International Journal of Chemical Studies

P-ISSN2349–8528
E-ISSN 2321–4902
IJCS 2015; 3(2): 116-119

Received: 10-06-2015
Accepted: 08-07-2015

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Polyurethane Surface Coatings derived from (Rosinified phenolic resin-Coconut alkyd resin) blends with Aliphatic and Aromatic Diisocyanates

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Abstract
In recent years an increasing interest is observed in the development of more environment friendly paints and coatings. This paper discusses advances in the use of renewable resources in formulations for various types of coatings. In this contest, polyurethane prepolymers were synthesised from coconut oil based alkyd resin and rosinified phenolic resin as polyol with aromatic and aliphatic diisocyanates by varying NCO/OH mole ratio. The effect of NCO/OH mole ratio on the structure and properties of these polyurethanes were characterized by physico-mechanical and chemical resistance properties of the coated panels.

Keywords: Polyurethane surface coating, Coconut alkyd resin, rosinified phenolic resin, Isophorone Diisocyanate (IPDI), Toluene diisocyanate (TDI), Coating

1. Introduction

Alkyd resin is a prime candidate for the surface coating material because alkyds are relatively inexpensive in terms of raw materials and manufacturing costs. Alkyd resins are compatible with most substances used in surface coating industries and hence they can be easily modified for special applications. Other polymers may offer better properties in some specific area of application but alkyds have widest range of acceptable properties in terms of surface coating Usage along with coat and versatility. It is generally manufactured from phthalic anhydride, polyol and drying oils. In order to improve properties of alkyd resins, modification with various other materials is the best method. These other materials, used for the modification may be present in physical or chemical combination. Modification of alkyd resin with cellulose nitrate gives fast-drying, modification of alkyd resin with chlorinated rubber gives good fire-resistance property. Alkyd resin is also used in number of applications [1-4].

Some research publications show that phenolic resins have been used to in direction [5-8]. While, the reports show that phenolics based polyurethanes are used for other application [9-23]. The modified phenolic by rosin (RPR) has attained the application of coating [24].

In the present work, polyurethanes are synthesised using rosinified phenolic rein (RPR), Coconut alkyd resin (CAR) reacted with Isophorone Diisocyanate (IPDI) and Toluene Diisocyanate (TDI) to get the transparent polyurethane coating.

2. Materials

Hydroxy terminated alkyd resin (-OH value 130 mg KOH/gm) as polyol was purchased from Reliable Paints, Makarpura G.I.D.C., Vadodara. Rosinified Phenolic Resin (RPR) was purchased from local market. Dibutyltin dilaurate (DBTDL) used as a catalyst which was purchased from himedia. Toluene diisocyanate (TDI) and Isophorone diisocyanate (IPDI) were purchased from bayer co., (Berlin, Germany). Xylene used as a solvent was purchased from the S.d. fine chemical limited, (Mumbai). All the reagents were used as received without further purifications.

2.1 Preparation of CAR-RPR Blends

The blending process carried out an earlier publication [25, 26]. The physical properties of resultant different percentage composition blends (CAR-RPR) are given in Table -1.

Table 1: Physical Properties of RPR and CAR blends

Sr. No.	Composition CAR+ RPR	OH Value in mg of KOH/gm	Colour	Moisture content, %
C1	40:60	105	Pale yellow	0.042
C2	50:50	87.5	Pale yellow	0.031
C3	60:40	70	Pale yellow	0.052

2.2 Synthesis of polyurethane

The polyurethane preparation process carried out an earlier publication [25, 26].

Table 2: PU Compositions Based on (CAR-RPR) Blends for TDI and IPDI (Weight of Diisocynates/10gm of polyol):-

Sr. No.	Composition CAR+RPR	IPDI		TDI	
		I1	I2	T1	T2
C1	40:60	4.360	5.232	3.900	4.680
C2	50:50	5.400	6.480	4.900	5.880
C3	60:40	6.660	7.992	5.940	7.128

Table 3: Properties of Films Prepared from PU Compositions Based on (CAR-RPR) Blends with TDI and IPDI

Polyurethane code	Drying time in minutes		Cross-hatch Adhesion	Flexibility
	Surface dry	Tack-free dry		
C1PUI1	144	220	VG	P
C2PUI1	139	215	VG	p
C3PUI1	134	209	EX	p
C1PUI2	140	216	EX	P
C2PUI2	135	207	VG	P
C3PUI2	129	196	VG	P
C1PUT1	56	108	VG	P
C2PUT1	49	102	G	P
C3PUT1	45	95	G	F
C1PUT2	52	101	VG	P
C2PUT2	45	96	EX	P
C3PUT2	41	89	VG	F

P=Pass, F=Fail, Ex-Excellent, VG-Very Good, G-Good

Table 4: Mechanical Properties of PU cured coating from (CAR-RPR) blends with TDI and IPDI

Polyurethane Code	Scratch hardness in gms.	Pencil hardness	Impact resistance in·lb
C1PUI1	1820	2H	159
C2PUI1	2124	3H	169
C3PUI1	2372	3H	178
C1PUI2	2014	3H	165
C2PUI2	2262	4H	171
C3PUI2	2474	5H	182
C1PUT1	3010	4H	245
C2PUT1	3305	5H	256
C3PUT1	3510	4H	278
C1PUT2	3260	5H	262
C2PUT2	3475	5H	270
C3PUT2	3650	5H	285

6H>5H>4H>3H>2H>1H>H>HB>1HB>2HB>3HB>4HB>5HB>6HB

Table 5: Chemical Properties of PU curd coating from (CAR-RPR) blends with TDI and IPDI

Polyurethane code	Acid resistance 5% HCl 24 hrs.	Alkali resistance 3% NaOH 2 hrs.	Water resistance (Dist. Water) 168 hrs.
C1PUI1	3	3	4
C2PUI1	3	4	5
C3PUI1	4	5	5
C1PUI2	4	4	4
C2PUI2	5	5	5
C3PUI2	5	4	5
C1PUT1	4	5	4
C2PUT1	4	5	5
C3PUT1	5	4	5
C1PUT2	5	4	5
C2PUT2	5	5	5
C3PUT2	5	5	4

0	Film completely removed	3	Loss of gloss
1	Film cracked and partially removed	4	Slight loss of gloss
2	Film partially cracked	5	Film Practically affected

2.3 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 from the surface. After xylene has been evaporated the panels were coated by the above prepared coating composition.

2.4 Film Characterization

The coated panels were examined for drying time, adhesion test, flexibility test, scratch hardness, pencil hardness, impact resistance and chemical resistance properties by standard methods. The results are given in Tables 3, 4 and 5 respectively.

2.5 Determination of Drying Time

The mild steel panels were used to determine the air drying time of films of various blends. The panels were prepared in a similar manner written above and coating compositions were applied. The films were checked for 'surface dry' and 'tack-free dry' stages at regular interval of time. The results of drying time determination are given in Table 4.

2.6 Determination of Adhesion Test

Adhesion of films were determined by employing cross-hatch adhesion test and panels for the test were prepared exactly in a similar manner to that of drying time determination test. Cross-hatch adhesion test was carried out after 168 hour of coating application. Adhesion test was carried out using reported method [19]. The results are given in Table 4.

2.7 Determination of Flexibility

For the determination of flexibility, mild steel panels were used. The coating compositions were applied and cured in the same manner as mentioned above. Flexibility test were carried out using mandrels having specific rod diameter. Generally 1/8 inch rod diameter mandrel was used and if film passed through 1/8 inch mandrel then it was said to be passed for the flexibility test. The results are given in Table 4.

2.8 Determination of Scratch Hardness
In this method, 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 was scratched. The results are given in Table 5.

2.9 Determination of Pencil Hardness
In this method the use of pencil having different hardness are 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 45o 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 and hardness off that pencil was reported as the pencil hardness test. The results are given in Table 5.

2.10 Determination of Impact Resistance
The coated test panels for impact resistance test were prepared in the same manner as described above. The test was carried out after 168 hour of coating application. The coated panel was kept on a platform (coated side upward). The panel was then indented with an object of specific weight from the 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 given in Table 5.

2.11 Determination of Chemical resistance properties
The assessment of chemical resistance of the films to various chemicals, mild steel panels were used which were prepared, coated and cured as mentioned above. The immersion method was utilized to assess the chemical resistance of films in which the panels were immersed vertically in the baths containing solutions of different chemicals with 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 results of resistance against chemicals are given in Table 6.

3. Result and Discussion
The drying time of films based on PU compositions is much lower than that of CAR-RPR blends. This can be attributed to presence of urethane linkages which is known for the fast drying characteristic [20]. Comparison of drying time of PU films based on TDI and IPDI shows that the PU films based on TDI have higher drying time than PU films based on IPDI. This can be due to structural difference in both isocyanates; TDI is aromatic while IPDI is aliphatic. Also, results of adhesion test and flexibility suggest that, these films give good adhesion and flexibility. Flexibility of all the films was measured by using 1/8” mandrel as per ASTM D 622. Excellent scratch hardness was obtained from the films, prepared from these blends. The pencil hardness and impact resistance are also good for such kind of films. Chemical resistance properties of all the films give satisfactory results.

4. Conclusion
From the results presently discussed it can be concluded that room temperature curing composition can be prepared easily and give satisfactory results. Drying time of films based on TDI shows faster drying than compared to PU films based on IPDI. PU films based on TDI shows improved scratch hardness than PU films based on IPDI. Also results of scratch hardness, pencil hardness and resistance against chemicals are higher in case of PU films prepared from TDI as compared with PU films prepared from IPDI.

5. Acknowledgement
Authors thankful to Head, Department of chemistry, Sardar Patel University for providing research facilities.

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