

Synthesis of Ecofriendly Detergent by Using White Dextrin Sorbitol Maleic Anhydride

B.B. GOGTE† and J.R. DONTULWAR*

*Department of Chemistry, Dr. C.V. Raman Institute of Technology
M.I.D.C., Hingna, Nagpur-400 016, India*

Esters of carbohydrates have been synthesized by using white dextrin, sorbitol, maleic anhydride. This resin has shown favourable data for detergent synthesis. The detergent prepared has shown appreciable reduction of surface tension of water at different concentrations. This is the exclusive characteristic of the surfactant to reduce the surface tension of water. At concentrations 0.33 g, 0.25 g and 0.2 g per 100 mL of water, the detergent has shown 56.16, 35.31 and 27.77% reduction in surface tension of water respectively.

Key Words: White dextrin, Sorbitol, Maleic anhydride, Hydrophilic-lipophilic balance, Surface tension.

INTRODUCTION

Maleic vinyl ether was the first polymer used as an additive in detergent formulation as anti-redeposition agent in 1975. In the last 25 years, there has been a systematic effort to produce low and zero phosphate detergents¹. The incorporation of polymers has a positive effect on the following performance features in detergents: calcium and magnesium sequestration; clay soil discrepancy and removal; calcium carbonate inhibition; prevention of soil redeposition and fabric anti-incrustation.

In the present work, novel resins based on white dextrin, sorbitol and maleic anhydride have been prepared and analyzed systematically for acid value, molecular weight, viscosity and other physico-chemical characteristics.

The determination of hydrophilic-lipophilic balance indicated the possibility of using this resin as an active replacement of linear alkyl benzene sulphonate in liquid detergent formulation. There is a global need to replace petroleum-based products with renewal vegetable based products. The use of novel resin will give superior eco-friendly products, which will reduce water pollution.

EXPERIMENTAL

A glass reactor fitted with stirrer, heating mantle and condenser has been used in the synthesis of novel polymers. The temperature control of 2°C can be

†Department of Oil Technology, Laxminarayan Institute of Technology, Nagpur, India.

achieved by using an efficient temperature regulator. A constant water supply through a condenser helps to control reactor temperature. Initially stoichiometric quantity of sorbitol, white dextrin and maleic anhydride was added in the reactor. Hydrochloric acid was used as a catalyst. Now about 200 mL of water was added so that a free flowing homogeneous paste was formed. The temperature was raised slowly and steadily in about 0.5 h to 120°C. The reaction was continued for 3.5 h till the desired molecular weight was achieved. The consistency of the paste was maintained by adding additional water after 0.5 h. At the end of this period the reaction was terminated and the prepared polymer was collected in a glass-stoppered bottle with least air gap. The final yield of the product was measured. The molecular weight of the polymer was determined by viscosity average method. This method depends upon the principle that the limiting viscosity number is proportional to the molecular weight. The molecular weight is related to limiting viscosity number (η), specific viscosity (η_{sp}) and ratio of amount of non-volatile to the amount of volatile (C) by the following equations:

$$\frac{\eta_{sp}}{C} = \eta + K'[\eta]^2\eta_{sp} \quad [\text{Suhulz-Blachkeel equation}]$$

$$\eta = K_s M \quad [\text{Suhulz equation}]$$

where K_s is the proportionality constant, which depends on polymer (non-volatile), solvent and temperature and M is the molecular weight of the non-volatile compound. Thus it is clear from the above equations that knowledge of K_s is required for calculating the molecular weight of the polymer. This can be done by calculating K_s from the known molecular polymer (reference polymer). We choose this method for calculating the molecular weight of our polymer. We take polyethylene glycol as a reference polymer of average m.w. 400. From this we calculate the constant and for confirmation of the constant we use polyethylene glycol having m.w. 3500–4000. By using this we got molecular weight nearly 3750. The operation was carried out in Redwood viscometer. The viscometer has a heating arrangement so that we can measure the viscosity at different temperatures. The temperature of operation and C (amount of non-volatile to amount of volatile compound) is selected in such a manner that the viscosity falls within measurable range (20–300 s).

Procedure

- Take the known molecular weight of sample. Mix the sample with suitable solvent in proportion to achieve the different non-volatile concentrations (like 70, 68, 66, 64, 62, 60).
- Measure the time of fall for each solute concentration for filling the 60 mL cup of Redwood viscometer at fixed temperature. Note this reading as η_c .
- Measure the time fall for solvent for filling the 60 mL cup of Redwood viscometer at fixed temperature. Note this reading as η_0 .
- Repeat step nos. 1 and 2 for unknown molecular weight sample.
- Calculate η_{sp} by using different η_c and η_0 by using the following formula:

$$\eta_{sp} = (\eta_c - \eta_0)/\eta_0$$

- Record the η_{sp} and η_{sp}/C for both the reference sample and an unknown molecular weight sample.
- Plot η_{sp}/C vs. η_{sp} for both reference and unknown sample. The y-intercept of this plot gives the limiting viscosity number (η).
- From the Suhulz equation calculate K_s , the proportionality constant from the reference sample. The calculated K_s is confirmed using another reference sample.
- Use the calculated K_s to calculate the molecular weight of unknown sample.

The acid value, sap value and other physico-chemical constants were determined (see Table-1)^{2,3}

TABLE-1
STOICHIOMETRIC PROPORTION FOR RESIN SYNTHESIS

S.No.	Raw material	(%)
1.	Sorbitol	53.84
2.	White Dextrin	30.76
3.	Maleic anhydride	15.38
4.	Water as solvent	700 ml (Total)

RESULTS AND DISCUSSION

Four different compositions of liquid detergent have been prepared based mainly on neutralized acid slurry, novel polymer, small quantities of urea, sodium lauryl ether sulphate (SLES), sodium lauryl sulphate (SLS), sodium tripolyphosphate (STPP), carboxy methyl cellulose (CMC), have been used in the composition. The level of sodium tripolyphosphate (STPP) has been maintained at the lower level of 5%. Normally we used 15–20% active material in liquid detergents. Here we have used only 10% of active material.

The method of determining saponification value has been modified for the polymer. Double concentration of alkali and reflux has been used to completely saponify the resin. Thus 100 mL of KOH has been used and the time of saponification is 2 h. The hydrophilic-lipophilic balance (HLB) value is based mainly on saponification value and acid value of original substance. The hydrophilic-lipophilic balance (HLB) of resin is 11.89, which suggests its use as active material for detergent. The saponification value and hydrophilic-lipophilic balance (HLB) value have been determined by standard methods. Formulae are as follows:

Saponification value

$$= (\text{mL of N/2 KOH consumed}/\text{weight of the resin taken in g}) \times 28$$

Hydrophilic-lipophilic balance (HLB)

$$= 20(1 - \text{saponification value of the resin}/\text{acid value of the raw product})$$

For HLB refer to Table-2.

TABLE-2

S.No.	Batch property/ Resin property	Observation
1.	Acid value of the resin	115.40
2.	pH value (by pH paper)	2.00
3.	Saponification value	156.24
4.	Solid (%)	62.00
5.	Yield of the resin (%)	53.84
6.	Acid value of the dextrin	0.90
7.	Acid value of maleic anhydride	1144.00
8.	Solubility of the resin	
	(1) In water	Soluble
	(2) In xylene	Insoluble
	(3) In alcohol + water	Partially soluble
	(4) In NaOH solution	Soluble
9.	Hydrophilic-liphophilic balance of the resin	11.89

TABLE-3
LIQUID DETERGENT FORMULATIONS BASED ON COMBINATION OF
NEUTRALIZED ACID SLURRY AND NOVEL POLYMER

Sample A	Sample B	Sample C	Sample D
Neutralized polymer 5%	Neutralized polymer 6%	Neutralized polymer 7%	Neutralized polymer 8%
Neutralized acid slurry 5%	Neutralized acid slurry 4%	Neutralized acid slurry 3%	Neutralized acid slurry 2%
Sodium lauryl sulphate 1%	Sodium lauryl sulphate 1%	Sodium lauryl sulphate 1%	Sodium lauryl sulphate 1%
Sodium lauryl ether sulphate 1%	Sodium lauryl ether sulphate 1%	Sodium lauryl ether sulphate 1%	Sodium lauryl ether sulphate 1%
Sodium tripoly-phosphate 5%	Sodium tripoly-phosphate 5%	Sodium tripoly-phosphate 5%	Sodium tripoly-phosphate 5%
Carboxymethyl cellulose 1%	Carboxymethyl cellulose 1%	Carboxymethyl cellulose 1%	Carboxymethyl cellulose 1%
Urea 3%	Urea 3%	Urea 3%	Urea 3%
Distilled water 79%	Distilled water 79%	Distilled water 79%	Distilled water 79%

As mentioned in Table-4, after each addition of detergent in 100 mL of water, the surface tension of water is progressively decreasing. This is one of the most important properties of detergents. As we know, every detergent reduces the surface tension of water. It is evident from Table-4 that Sample A, Sample B, Sample C and Sample D are reducing the surface tension of water at varied

concentrations. The fundamental nature of the detergent to reduce the surface tension of water is proved beyond doubt from the data mentioned in Table-4.

TABLE-4
CHANGE OF SURFACE TENSION OF WATER WITH THE ADDITION
OF DETERGENT AT DIFFERENT CONCENTRATIONS

Surface tension of water at 30°C is 71.18 dynes/cm.

S.No.	Sample	Surface tension (dynes/cm)	% Reduction in surface tension of water
1.	Sample A		
	0.33 g detergent addition/100 mL of water	35.47	56.16
	0.25 g detergent addition/100 mL of water	46.04	35.31
	0.2 g detergent addition/100 mL of water	51.41	27.77
2.	Sample B		
	0.33 g detergent addition/100 mL of water	43.16	39.36
	0.25 g detergent addition/100 mL of water	48.34	32.08
	0.2 g detergent addition/100 mL of water	56.75	20.27
3.	Sample C		
	0.33 g detergent addition/100 mL of water	56.17	21.08
	0.25 g detergent addition/100 mL of water	56.46	20.67
	0.2 g detergent addition/100 mL of water	64.80	8.96
4.	Sample D		
	0.33 g detergent addition/100 mL of water	35.37	50.30
	0.25 g detergent addition/100 mL of water	44.50	37.48
	0.2 g detergent addition/100 mL of water	45.82	35.62

From Table-4, good results are obtained by using 5% neutralized polymer + 5% neutralized acid slurry (Sample A). By using this sample weight of 0.2 g/100 mL, the surface tension of water is reduced to 27.77%. Similarly, Sample B, sample C and sample D reduce the surface tension of water up to 20.27, 8.96 and 35.62% respectively at same concentration of detergent, *i.e.*, 0.2 g/100 mL of water. The reduction of surface tension of water upto 56.16% is observed at 0.33 g of detergent/100 mL by using sample A. Similar results are

obtained for sample B, Sample C and Sample D, *i.e.*, 39.36, 21.08 and 50.30% at 0.33 g detergent addition in 100 mL of water.

This detergent formulation suggests about its efficiency and its capacity to replace the petroleum product to a considerable extent. Detergent of such combination will reduce our dependence on petroleum product for detergent formulation. Such detergents have renewable and non-pollutive materials, which are eco-friendly in nature, which will reduce water pollution to a considerable extent.

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