A THERMOSETTING PLASTIC FROM HORNS AND HOOFS

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(Received March 16, 1965)

Steam-distilled horns and hoofs powder is reacted with formaldehyde and ammonia. The polymer, on blending with saw-dust and a resin such as urea or phenol-formaldehyde or furfuraldehyde, yields a thermosetting composition which exhibits the characteristics of urea formaldehyde or phenol-formaldehyde or furfuraldehyde plastics.

Introduction

Large quantities of horns and hoofs, because of the vast indigenous animal wealth, are available in the country. It has been estimated, on the basis of 54,00,000 pieces of hides and 77,00,000 pieces of skins,[1] which are annually produced in Pakistan, that 11,334 tons of horns and hoofs accrue as a bye-product. The bulk of these materials is exported abroad where it is utilised in the manufacture of sticks, umbrellas, cutlery, buttons,[2–4] trays, dishes, sheets, fertilizers,[5] fire extinguishing composition,[6-8] etc.

Moulding compositions from horns and hoofs have been obtained by treating them with urea or its derivatives,[9–14] phenol[15] and formaldehyde in the presence of ammonium hydroxide or hexamethylenetetramine and salicylic acid[16] or boric acid[17] or glycol[18] in the presence of glycerine. Such a composition has also been obtained by reacting horns and hoofs with sodium hydroxide and finally with formaldehyde.[19]

This communication deals with the production of a moulding composition from horns and hoofs by a modified method. The method yields plastics having better performance and strength and effects considerable economy in the production conditions.

Materials and Method

Materials

Horns and hoffs: They were obtained in the crushed form from Crushing (Pakistan) Ltd., Lahore.

Urea-formaldehyde, phenol-formaldehyde and furfuraldehyde plastics: These were made by the methods of Redfarn, Allcot [20,21] and Barron [22] respectively.

Sulphuric acid (d, 1.84); 10% of formalin aqueous solution; 15% ammonium hydroxide aqueous solution; all the chemicals were of commercial grade. Saw-dust 200 (mesh).

Method

Steam-Distllation of Horns and Hoofs.—The crushed horns and hoofs were ground to 120 mesh. The powder was steam--distilled for three hours to remove foul smelling low split water soluble material. After the distillation was over, the powder was dried and reduced to the original mesh.

Horns and Hoofs Thermosetting Base.—The steam-distilled powder was immersed in the formalin solution in a round-bottomed flask. The pH of the mixture was adjusted to 10 by the addition of the ammonium hydroxide solution and the powder was converted into a plastic mass by refluxing the mixture for an hour and a half. After cooling, the plastic mass was taken out, dried, ground in a ball-mill, sieved through 200 mesh and finally stored for making the moulding base.

Moulding of the Base with Saw-Dust Alone (I).—The base was mixed thoroughly with saw-dust in the ratio of 3:1 respectively. Discs of 1″ diameter and having different weights were made by hot pressing the mixture at 165°.

With Urea-Formaldehyde only (II) and with Saw-Dust (IIA).—The base in combination with urea-formaldehyde powder without saw-dust and with saw-dust was blended in the ratio of 3:1 and 3:1:1 (w/w) respectively. Discs of each composition having different weights were made at 145°.

With Furfuraldehyde only (III) and with Saw-Dust (IIIA) Similarly with Phenol-Formaldehyde only (IV) and with Saw-Dust (IVA).—Discs of the base with furfuraldehyde or pheno-formaldehyde were made as before at 150°.

Moulding 'Bakelite' (V).—Discs, in the same manner as described for horns and hoofs, base were also moulded from 'Bakelite' powder at 125°.

Testing of Specimens.—Three specimens from each composition were tested for compressive strength, water absorption, surface hardness and break-down insulation. Each value reported in Tables 1-4 is the average of three or more than three determinations. The average mean deviation has also been recorded in each case. There was, however, no deviation in the break-down insulation values. The compressive strength of moulding Bakelite was compared with discs based on horns-hoofs base, saw-dust and a resin, (Table 1).

Water absorption values in percentage of the discs were determined on (w/w) basis (Table 2).

Discs of 3 mm. thickness of each composition were made for the test of break-down insulation (Table 4). Surface hardness in terms of Brinell and break-down insulation in KV were determined with the Barcol Impressor (Barber Colmans Rockford Illionois U.S.A) and Break-Down Insulation Tester (Siemens Germany) respectively.

Discussion and Conclusions

It is observed from the results (Table 1) that discs made from horns, hoofs and saw-dust alone gave the compressive strength which was greater than that of the composition based on horns and hoofs base, urea-formaldehyde and with or without saw-dust. The base with saw-dust alone also gave better results in compressive strength than those obtained with the base in combination with furfuraldehyde or phenol-formaldehyde as a resin. However, when saw-dust was also present the strength of the discs was better than that of discs with the base and saw-dust alone.

Base plus saw-dust composition was workable only for flat discs, sheets, etc., but for articles in which flow properties of the plastic were required, the composition did not work, therefore, the addition of a resin like urea formaldehyde, phenol-formaldehyde or furfuraldehyde was essential. Urea formaldehyde as a resin cannot be used because discs made with it lack strength. The use of furfuraldehyde was also not practicable due to its prohibitive cost. Thus phenol-formaldehyde appeared to be the only alternative. Although it was costlier than urea-formaldehyde it is still cheaper than furfuraldehyde and compositions containing it gave better results than those compositions having urea-formaldehyde and furfuraldehyde plastics.

The percentage of phenol-formaldehyde in the composition can be varied to increase strength and impart flow characteristics which are necessary for moulding.

TABLE 1.—COMPRESSIVE STRENGTH (PSC) OF DISCS FROM DIFFERENT MOULDING COMPOSITIONS.

Weight of discs in g.	I	Average mean deviation	II	Average mean deviation	IIA	Average mean deviation	III	Average mean deviation	IIIA	Average mean deviation	IV	Average mean deviation	IVA	Average mean deviation	V	Average mean deviation
5	9674	Nil	2564	±10	6382	Nil	8234	±11	9802	± 6	9061	Nil	14018	Nil	17950	Nil
6	9659	Nil	1140	±10	6268	± 9	8120	∓12	9830	±11	9004	Nil	13932	±6	17148	Nil
7	9602	∓11	1026	∓15	6211	±11	8092	±15	9773	±11	8975	±6	13876	±9	17836	± 8
8	9545	±18	997	±15	6189	±17	9033	±18	9773	±22	8918	∓11	13870	±11	17806	±14

Discs, made from Bakelite alone, have also been investigated with respect to their breaking strength. This was done in order to compare their compressive strengths with those products obtained from horns and hoofs base. It was found that result with phenol-formaldehyde and saw-dust were comparable in all respects with those of the Bakelite discs.

Discs made from horns and hoofs base with saw-dust were adversely affected by water absorption (Table 2). Replacement of saw-dust with phenol-formaldehyde resin is comparable with the discs of moulding Bakelite.

Break-down insulation values of discs made from horns-hoofs base and saw-dust only were found to be highest, whereas the lowest values were observed in case of discs made from the composition having urea formaldehyde, therefore, the break-down insulation values of the discs made from horns-hoofs base and saw-dust alone are better even than the discs made from the moulding Bakelite (Table 4).

TABLE 2.—PERCENTAGE OF WATER ABSORPTION OF DISCS DIPPED IN WATER FOR 24 HOURS.

I				II			IIA			III		
Weight of discs before absorption of water in g.	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)
5	5.550	11	±2.60	5.510	10.2	∓2.070	5.535	10.7	∓2.09	5.475	9.5	∓2.00
6	6.660	11	±2.58	6.612	10.2	∓2.078	6.642	10.7	±2.10	6.570	9.5	∓2.04
7	7.770	11	∓2.54	7.714	10.2	∓2.089	7.749	10.7	±2.11	7.665	9.5	∓2.06
8	8.880	11	∓2.52	8.816	10.2	±2.090	8.856	10.7	±2.15	8.760	9.5	±2.08

TABLE 2 (*Continued*)

IIIA			IV			IVA			V		
Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)	Weight of discs after absorption of water in g.	Water absorption (%)	Average mean deviation (%)
5.490	9.8	±2.07	5.205	4.1	Nil	5.210	4.2	±.468	5.190	3.8	Nil
6.588	9.8	±2.098	6.246	4.1	±.45	6.252	4.2	Nil	6.228	3.8	Nil
7.686	9.8	∓2.126	7.287	4.1	Nil	7.294	4.2	∓.469	7.266	3.8	∓.362
8.784	9.8	±2.129	8.328	4.1	∓.467	8.336	4.2	∓.470	8.304	3.8	±.368

phenol-formaldehyde resin in the composition having horns and hoofs base had the least water absorption. Therefore, from the water absorption and strength point of view the horns and hoofs base with phenol-formaldehyde is preferred over all other compositions.

It is seen from (Table 3) that the surface hardness of discs made from horns-hoofs base and

The effect of temperature in the moulding of various compositions was found to play an important role. Uniform heat should, therefore, be applied to the moulding material from all sides of the die. Maintenance of controlled temperature during moulding is essential otherwise discs obtained at low temperature are friable and high temperature leads to the formation of cracks in the product.

Table 3.—Hardness (Brinell) of Discs from Different Moulding Compositions.

Weight of discs in g.	I	Average mean deviation	II	Average mean deviation	IIA	Average mean deviation	III	Average mean deviation	IIIA	Average mean deviation	IV	Average mean deviation	IVA	Average mean deviation	V	Average mean deviation
5	29	±1	28	∓1	27	±1	25	∓1	24	±1	34	±.5	33	±.5	35	Nil
6	29	Nil	28	∓1	27	±1	25	∓1	24	±1	34	Nil	33	∓.5	35	∓.5
7	29	Nil	28	±1	27	±1	25	∓1	24	∓1	34	∓.5	33	Nil	35	Nil
8	29	∓1	28	∓1	27	∓1	25	±1	24	±1	34	Nil	33	±.5	35	±.5

Table 4.—Break-down Insulation (KV) of Discs from Different Moulding Compositions.

I	II	IIA	III	IIIA	IV	IVA	V
4.7	4.0	3.9	4.0	3.8	4.3	4.0	4.5

From these studies, the following conclusions are drawn:

1. Large quantity of horns and hoofs available in the country can be used for the production of a plastic material.

2. Steam-distillation of crushed horns and hoofs eliminates a foul smell at the moulding stage. The treatment at the same time, renders horns and hoofs liable to a maximum reaction with formaldehyde.

3. The importance of saw-dust as a filler in this plastic has been realized by determining compressive strength of different compositions with or without its presence.

4. Urea-formaldehyde is not as satisfactory a resin as phenol-formaldehyde although it is cheaper than the latter.

5. Furfuraldehyde is a satisfactory resin, but its cost is high.

6. Phenol-formaldehyde is the best resin for low cost, desirable strength, surface hardness, water absorption and break-down insulation.

7. Compositions containing the horns and hoofs plastic base have the following characteristics:

   (A) They are bad conductor of heat and electricity and are water-proof. Therefore, they can be used in making sheets, discs, trays and electric appliances.

   (B) The so-prepared discs can be drilled, threaded, milled and machined and can also be painted like wood.

8. As regards the economic aspect the horns and hoofs based moulding composition is cheaper than the Bakelite plastic alone, because the cost of the former has been estimated to be Rs. 1.27 and that of the latter is Rs. 2.13 per lb.

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