

Bulletin No. 71

INDIAN LAC RESEARCH INSTITUTE
Namkum, Ranchi, Bihar.

**MELT VISCOSITY: PART III. PLASTICIZED
SHELLAC**

By
SADHAN BASU, M. Sc.
RESEARCH ASSISTANT, INDIAN LAC RESEARCH INSTITUTE.

*(Reprinted from the Indian Journal of Physics,
Vol. 22, part I, January, 1948.)*

RANCHI

Price 5 as

MELT VISCOSITY: PART III. PLASTICIZED SHELLAC

BY SADHAN BASU

(Received for publication, July 17, 1947)

ABSTRACT.—The presence of plasticizers in general brings about a lowering of activation energy for viscous flow.

Plasticizers which are miscible with shellac increase the viscous volume while those which are incompatible or immiscible lower it.

INTRODUCTION

In the two previous communications (Basu, 1947) it has been shown that shellac and its constituent resins are greatly aggregated in the melted condition and the contribution of the polar groups towards this aggregate formation has been clearly brought out. In the present paper an attempt has been made to find out the effect of plasticizers on shellac in relation to its internal structure as revealed by the previous measurements, and thus to get an improved understanding of their action.

EXPERIMENTAL

To incorporate a plasticizer into shellac, it was found sufficient to hot-roll it with shellac for five minutes at 90°C; the resulting mass was then cooled, powdered and dried. The melt viscosity measurements, were done with the same apparatus as described in the previous communication (Basu 1947a).

The temperature regulation was done by means of Cenco bi-metallic thermoregulator, which kept the temperature accurate within $\pm 0.5^\circ\text{C}$ in the range 50°–125°C.

RESULTS

The results of viscosity measurements on shellac in presence of various plasticizers (10% of the weight of shellac) are summarised in Tables I and II and the corresponding graphs given in Figs. 1 and 2.

The values of E_0' and $\lambda_2 \lambda_3$ as calculated from the above data and Figs. 1 and 2, are given in Table III.

DISCUSSION

A consideration of the values of E_0' as given in Table III shows that the presence of plasticizers brings about a lowering of the energy of activation. This can be easily understood, since the presence of plasticizers, usually substances having high dielectric constants, lowers the intermicellar forces, which appear to be of electrical origin.

TABLE I

$$f = 5.495 \times 10^{-3} \text{ dynes/cm}^2$$

Plasticizer	$1/T \times 10^3$	Viscosity η (in poise)	$\log \eta$
Diamyl phthalate	2.84	8,809.10	3.9449
	2.72	3,411.45	3.5329
	2.64	1,511.05	3.1793
	2.56	868.05	2.9385
Tributyl phosphate	2.84	8,005.35	3.9034
	2.72	3,954.45	3.5970
	2.62	1,929.00	3.2853
	2.56	1,125.25	3.0512
Castor oil	2.82	20,929.65	4.3207
	2.72	10,609.50	4.0257
	2.62	4,147.35	3.6177
	2.52	1,864.70	3.2706
Sextone " B "	2.72	1,993.30	3.2995
	2.62	1,189.55	3.0778
	2.58	868.05	2.9385
	2.52	610.85	2.7859
Santicizer 17	2.84	4,661.75	3.6686
	2.72	1,736.10	3.2395
	2.62	830.75	2.9046
	2.58	514.40	2.7113

TABLE II

Temp.	Plasticizer	$f(\text{dynes/cm}^2) \times 10^{-3}$	$\eta(\text{poise})$	$\log \eta/f$
348°K	Diamyl phthalate	12.4875	4,372.40	-0.4559
		19.4805	2,443.40	-0.9017
		22.4775	1,768.25	-1.1042
356°K	Tributyl phosphate	11.4885	3,022.10	-0.5949
		20.9790	1,543.20	-1.3341
		25.4745	1,157.40	-1.3424
369°K	Castor oil	5.4950	4,661.75	-0.0633
		11.4885	1,186.20	-0.9863
		17.4795	1,125.25	-1.5731
353°K	Sextone 'B'	12.4875	4,211.65	-0.4722
		20.9790	2,118.35	-0.9959
		24.9750	1,736.10	-1.1581
352°K	Santicizer 17	5.4950	2,121.90	-0.4133
		12.4875	1,575.35	-0.8993
		20.4795	964.50	-1.3270

TABLE III

	E_o' (K-cal)	$\lambda\lambda_2\lambda_3$ (in c.c.) $\times 10^{18}$
Diamyl phthalate	16.20	14.30
Tributyl phosphate	20.78	12.04
Sextone 'B'	10.35	13.78
Santicizer 17	16.89	15.43
Castor oil	25.90	3.51

The values of $\lambda_1\lambda_2\lambda_3$ however, present some interesting features. Thus for the first four compounds the values are much higher than the value for unplasticized shellac (Basu 1947a) but in the case of castor oil it is comparatively low. To explain these we must first try to get a clear idea of the interaction between a polymer and its plasticizer. The recent idea of swelling and dispersion of polymers by liquids can give us some clue to that.

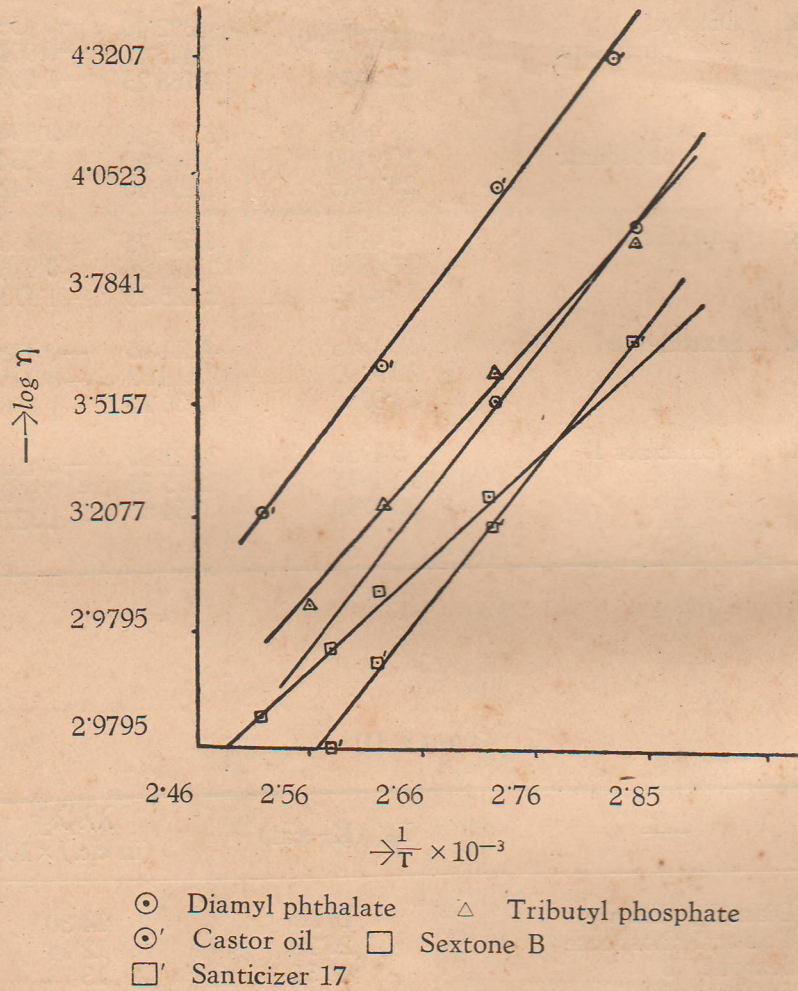


Fig. 1

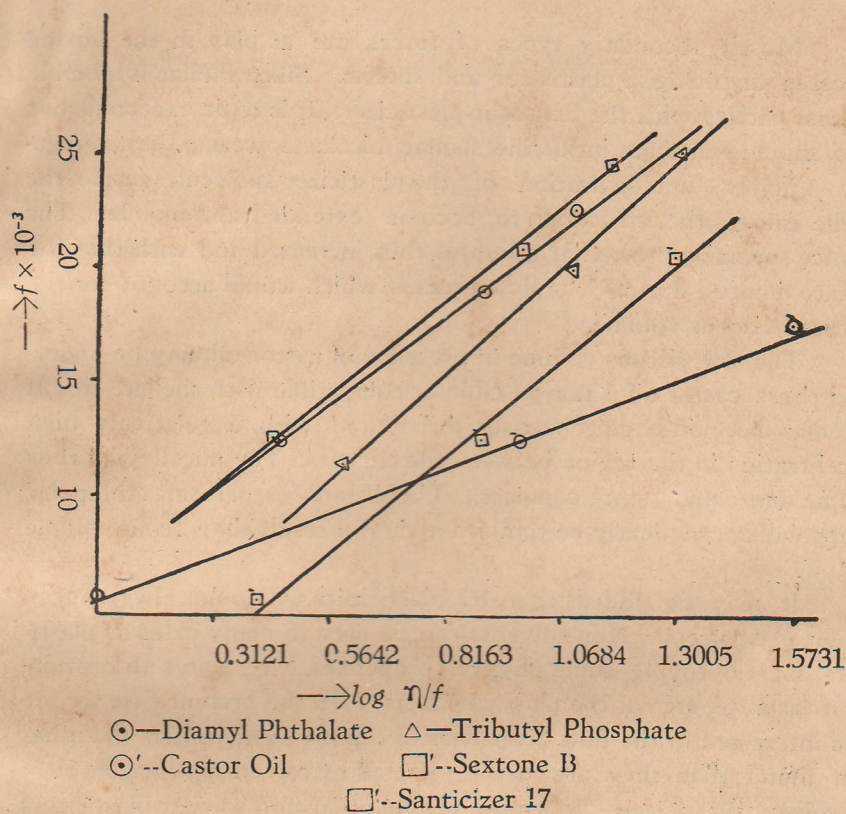


FIG. 2

The extents of interaction of shellac with plasticizers, as related to the dispersing capacity of the former, are summarised in Table IV.

TABLE IV

Plasticizer	Cold	Hot (75°C)
Tributyl phosphate	Swelling	Miscible (complete)
Diamyl phthalate	Swelling	Miscible (partial)
Sextone 'B'	Swelling	Miscible (complete)
Santicizer 17	Swelling	Miscible (partial)
Castor oil (anhydrous)	No action	Sets to gel on cooling No action

Mostly secondary types of forces are at play in the mixing processes involving a plasticizer and shellac. Since shellac is miscible (at least partly) with the first four plasticizers, it is to be expected that these should penetrate inside the shellac micelle, lowering the aggregation. Further, immobilisation of the plasticizer molecules inside the micelle causes the structure to become extended and mobile. The distance separating the polar groups is thus increased and with that the distance jumped during the flow-process, which would account for the increased viscous volume.

The low viscous volume in presence of castor oil may be understood thus: castor oil is not miscible or compatible with shellac, it will therefore be non-homogeneously distributed with a relatively high concentration in the region between the clusters. The micelle will thus become dense and more compact. The distance separating the polar groups will consequently be reduced and, as a result the viscous volume also.

It may be added that by plasticizers we do not always mean solvent plasticizers. Non-solvents can be used in many cases as plasticizers for improving some physical properties, e. g., water absorption, heat resistance, etc., of the plastic material. In the present case we are more interested in the flow properties of the plastic materials and it has been found that they are better affected by solvent plasticizers than non-solvent plasticizers. It is quite possible that non-solvent plasticizers may increase water absorption, elastic property etc., but in that we are not interested at present.

ACKNOWLEDGMENT

Author is grateful to Dr. P. K. Bose, D. Sc. F. N. I., Director, Indian Lac Research Institute for his great interest in the present work.

INDIAN LAC RESEARCH INSTITUTE
NAMKUM, RANCHI

REFERENCES

- Basu, S., 1947a, *Ind. Jour. Phys.*
.. .. 1947b *ibid.*, 21, 83.

The Education Press, Ranchi