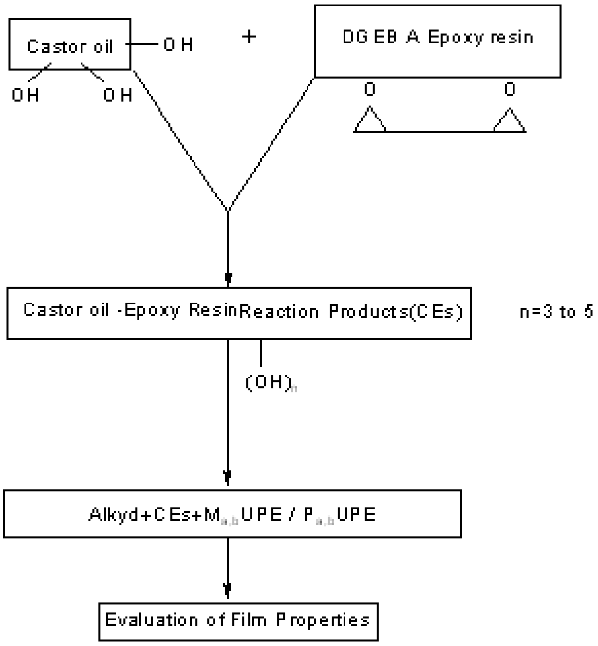
Castor oil (C) was reacted with commercial epoxy resin (E) (diglycidylether of bisphenol-A, DGEBA) at various mole ratios. The resultant products were designated as CEs. Unsaturated polyester resins were prepared by reacting DGEBA with maleated / tetrahydrophthalated cyclohexanone formaldehyde resins based on cyclohexanone formaldehyde (CHF) resins and designated as ($M_{a,b}$UPE and $P_{a,b}$ UPE) respectively. A commercial alkyd resin was blended with various proportions of CEs and $M_{a,b}$UPE and $P_{a,b}$UPE. A unique solvent system, which shows a one - phase clear solution and a clear coat of binder system, was used. All the blends were applied on mild steel panels and characterized for drying time, adhesion, flexibility, hardness, impact resistance and chemical resistance properties.

Keywords: alkyd resin; blends; coating; maleated / tetrahydrophthalated cyclohexanone-formaldehyde resin; epoxy resin (DGEBA).

INTRODUCTION

During the past two decades, protective coating industry has witnessed spectacular growth in the field of high performance coatings. Development of a series of new product based on different chemistries along with improved techniques and process enhanced the service life of the high performance coating systems to a significant extent [1].

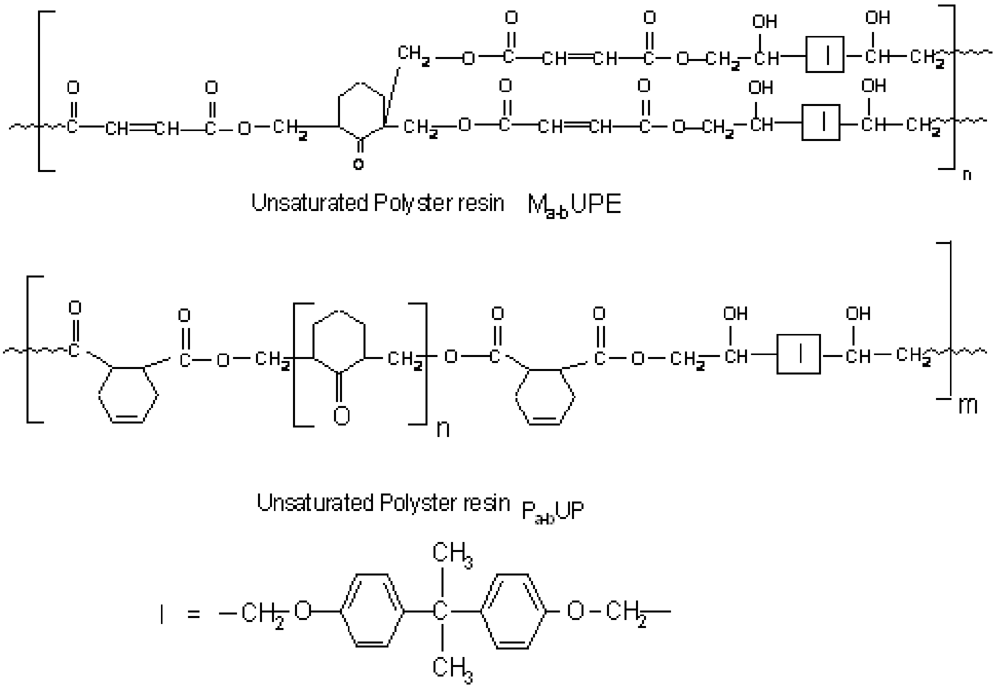
Alkyd resins [2-11], epoxy resins [12-19] and unsaturated polyester resins [20-23] are the versatile materials for the production of surface coating materials. Castor oil (C) is a renewable source of agriculture. It is valuable in terms of number of applications like raw materials for manufacturing of number of industrial utility products, coatings, urethane derivatives, surfactants, dispersant, cosmetics, fungicides, textile, nylon –type plastics and lubricants[24-27]. Both composition and high oil content of the castor seed also makes it an attractive source for biodesel production [28-30]. The presence of trifunctionalities such as double bonds, hydroxyl groups and esters are responsible for the attaining these applications.



Where:

M_a : Maleated CHF resin based on CHF of 300 mg/gm resin OHV
M_b : Maleated CHF resin based on CHF of 235 mg/gm resin OHV
P_a : Tetrahydrophthalated CHF resin based on CHF of 300 mg/gm resin OHV
P_b :Tetrahydrophthalated CHF resin based on CHF of 235 mg/gm resin OHV
M_aUPE : Unsaturated polyester based on M_a
M_bUPE : Unsaturated polyester based on M_b
P_aUPE : Unsaturated polyester based on P_a
P_bUPE : Unsaturated polyester based on P_b

One of the nonconventional resins i.e. cyclohexanone formaldehyde (CHF) resins has been known for the last five decades [31], it is an acidless unsaponifiable thermoplastic resin. CHF resin, which is very light in colour, has excellent light resistance, and plays a prime role in the field of coating due to their high compatibility and solubility [32]. CHF resin used in several applications, it is used in the manufacture of various types of lacquers and coatings [33]. Due to its hydroxyl polarity, it exhibits better adhesion and wetting of pigments and surfaces hence can be used in the pressure –sensitive adhesives [34] and paint compositions, for excellent adhesion in plastics [35] .It is also used in the production of various types of inks [36,37] and as coloring agent for plastics[38]. A literature survey reveals that CHF resin is used as an additive to improve the coating properties of alkyd resin [39-40], and when 30 % w/w concentration of CHF resin is blended with alkyd resin significant improvement in film properties was observed [41] .Recently we have studied the blend of ketonic resin with alkyd-castor oil –epoxy blends [42]. Hence , it was thought interesting to blend unsaturated polyester resins based on maleated and tetrahydrophthalated CHF resins with alkyd – (castor oil- epoxy resin) (as shown in scheme -1), and study the coating properties of the resulting blends.



Scheme 1 Surface coating materials based on blending of alkyd resin, CE and UPE

EXPERIMENTAL SECTION

Materials

Dehydrated castor oil (DCO) rosinated alkyd resin was procured from Pacific Paints (V.U. Nagar, India). Specifications of DCO alkyd resin, viscosity at 30 ^{o}C 130 ±10 s, % of non volatile materials 50%, acid value (max) 10 mg/ gm resin. Castor oil was purchased from the local market. Specifications of castor oil: Viscosity at 30 ^{o}C 130s, density at 28 ^{o}C 0.95 g/ml, number of hydroxyl value $2.45 \approx 3$ / mole castor oil, number of unsaturation 2 /mole castor oil. Epoxy resin i.e (Diglycidylether ether of bisphenols A (DGEBA) was obtained from Synpole Product Pvt. Ltd., Ahmadabad, India, epoxy equivalent weight 190 g/mole, viscosity 400- 1000 cp at 25 ^{o}C. Two cyclohexanon-formaldehyde (CHF) resins of different hydroxyl values (OHV), were obtained from Polyols and Polymers Vapi, Gujarat, India their specifications as follows:

CHF_a of 300 OHV, physical form; pearl –shaped granular solid. CHF_b of 235 OHV, physical form; pearl – shaped granular solid. All other chemicals used were obtained from Chiti –Chem. Corp., Baroda. India and were of laboratory pure grade.

Preparation of Castor Oil-Epoxy Resin Condensate Products (CEs)

(CE) was prepared by the method reported from our laboratory [42], this method is described below.

Castor oil (0.268 mole) was taken in three necked round bottomed flask equipped with a mechanical stirrer and placed in a water bath where temperature was maintained at 70-80 ^{o}C. Under continuous stirring, the desired amount of epoxy resin (as shown in Table 1) was added gradually. Triethyl amine (0.05 % based on epoxy resin weight) was added as a base catalyst. At a regular interval of time, a sample was withdrawn from the reaction mixture using a siphoning device and a test was performed for the negative epoxy group [43, 44]. When the sample showed the negative test for the epoxy group, reaction was stopped and the product was allowed to cool at room temperature. The resultant products were designated as castor oil –epoxy resin (CEs) products. The varying type of mole ratios of castor oil(C): epoxy resin (E) used for the preparation of (CEs) and physical properties of the resulting products (CEs) are given in Table 1. Chemical properties of the products (CEs) are given in Table 2.

Table 1 Mole ratios of C: E and physical properties of CEs

Mole of reactant		Designation	Appearance	*Viscosity seconds	Specific gravity gm/ml
Castor oil (C)	Epoxy resin(E)				
0.268	0.134	CE-1	Pale yellow and clear	135	0.98
0.268	0.268	CE -2	Pale yellow and clear	240	1.01
0.268	0.402	CE- 3	Pale yellow and clear	N/A**	1.05

**Viscosity time was measured using ford cup type B – IV at 30 ^{o}C*
*** N/A not analyzed*

Table 2 Chemical properties of CEs

Type of CEs	Hydroxyl number	Hydroxyl value mg KOH/ gm	% Hydroxyl	Number of unsaturation Per molecule
CE -1	3	145	4.56	2
CE -2	3	130	3.89	2
CE -3	3	113	3.37	2

Preparation of Unsaturated Polyester Resins Based on (Maleated / Tetrahydrophthalated CHF Resin-Epoxy Resin)

These resins were prepared in our previous work as follows [45]:

Equal molar of each of the two CHF resins and maleic anhydride (MA) or tetrahydrophthalic anhydride (THPA) in pyridine (Py) was refluxed at (~120 ^{o}C) for three hours, the ratio of anhydride to Py was kept at 1:3.The mixture was cooled and poured in cold water. Then precipitate was dissolved again in methanol and re precipitated by adding water. The precipitate was dried at 105 ^{o}C in a vacuum oven. The modified CHF resins which are based on CHF resin of 300 and 235 OHV and MA are designated as maleated cyclohexanone formaldehyde resin (MCHF) M_a and M_b and those which are based on THPA are designated as tetrahydrophthalated cyclohexanone formaldehyde resin (PCHF) P_a and P_b respectively .Then a stiochiometric amount of DGEBA epoxy resin was added to a well stirred solution of each (M_a, $M_{b,}$ P_a, $P_{b)}$ (0.5 mole) in THF and mixed well by vigorous agitation. Then pyridine (8 % of total weight) was added as a catalyst. The resulting mixture was heated to 85 ^{o}C with continuous stirring. Sample was taken at regular intervals to check the acid value. The reaction was continued until the acid value fell below 55mg KOH/gm. All the four unsaturated polyester resins (UPE) were obtained in the form of solid mass, and designated as maleated unsaturated polyester resins ($M_{a,b}$UPE which are based on M_a, M_b respectively) and terahydrophtalated unsaturated polyester resins ($P_{a,,b}$UPE which are based on P_a, P_b respectively).

Preparation of Alkyd – CEs –UPE Blends

To achieve the desired results of solvency, evaporation, several combinations of solvents were tried. The solvent system that produced a one – phase clear solution and a clear coat of the binder system was as follows: 50 % THF, 40 % cyclohexanone, and 10 % toluene by volume) .So the prepared UPE resin was dissolved in the above solvent system to prepare 50 % solutions of resin which was then utilized to prepare alkyd - CEs –UPEs.

In a three-necked round-bottom flask equipped with a mechanical stirrer, alkyd resin was charged and stirred for 5 min. Under continuous stirring, the desired amount of specific CEs was added, and mixing allowed for 15 min. Solution of UPE resin thus prepared, was then slowly added to CE-alkyd mixture with continuous stirring. Upon completion of the addition of UPE resin solution, the final alkyd- CE -UPE mixture was stirred for 30 min to have a homogeneous mixture. After stirring, the mixture was kept in a cylindrical glass container overnight to check for any tendency of separation of layers. In neither case separation of distinct layers was observed. The proportions of alkyd- CEs -UPE blends along with designations are given in Table 3 and 4.

Table 3 Proportion of alkyd – CEs- $M_{a,b}$ UPE blends

Type of CE	Weight of alkyd resin gm	Weight of CE gm	Weight of $M_{a,b}$UPE gm	Designation
CE-1	100	10	10	M_aUPE-101
	100	10	10	M_bUPE-101
	100	10	20	M_aUPE-201
	100	10	20	M_bUPE -201
	100	10	30	M_aUPE-301
	100	10	30	M_bUPE-301
CE-2	100	10	10	M_aUPE-102
	100	10	10	M_bUPE-102
	100	10	20	M_aUPE-202
	100	10	20	M_bUPE-202
	100	10	30	M_aUPE-302
	100	10	30	M_bUPE-302
CE-3	100	10	10	M_aUPE-103
	100	10	10	M_bUPE-103
	100	10	20	M_aUPE-203
	100	10	20	M_bUPE-203
	100	10	30	M_aUPE-303
	100	10	30	M_bUPE-303

Preparation of Coating Composition Based on Alkyd- CEs –UPE Blends

To study the film properties of alkyd-CEs-UPE blends, the coating compositions of various blends were prepared in the following manner:

50.0 g of the desired blend was taken in a 250 ml glass beaker. The driers lead octoate (18% Pb), cobalt octoate (6% Co) and manganese octoate (6% Mn) were added to it in the proportions of 0.5, 0.05, and 0.05 %, respectively. The resultant blends of alkyd-CEs-UPE resins were diluted with the above solvent mixture to obtain a viscosity appropriate for application with a brush on clean mild steel panels.

Table 4 Proportion of alkyd – CE s- $P_{a,b}$ UPE blends

Type of CE	Weight of alkyd resin gm	Weight of CE Gm	Weight of $P_{a,b}$ UPE gm	Designation
CE-1	100	10	10	P_aUPE-101
	100	10	10	P_bUPE-101
	100	10	20	P_aUPE-201
	100	10	20	P_bUPE -201
	100	10	30	P_aUPE-301
	100	10	30	P_bUPE-301
CE-2	100	10	10	P_aUPE-102
	100	10	10	P_bUPE-102
	100	10	20	P_aUPE-202
	100	10	20	P_bUPE-202
	100	10	30	P_aUPE-302
	100	10	30	P_bUPE-302
CE-3	100	10	10	P_aUPE-103
	100	10	10	P_bUPE-103
	100	10	20	P_aUPE-203
	100	10	20	P_bUPE-203
	100	10	30	P_aUPE-303
	100	10	30	P_bUPE-303

Panel Preparation

The mild steel panels were first degreased in alkali solution and subsequently swabbed with xylene to remove any type of oily material or contaminant. After the xylene has evaporated, panels were burnished with emery paper as per Indian Standards [46]. Panels were again washed with xylene after burnishing to remove any trace of emery paper particles or metal particles. As soon as the panels were dry, coatings were applied on them without any delay.

Film Characterization

The coated panels were examined for drying time, adhesion test, flexibility test, scratch hardness, pencil hardness, impact resistance and chemical resistance by standard methods. The results are given in Tables 5- 10 respectively.

Determination of Drying Time

Mild steel panels were used to determine the air-drying time of films of various coats [47]. The panels were prepared in the above manner and coating compositions were applied. The films were checked for ‘‘surface dry’’ and ‘‘tack-free dry’’ stages at regular intervals of time. While moving the finger on the film without applying any pressure if impression of fingerprint is not observed on the film, it was said to be ‘‘surface dry’’ .If the thumb is pressed on the film and twisted with applying some pressure and yet no thumb impression or detachment of film is observed then it was said to be “tack – free dry”. The results are given in Tables 5 and 6.

Determination of Adhesion

Adhesion of films to substrate was determined by employing cross-hatch adhesion test according to ASTM D-3359 and panels for the test were prepared in the manner described above. Cross-hatch adhesion test was carried out after 168 hours of coating application.

By using a sharp - edged knife, 10 parallel lines 1mm apart from each other were drawn on the film. Another set of such lines at right angles of 90 ^{o} to previous lines was superimposed to give a pattern of squares consisting of 100 squares with each square having 1 mm side length. A self - adhesive tape was stuck over the square pattern in such a way that no air is present between tape and film. Intimate contact between tape and film was ensured by pressing the tape over the length with fingers. The tape was kept in contact for 10 seconds and then the tape was rapidly pulled off in a single stroke at an angle of 120 ^{o} approximately. The test was rated “passed” if not more than 5% of squares were removed. The results of cross-hatch adhesion test are given in Tables 5 and 6.

Determination of Flexibility

For the determination of flexibility [48], tinned mild steel panels were used. The coating compositions were applied and cured in the manner mentioned above. Flexibility test were carried out using mandrels having specific rod diameter. A test panel was inserted between the hinges and rod in such a way that the coated side was kept outside to the direction of bending. The hinge was closed at a single stretch without jerking in about a second causing the test panel to bend through an angle of 180^{o}. The panel was examined for presence of cracks or loss of adhesion without removing the panel from the mandrill. Generally 1/4 inch rod diameter mandrel was used and if film passed through 1/4 inch mandrel then it was said to pass the flexibility test. The results of flexibility test are given in Tables 5 and 6.

Determination of Hardness

Hardness of films of various alkyd- CEs – UPE Blends were determined using tinned mild steel panels after 168 hours of coating application . Two different methods were used to determine the hardness.

- **Scratch Hardness**

In first method [49], a hand operated instrument was used in which test panel was kept on a sliding base with coated side upward and scratched under specific load with a needle which was in contact with film on test panel. The load was kept increasing till the film was scratched which was indicated by a light bulb that glows when film is scratched. The results were expressed in (Kg) corresponding to the load at which film is scratched.

- **Pencil Hardness**

In this method [50], pencils having different hardness were used.Sharp tipped pencils having hardness 4B (soft) and 6H (hard) were used to scratch the film. The pencil was held approximately at an angle of 45^{o} to the film and with uniform pressure pulled down over the length of the film. The test was repeated till a pencil with specific hardness was able to scratch the film. The hardness of that pencil was reported as the pencil hardness test. The results of hardness determination are given in Tables 7 and 8.

Determination of Impact Resistance

The coated test panels for the impact resistance test were prepared in the manner described above. The test was carried out after 168 hours of coating application. The coated panel was kept on a platform with the coated side upward. The panel was then indented with an object of specific weight from varying heights. The test was repeated by increasing the height from which the object falls till the film was cracked or detached. The results are generally expressed in (in. Ib) i.e. the number of inches the weight falls times its weight [51]. The results of impact tests are reported in Tables 5.7 and 5.8.

Determination of Chemical Resistance Properties

For the assessment of chemical resistance of the films to various chemicals [52], tinned mild steel panels were used which were prepared, coated and cured as mentioned above. Before subjecting the test panels to chemical resistance test, the backside of coated panel (i.e. the non coated side) was coated with epoxy resin and cured at room temperature for 48 hours. Subsequently all the four edges of the panel were sealed with paraffin wax by dipping approximately 1 cm of each side in molten wax and cooling at room temperature to form a 1 cm thick impervious and continuous layer of wax.

When the panels were subjected to solvent resistance test particularly, the edges of the panel were sealed with epoxy resin cured at room temperature for (48 hrs.) instead of wax.

The immersion method was utilized to asses the chemical resistance of films in which the panels were immersed vertically in the baths containing solutions of different chemicals in specific concentration at room temperature for the specific time period. Upon completion of the specified time period the panels were removed from the baths and allowed to dry before visual examination. The following solutions with their respective concentrations were used for chemical resistance test:

(1) For acid resistance : 5% H Cl solution
(2) For alkali resistance : 3% Na OH solution
(3) For water resistance : Distilled water
(4) For solvent resistance : xylene

The results of chemical resistance test are furnished in Tables 9 and 10.

RESULTS AND DISCUSSION

The results of evaluation of films properties of alkyd – CE –UPE blends are shown in Tables 5 - 10. For sake of the convenience, the amount of CEs was kept constant for all the blends (Tables 3 and 4). The prime concern is to study the effect of UPE resins on properties of alkyd - CEs blends, so amount of UPE resins was varied keeping the amount of CEs constant.

Viscosity of various CEs was measured using Ford cup B IV at ambient room temperature (30 ^{0}C) and flow time was reported in seconds as a measure of viscosity. In case of CE -3, the sample was much viscous and so the viscosity could not be measured accurately with Ford cup B-IV.

From Table 1, we can say that the viscosity of CEs increases as the mole ratios of epoxy resin increases. Specific gravity of CEs increases as the amount of epoxy resin increases in CEs. From Table 2, it is evident that the number of hydroxyl groups in all three CEs is 3, but hydroxyl value and % hydroxyl decreases as the mole of epoxy resin increases. From the unsaturation test it is clear that the number of unsaturation per molecule in each CE is 2, as in castor oil. It means that the reaction of epoxy resin has not occurred at the double bonds of castor oil.

Table 5 Properties of films prepared from alkyd –CEs - $M_{a,b}$ UPE blends

Designation	Drying time in minutes		Adhesion	Flexibility
	Surface dry	Tack-free dry		
M_aUPE-101	81	241	P	P
M_bUPE-101	83	244	P	P
M_aUPE-201	66	216	P	P
M_bUPE -201	68	217	P	P
M_aUPE-301	54	194	P	P
M_bUPE-301	57	196	P	P
M_aUPE-102	54	211	P	P
M_bUPE-102	57	215	P	P
M_aUPE-202	51	196	P	P
M_bUPE-202	54	199	P	P
M_aUPE-302	41	180	P	P
M_bUPE-302	43	182	P	P
M_aUPE-103	55	212	P	P
M_bUPE-103	57	215	P	P
M_aUPE-203	41	192	P	P
M_bUPE-203	44	196	P	P
M_aUPE-303	30	170	P	P
M_bUPE-303	33	173	P	P

Table 6 Properties of films prepared from alkyd –CEs - $P_{a,b}$ UPE blends

Designation	Drying time in minutes		Adhesion	Flexibility
	Surface dry	Tack-free dry		
P_aUPE-101	79	240	P	P
P_bUPE-101	82	243	P	P
P_aUPE-201	63	215	P	P
P_bUPE -201	66	217	P	P
P_aUPE-301	52	191	P	P
P_bUPE-301	55	194	P	P
P_aUPE-102	52	209	P	P
P_bUPE-102	55	211	P	P
P_aUPE-202	48	193	P	P
P_bUPE-202	50	195	P	P
P_aUPE-302	39	178	P	P
P_bUPE-302	41	180	P	P
P_aUPE-103	51	208	P	P
P_bUPE-103	53	211	P	P
P_aUPE-203	38	189	P	P
P_bUPE-203	42	193	P	P
P_aUPE-303	28	168	P	P
P_bUPE-303	31	172	P	P

From the results given in Tables 5 and 6 it suggests that these films give good surface dry and good tack-free dry properties as well as good adhesion and flexibility. The drying time reduces on increasing the amount of UPE resin added. The good drying time can be attributed to the presence of carbonyl groups in the polymer backbone, which activate the methylene groups in the UPE resin. Therefore in the presence of suitable driers, the oxygen activation of the methylene group is further accelerated, which results in faster drying time. The drying time is further improved as the concentration of epoxy resin increases.

Table 7 Mechanical properties of films prepared from alkyd-CEs- $M_{a,b}$ UPE blends.

Designation	Scratch hardness Kg	Pencil hardness	Impact resistance Direct in.lb
M_aUPE-101	2.10	3H	130
M_bUPE-101	2.15	2H	125
M_aUPE-201	2.40	4H	135
M_bUPE -201	2.30	3H	130
M_aUPE-301	2.45	5H	150
M_bUPE-301	2.35	4H	145
M_aUPE-102	2.35	4H	130
M_bUPE-102	2.30	3H	125
M_aUPE-202	2.50	5H	150
M_bUPE-202	2.40	4H	145
M_aUPE-302	2.55	6H	165
M_bUPE-302	2.50	5H	160
M_aUPE-103	2.65	7H	150
M_bUPE-103	2.60	6H	145
M_aUPE-203	2.75	8H	170
M_bUPE-203	2.70	7H	165
M_aUPE-303	2.80	9H	200
M_bUPE-303	2.75	8H	195

Table 8 Mechanical properties of films prepared from alkyd-CEs- $P_{a,b}$ UPE blends

Designation	Scratch hardness Kg	Pencil hardness	Impact resistance Direct in. lb
P_aUPE-101	2.20	3H	135
P_bUPE-101	2.10	2H	130
P_aUPE-201	2.45	5H	140
P_bUPE -201	2.35	4H	135
P_aUPE-301	2.55	6H	155
P_bUPE-301	2.45	5H	150
P_aUPE-102	2.45	5H	135
P_bUPE-102	2.35	4H	130
P_aUPE-202	2.60	6H	155
P_bUPE-202	2.50	5H	150
P_aUPE-302	2.65	7H	170
P_bUPE-302	2.55	6H	165
P_aUPE-103	2.70	7H	155
P_bUPE-103	2.60	6H	150
P_aUPE-203	2.80	8H	180
P_bUPE-203	2.70	7H	175
P_aUPE-303	2.90	9H	210
P_bUPE-303	2.80	9H	205

Excellent scratch hardness was obtained from the films prepared from these blends (Tables 7 and 8). As the concentration of UPE resin increases, gradual increase in hardness is observed. Also the films show significant improvement in hardness in blends with higher epoxy content in CEs and higher concentration of UPE resin in alkyd – CE – UPE blends. This improvement can be attributed to excellent structural compatibility of components in the blend which form a crosslinked polymer. Pencil hardness and impact resistance were also good.

Chemical resistance tests of the films gave satisfactory results as shown in Tables 9 and 10, due to combination of individual properties of components. Each individual components of the blend shows good acid, alkali, solvent and water resistance and so the resistance of resultant blend is also improved.

It was observed that all films of resins based on CHF resin of 300 OHV exhibited better performance than those based on CHF resin of 235 OHV.This can be attributed to the fact that the higher hydroxyl values will give tighter, more cross-linked polymer, resulting in a harder coating film with greater chemical resistance. On the other hand all films based on tetrahydrophthalated CHF resins showed better performance than those based on maleated CHF resins due to the rigidity of cyclic ring system.

Table 9 Chemical resistances properties of films prepared from alkyd-CEs- $M_{a,b}$ UPE blends

Designation	Acid resistance 5% HCl 24 h	Alkali resistance 3% NaOH 2h	Water resistance (Dist. Water) 168 h	Solvent resistance Xylene 168 h
M_aUPE-101	2	3	1	2
M_bUPE-101	2	3	1	2
M_aUPE-201	3	4	2	2
M_bUPE -201	3	4	2	2
M_aUPE-301	4	4	3	3
M_bUPE-301	4	4	3	3
M_aUPE-102	3	4	3	3
M_bUPE-102	3	4	3	3
M_aUPE-202	4	4	3	4
M_bUPE-202	4	4	3	4
M_aUPE-302	4	5	4	4
M_bUPE-302	4	5	4	4
M_aUPE-103	4	4	4	4
M_bUPE-103	4	4	4	4
M_aUPE-203	5	5	4	5
M_bUPE-203	5	5	4	5
M_aUPE-303	5	5	5	5
M_bUPE-303	5	5	5	5

**0 = film completely removed.*
**1 = film removed and particularly cracked.*
**2 = film partially cracked.*
**3 = loss in gloss.*
**4 = slight loss in gloss.*
**5 = film largely unaffected.*

Table 10 Chemical resistances properties of films prepared from alkyd-CEs- $P_{a,b}$ UPE blends

Designation	Acid resistance 5% HCl 24 h	Alkali resistance 3% NaOH 2h	Water resistance (Dist. Water) 168 h	Solvent resistance Xylene 168 h
P_aUPE-101	2	3	1	2
P_bUPE-101	2	3	1	2
P_aUPE-201	3	4	2	2
P_bUPE -201	3	4	2	2
P_aUPE-301	4	4	3	3
P_bUPE-301	4	4	3	3
P_aUPE-102	3	4	3	3
P_bUPE-102	3	4	3	3
P_aUPE-202	4	4	3	4
P_bUPE-202	4	4	3	4
P_aUPE-302	4	5	4	4
P_bUPE-302	4	5	4	4
P_aUPE-103	5	5	4	5
P_bUPE-103	5	5	4	5
P_aUPE-203	5	5	4	5
P_bUPE-203	5	5	4	5
P_aUPE-303	5	5	5	5
P_bUPE-303	5	5	5	5

**0 = film completely removed.*
**1 = film removed and particularly cracked.*
**2 = film partially cracked.*
**3 = loss in gloss.*
**4 = slight loss in gloss.*
**5 = film largely unaffected.*

CONCLUSION

Room temperature curing composition can be prepared easily and give satisfactory results. Castor oil and epoxy resin reaction products upon blending with resins like alkyd and UPE resin (based on maleated / tetrahydropthalated cyclohexanone formaldehyde resin) give good mechanical and chemical properties. All films based on CHF resin of 300 OHV exhibited better performance than those based on CHF resin of 235 OHV. Films based on tetrahydrophthalated CHF resins showed better performance than those based on maleated CHF resins.

REFERENCES

[1] B. P. Mallik, *Paintindia*, Exhibition Special Issue, *21–23* February, **2002**, 35-46.
[2] G.Gamze,*Polymer Bulletin*,**2010**, 64 (8), 739-748 .
[3] J. E. Vitela and E. Nahmad-Achar, *JCT Research*, **2006**, 3, (2), 141-149.
[4] V.C.,Karandikar ,*Paintindia*,**2006**, 2, 55–74 .
[5] V.Atimuttgul; S. Damrongsakkul and W.Tanthapanichakoon , *Korean J. Chem. Eng.,***2006**, 23(4),672-677.
[6] J.G.Tsavalas , Y.Luo , F.J.Schork , *J. Appl. Polym. Sci.*, **2003**, 11, 1825–1836.
[7] L. Hudda , J.G. Tsavalas , F.J.Schork , *Polymer*,**2005**, 4 , 993– 1001 .
[8] J.G.Tsavalas , Y.Luo , L.Hudda , F.J.Schork , Polym. React. Eng.,**2003**, 3, 277–304 .

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[9] E.U. Ikhuoria, M.Maliki, F.E.Okieimen, A.I.Aigbodion, E.O. Obaze and I.O.Bakare, Progress in Organic Coatings ,2007,59(2), pp.134-137 .

[10] R. Z. Radicevic and J. K.Budinski-Simendic, J. Serb. Chem. Soc.,2005, 70(4), pp.593-599.

[11] M. C.Jovii, R. Radievi and J. K.Budinski-Simendi, *Journal of Thermal Analysis and Calorimetry*, *2008*, 94 (1), 143–150.

[11] V. Shukla , *Pigment & Resin Technology* , **2006**,35(6), 353 -357 .

[12] M.Nematollahi ; M. Heidarian ;M. Peikari ; S.M.Kassiriha ; N.Arianpouya and M. Esmaeilpour ,*Corrosion Science*, **2010**, 52 (5), 1809-1817 .

[13] [14] P. Bajpai ; M.Bajpai ;*Pigment & Resin Technology* ,**2010**,39(2), 96-100.

[14] [15] S. Bahadoorsingh ; S.M. Rowland ,*IEEE Transactions on Dielectrics and Electrical*

[15] *Insulation*, **2010**, 17 (3), 701-708.

[16] Bal Smrutisikha. *Materials and Design*,**2010**, 31(5), 2406–2413.

[17] J. Zang , Q.Guo, B. L. Fox , *Composite Science and Technology*,**2009**, 69(7- 8), 1172-1179.

[18] Y. Qing;W.Zhou ; S.Jia ; Fa Luo and D. Zhu , *Journal of Materials Science*, **2010**,45 (7), 1885-1888 .

[19] L.Chen; Y.Duan; L.Liu; J.Guoand S.Liu, *Materials and Design*, **2011**, 32(2), 570-574.

[20] V.Morote-Martinez ; V.Pascual-Sanchez ; J.M. Martin-Martinez , *European Polymer Journal* , **2008**,44 (10) , 3146-3155.

[21] J.M. Ferreira ; O.A.Z.Errajhi ;M.O.W. Richardson ,*Polymer Testing* ,**2006**, 25 (8), 1091-1094.

[22] A.Nebioglu ; M. D.Soucek ,*Journal of Coatings Technology and Research*, **2006**, 3(1), 61-68.

[23] R. R.Thomas ; D. F.Glaspey ; D. C. DuBois ; J. R.Kirchner ; D.R.Anton, K. G.Lloyd ; K. M.Stika , *Langmuir , the ACS journal of surfaces and colloids*,**2000** ,16 (17), 6898-6905 .

[24] N. Azcan; E.Demirel; O.Yılmaz; A. T. Erciyes,*Industrial & Engineering Chemistry Research*,**2011**, 50 (1) ,398-403 .

[25] S.Chen ; Q.Wang ;T.Wang ; X.Pei , *Materials and Design*,**2011**, 32(2), 803- 807 .

[26] N. Weber ; K.Vosmann; E.Fehling ; K. D.Mukherjee ;D., J. Bergenthal, *Am. Oil Chem. Soc.*,**1995**, 72 (3), 361-368 .

[27] Y. Sheng Hu; Y. Tao, and C. Pu Hu. *Biomacromolecules* ,**2001**, 2, 80-84.

[28] M. M.Conceicao ; R. A.Candeia ; F. C. Silva ; A. F Bezerra .; V. J. Fernandes Jr.; A. G. Souza, *Renewable Sustainable Energy Rev*., **2007**,11, 964– 975.

[29] S. Nlvea de Lima da; B. B.Cesar ; M. F. Rubens and R. W. M. Maria, *Energy Fuels*, **2009**, 23 (11), 5636–5642.

[30] V.M.L.Dos Santos ; J.A.B.da Silva ;L.Stragevitch ; R.L. Longo; *Fuel*, **2011**, 90 (2), 811-817.

[31] H. F. Mark ,Encyclopedia of polymer technology, Ketone polymers 3rd Edition **2003** , 678

[32] V.Athawale and N. J.Shetty ,*Paintindia*,**2009**, LIX (2), 75-106.

[33] H.Heinz; R.Dhein; K.Stahlke, EP 473, 034. *Chem. Abstr*. 117: 9175_e,1992.

[34] W.Druschke , G.Heil, H. Buensch H.Jaeger, DE 3, 208, 217. *Chem. Abstr*. $100:35520_e$,**1984.**

[35] K .Ebisawa; K.Hashitani, JP 74 33,331 *Chem. Abstr*.82: $P100278_h$,**1975**.

[36] T. Takayanagri ; S.Ooyama , JP 0848,927. *Chem. Abstr*. $124:346244_v$,**1996**.

[37] H.Ueda ; M.yokoi ; Y.Okuda, EP 691,387. *Chem. Abstr*. 124: 205238_j ,**1996** .

[38] G.Moltrasio, EP 432,480 *Chem. Abstr*.$115:210284_q$,**1996** .

[39] J.Bognar ; L.Kovacs, L.Szabo; HU patent 55,420 , **1991**.
[40] J. Bognar ; L.Kovacs ; L.Szabo; HU patent 55,421 ,**1991** .
[41] V. D.Athawale and A.V. Chamankar, , *JAOCS*, **1998**,75(7), 887-889 .
[42] H.S.Patel; B. K.Patel; K. B Patel. and S. N.Desai, *IJPM*,**2010**, 59(1), .25-32 .
[43] W. J. Roof, J. R. Scott and J.Pacitti, "Fibers, Films , Plastics and Rubbers, a Handbook of Common Polymers". Butterworths &Co. Publishers Ltd., London, **1971**, 269.
[44] S.Bance, "Handbook of practical organic microanalysis, recommended methods for determining elements and groups". 1st Ed. New York, John Wiley and Sons, **1980**, 151-160.
[45] H.S.Patel and A.M.Naji, *International Journal of Plastics Technology*,**2010**, 14(1),17-37.
[46] IS: 197 -1969, Methods of sampling and tests for varnishes and lacquers (1st Rev.), Indaian Standard institution, New Delhi, **1989**.
[47] ASTM D 1640-83, American Society for Testing and Materials, Philadelphia, Pa., 06.03, **1994**.
[48] ASTM D 522- $93_{a,}$ American Society for Testing and Materials, Philadelphia, Pa., 06.03, **1994**.
[49] W. M.Morgan, "Outlines of Paint Technology'', CBS Publishers and Distributors (New Delhi, India), **1996**, 436 .
[50] LB Odell, Encyclopedia of Industrial Chemical Analysis, Enamels, Edited by Foster Dee Snell and Leslie S. Ettre, Interscience Publishers a division of John Wiley and Sons, Inc. United States of America, 12, **1971**, 170 – 192.
[51] R.Lambourne, "Paint and Surface Coatings: Theory and Practice'', Ellis Horwood Ltd., Chichester, **1987**, 672.
[52] ASTM D 1647- 89, American Society for Testing and Materials, 06.03,**1994**.