Developing Good Formulation of Medium Oil Alkyd Resin Using Soybean Oil

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ABSTRACT

This paper presents the results of three formulations A, B and C of medium oil alkyd resin (MOAR) using soybean oil by the method of alcoholysis. The aim was to obtain a formulation that would give good resin quality, combining low acid value, high viscosity with good Gardner's colour and stability. The equipment used was polyester Cook/reactor with a partial condenser using nitrogen for an inert gas sparge. From the results obtained, the formulation C gave the overall best result.

KEY WORDS: *Alkyd resin, Alcoholysis, Acid value, Viscosity.*

INTRODUCTION

Alkyd resins are synthetic polyesters made from the condensation reactions between poly basic acid and polyhydric alcohol in the presence of the oil-derived fatty acid. The presence of the oil confers good pigment wetting properties and when unsaturated allows coherent film to be formed on cure. The use of these vegetable oil-derived acids from linseed and soybean gives resins that are soluble in organic solvents which are used in the manufacture of paints and vanishes[1].

Medium oil alkyd resin (MOAR) is the type of resin with percentage oil content between 45% and 55%. In the method of alcoholysis, the oil is first reacted with glycerol to give a combination of mono- and di-glycerides that would take part in the polycondensation reaction. The idealized equation of the reaction between the soyabean oil and glycerol is shown below:

$$\begin{array}{l} CH_2-OH \\ | \\ 2CH-OH \end{array} + \begin{array}{l} CH_2-OOCR \\ | \\ CH-OOCR \end{array} \longrightarrow \begin{array}{l} CH_2-OOCR \\ | \\ 3CH-OH \end{array}$$

CH_2 - OH	CH_2 – OOCR	CH_2 - OH
Glycerol	Triglyceride	Monoglyceride

where R represents linolenic acid (the acid component of soyabean oil).

In practice, complete conversion to monoglyceride is not possible or necessary. Diglycerides and small amount of triglyceride can be accommodated provided that randomization can occur during the polycondensation stage[2].

Despite the fact that the production of alkyd resin had been on for some decades, there is still need to try new formulations in an effort to develop a better and cheaper resin. The availability of the results of new formulations is very useful to the manufacturers as they compare the results with the ones currently in use and look out for areas of possible improvements. The focus on soyabean oil was because it is relatively cheaper and easier to source than the linseed oil[3].

MATRIALS AND METHOD

The raw materials used include:

Soyabean oil
Glycerol, $C_3H_5(OH)_3$
Phthalic anhydride, $C_6H_4(CO_2)O$
Pentaerithritol (Tetramethyol methane), $C(CH_2OH)_4$
Lithium hydroxide, LiOH
Xylene (Dimethyl benzene), $C_6H_4(CH_3)_2$
Nitrogen gas, N_2

The weight percentages of the raw materials on the basis of 800g batch size is shown in Table 1.

The equipment used was a polyester reactor of capacity 5000 cm^3 with a partial condenser. The oil was first charged into reactor and heating started. A light sparge of nitrogen was introduced to generate positive inert pressure to prevent the ingress of air that would otherwise result in the decoloration of the product. At the temperature of 100°C, lithium hydroxide was sent in as a catalyst. Glycerine was charged in at the temperature of 200°C and the mixture heated to 260°C and maintained there for about 15 minutes for alcoholysis to take place. Tests for the production of monoglycerides and diglycerides were carried out at this stage using ethanol. When satisfied, the reactor was cooled to 255°C and pentaerythritol was charged in. Pentaerythritol provides hard film thickness and uniform drying for the resin. The contents were further cooled to 210°C and phthalic anhydride, benzoic acid and xylene introduced.

The phthalic anhydride acts as a viscosity binder and also as organic acid that reacts with glycerides to form the polyester resin. The benzoic acid is a chain stopper that prevents gelation[4], while xylene is the solvent that promotes reflux. As the xylene-water evaporation started, reflux of xylene alone was achieved by means of the partial condenser.

The viscosity and acid values tests were conducted hourly until the resin had esterified to the required extent. The solution viscosity is a measure of the increase in polymer size while the acid value is a measure of degree of esterification[5].

The refluxing stage was maintained at 225°C and the cooking was stopped after 8 hours.

RESULTS AND DISCUSSION

The various results obtained from the formulation A, B and C are shown in Table 2, 3 and 4; and Figures 1 and 2.

DISCUSSION

The characteristics of a good resin are its ability to combine low acid value with high viscosity. It should also have good stability and Gardner's colour. Consumers require non-acidic paints derived from alkyd resins of low acid value. High viscosity gives high yield in paint production on dilution with solvents. Also good Gardner's colour promotes glossiness.

From Table 4, formulation A has the lowest acid value but unfortunately, the lowest viscosity as well. The colour and stability are good. Formulation B has moderately good viscosity but the highest acid value (undesirable). It also has bad colour (G_{11} – G_{12}).

Formulation C has the modest low acid value and highest (best) viscosity. The stability and colour are also good.

Critical examination of the final results shows that formulation C has the best combination.

CONCLUSION AND RECOMMENDATION

With regards to the four most desirable properties of alkyd resin which include low acid value, high viscosity, good colour and stability, formulation C gave the best results.

However, where an acidic resin is very objectionable, then, formulation A may present the best choice in spite of its low viscosity which invariably means low yield.

It is recommended that more formulations with different variations should still be made with the aim of producing better results.

The stability of the samples should be monitored for longer time to check for deterioration.

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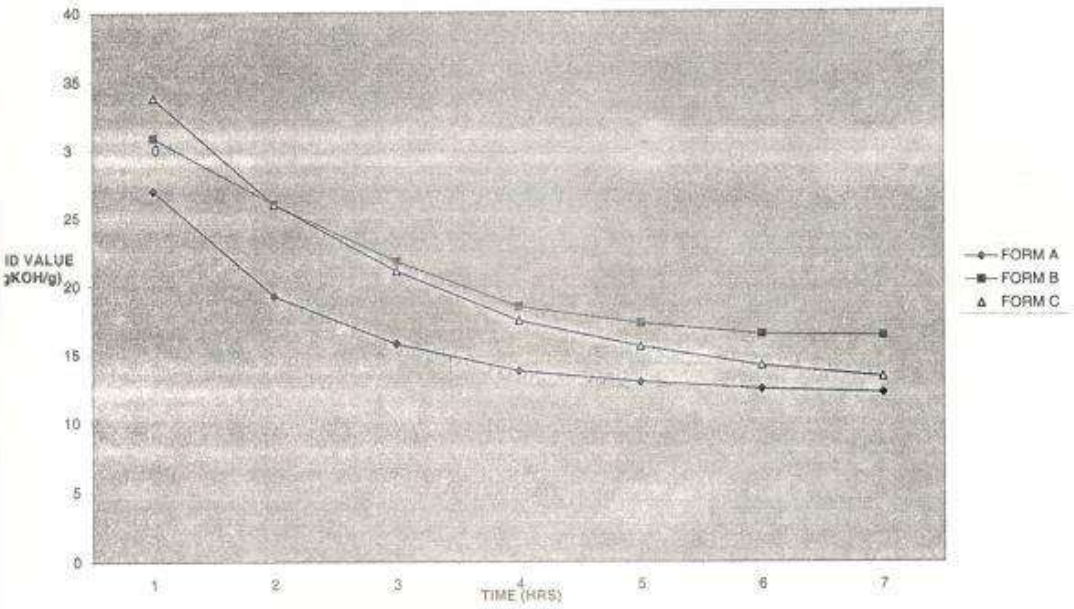

FIG. 1: VARIATION OF ACID VALUE WITH TIME

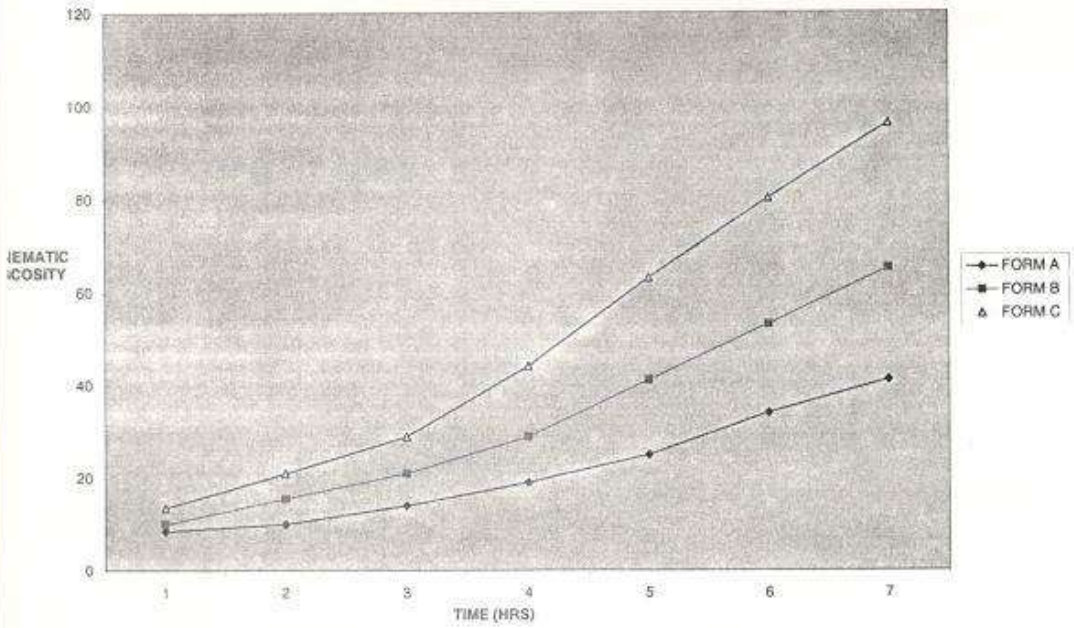

FIG. 2: VARIATION OF KINEMATIC VISCOSITY WITH TIME

TABLE 1: WEIGHT PERCENT FOR RAW MATERIALS IN THE FORMULATIONS

	WEIGHT PERCENT %		
	Formulation A	**Formulation B**	**Formulation C**
Soyabean Oil	51.38	50.38	49.13
Lithium hydroxide	0.025	0.025	0.020
Glycerol	12.87	12.45	14.50
Pentaerythritol	1.45	2.00	1.47
Phthalic anhydride	30.35	31.00	30.00
Benzoic acid	0.40	0.40	0.48
Xylene	3.525	3.745	4.40
Total	100	100	100

TABLE 2: VARIATION OF ACID VALUE WITH TIME

TIME HRS	ACID VALUE (mgKOH/g)		
	Formulation A	**Formulation B**	**Formulation C**
1	27.00	30.90	33.80
2	19.30	26.00	26.00
3	15.80	21.80	21.10
4	13.80	18.50	17.50
5	13.00	17.30	15.60
6	12.50	16.50	14.20
7	12.20	16.40	13.40

TABLE 3: VARIATION OF KINEMATIC VISCOSITY WITH TIME

TIME HRS	KINEMATIC VISCOSITY		
	Formulation A	Formulation B	Formulation C
1	8.5	10.0	13.5
2	10.0	15.5	21.0
3	14.0	21.0	29.0
4	19.0	29.0	44.0
5	25.0	41.0	63.0
6	34.0	53.0	80.0
7	41.0	65.0	96.0

TABLE 4: FINAL RESULT TABLE

PARAMETER	Formulation A	Formulation B	Formulation C
Acid Value mgKOH/g	12.0	16.5	13.0
Viscocity	43.0	72.0	105
Gardner's Colour	G5 – G6	G11 – G12	G5 – G6
Stability	Good	Good	Good