A MOULDING COMPOSITION FROM VEGETABLE-TANNED LEATHER SCRAP

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Tanned leather scrap was hydrolysed with sulphuric acid into a plastic mass which was dried and powdered. The powder was treated with formalin, blended with saw dust and other ingredients and then hot pressed or mixed with saw dust only, cold pressed, and later on, treated with formalin. The compositions obtained exhibit the requisites of urea-formaldehyde and phenol-formaldehyde resinous compositions.

Introduction

The raw material of hides and skins amounting to 16 million pieces per year, plays a vital role in the economy of Pakistan.[1] Shoes, belts, saddlery, bags, wallets, sports, and fancy leather goods command a large sale both at home and foreign markets. Large quantities of vegetable-tanned leather scrap are available in Pakistan as a by-product from the leather consuming industries. The work reported here, therefore, is the result of an attempt to utilise this product which otherwise finds little application at present. Already it had been shown that the scrap can be used for the production of plywood adhesives.[2] The scrap has now been converted into a moulding composition by a process which is simple and economical. Some of the earlier processes for the conversion of leather scrap into moulding compositions consist in general of the following steps:

1. The scrap, free from non-leather matter is first hydrolysed either with sulphuric acid[3] or hydrochloric acid[4] or ammonia.[5] In another process the leather scrap is first treated with phenolic solution before digestion with an inorganic acid.

2. The hydrolysed leather is converted into a plastic mass by the addition of casein,[6] zein[7] and formaldehyde and also formaldehyde alone.[8]

3. The plastic mass either as such or in combination with a filler[9] is then moulded into articles of desired shape and dimensions.

The process outlined in this communication essentially follows on the pattern of the earlier processes. However, during its development, several simplifications and modifications have been introduced with a view to making it economical and widely applicable. One such modification is that the acid hydrolysis of the scrap is carried out under pressure. The other is that the hydrolysed scrap is first converted into powder form which can be transformed, if and when required, into a moulding composition by first adding saw dust to it and then moulding it in the cold state. The moulded material is finally treated with for-malin. Alternatively, the leather powder is reacted with the aldehyde in hot water to yield a composition which in combination with a filler such as saw dust, and ester-gum, urea-formaldehyde and phenol-formaldehyde resins, can be hot-pressed into any shape.

For composition of low compressive strength, ester-gum constitutes an ideal additional plasticiser and binder whereas for materials of high compressive strength, saw dust, urea-formaldehyde and phenol-formaldehyde have been found most effective additives.

Materials and Methods

1. Leather scrap: it was supplied through the courtesy of local shoes manufacturers;[10] 2. Sulphuric acid: commercial grade, d. 1.84; 3. Formalin: commercial grade; 4. Ester-gum: the gum was prepared from rosin and glycerine according to Chatfield[11] and others;[12] 5. Urea or phenol-formaldehyde: the plastics were made by the method of Redfarn and Allcot[13] and Reffarn;[14] 6. Saw dust: it was procured from Laboratories' workshop.

Hydrolysis of Leather Scrap.—The scrap was cut into small pieces and washed with water to remove the adhering dirt. The pieces were then digested under 20 psig. pressure for 30 minutes in an autoclave with dilute sulphuric acid (1.4% V/V) in the ratio of 7:15 respectively. The resultant hydrolysed mass was washed with water to remove excess sulphuric acid and most of the tannins. It was then squeezed, dried, powdered and sieved for further processing.

Moulding

The powder was moulded either cold or hot as follows:

Cold Moulding.—The powder was mixed with saw dust as a filler in different ratios. The compositions were moistened and converted into $4'' \times 4'' \times \frac{1}{2}''$ sheets, each weighing 175 g. The sheets were dipped in different concentrations of formalin for 24 hours and were finally washed to remove the unreacted formalin. They were then dried under pressure to avoid warping. After they had been completely dried, the sheets were tested for their compressive strength on the universal testing machine[16] (Table 1).

Table 1.—Compressive Strength of Sheets Prepared by Cold Process.

Ratio of leather powder to saw dust	Concentration of formaldehyde in the immersion bath %	Compressive strength of sheets (psi)
2:1	20	266
2:1	10	308
2:1	5	145
3:1	20	74
3:1	10	281
3:1	5	42

Hot Moulding.—In this process, 8% formalin solution was heated at 60°C. and to it the leather powder was added in small quantities with vigorous stirring for uniform and thorough mixing. The ratio of leather powder to the solution was kept 1:1.75 on w/v basis. The resultant mass was further heated at 90°C. for 10 minutes to ensure completion of the reaction. The product which appeared as agglomerated rubber-like mass was taken out of the reaction vessel and washed with water to remove excess formalin. It was cut into small pieces to facilitate quick drying. The dried pieces were powdered in the ball mill to 200 mesh.

Four parts of the above powder were mixed separately with: (1) one part saw dust. (2) One part saw dust and one part phenol-formaldehyde or urea-formaldehyde resin and (3) one part saw dust and one part ester-gum. The resulting combinations were shaped into discs by means of the die under suitable conditions of pressure and temperature. The discs were tested for their compressive strength and the results were recorded (Table 2).

Table 2.—Compressive Strength of Discs Based on 4 g. Leather Powder, 1 g. Saw Dust and other Ingridients and Produced by the Hot Pressing at Different Temperatures.

Other ingredient	Temperature of moulding °C.	Compressive strength of disc (psi)
Nil	200	10622
1 g. phenol-formaldehyde	170	7271
1 g. urea-formaldehyde	180	6986
1 g. ester-gum	90	6558

In addition, discs from the leather powder with phenol-formaldehyde alone in different ratios were made at 160°C. and their compressive strengths were recorded (Table 3).

Table 3.—Compressive Strength of Discs from Leather and Phenol-Formaldehyde Powder by Hot Process at 160°C.

Ratio of leather powder to phenol-formaldehyde	Compressive strength of disc (psi)
3:1	8269
1:3	22528
3:2	10408
2:3	1675
3:3	14543
3:4	14971
4:3	11116

Discs were also moulded from 'Bakelite' powder at 125° in order to compare their compressive strengths with those of discs containing the leather powder as the basic material (Table 4).

TABLE 4.—COMPRESSIVE STRENGTH OF DISCS OF BAKELITE POWDER HOT PROCESS AT 125°C.

Wt. of the discs g.	Compressive strength of disc (psi)
3	14258.4
4	15399.1
5	20389.5

Discussion

Results recorded in Table 1 were for cold pressed sheets immersed in formaldehyde for 24 hours. This treatment has the advantage that it eliminates heating of the moulding die. Sheets made by mixing the leather moulding powder and saw dust in the ratio of 2:1 respectively and 10% formalin treatment had 308 psi of compressive strength. Similarly discs made by mixing the powder and saw dust in the ratio of 3:1 and 10% formalin solution recorded 281 psi of the compressive strength.

However, the drawback in this process is that although it does not involve heating, and, therefore, is cheaper, its industrial application will be restricted because it will require (i) prolonged formalin treatment, (ii) large quantities of formalin, and (iii) drying of moulded materials. All of these factors will cost in terms of time and money.

In the hot process, the leather powder, pretreated with formalin can be moulded under different conditions of temperature and composition. The products obtained show even a better performance than that of the cold moulded materials (Table 2).

The effect of temperature in the moulding of various compositions is very important. Uniform heat should be applied to the moulding material from all sides of the die. Maintenance of controlled temperature during moulding is essential otherwise discs obtained at lower temperature are friable and higher temperatures lead to the formation of cracks in the product.

It will be noticed (Table 2) that the maximum compressive strength of the discs in the case of leather powder and saw dust only is 10622 psi saw dust and the phenol-formaldehyde powder is 7271 psi and that of the leather powder, saw dust and ester-gum is 6558 psi Ester-gum plasticiser produces flow characteristics in the leather moulding powder but the strength of the final product is comparatively low. Therefore, the use of phenol or urea-formaldehyde is preferred. Maximum strength of discs is obtained from the leather powder in combination with saw dust only when moulding is carried out at 200°C. However,t he product obtained is not suitable due to the lack of flow characteristics. The best composition is the one obtained from leather powder, saw dust and phenol-formaldehyde resin and it covers all the requisite properties in moulding, such as moderate temperature of moulding, strength, better finish and flow characteristics.

It would be seen (Table 3) that whereas discs fabricated from three parts phenol-formaldehyde and one part of the leather powder gives the highest compressive strength, 22528 psi the ratio of the ingredients in the reverse order yields a product with 8269 psi compressive strength.

Discs made from imported Bakelite alone have also been investigated with respect to their breaking strength (Table 4). This was done in order to compare their strength with those products obtained from the leather powder and phenol-formaldehyde resin. It is evident that discs made from the composition having leather powder, saw dust and phenol-formaldehyde had compressive strength comparable to those made from Bakelite powder.

Conclusions

From these studies, the following conclusions are, therefore, drawn:

(1) Large surplus of leather scrap in the country can be used for the production of leather

moulding powder. (2) In the cold process of moulding, the best ratio for the maximum strength is two parts leather powder to one part of saw dust. (3) The appropriate concentration of formalin for the above process is 10%. (4) In the hot process of moulding, the preferred composition was obtained from the leather powder, saw dust as a filler, and phenol-formaldehyde resin as a plasticiser. (5) The compressive strength of discs made from the leather powder and phenol-formaldehyde resin is comparable to those of the Bakelite powder. Furthermore, it is seen that the 1:1, 2:3, and 1:3 ratios of the leather powder to phenol-formaldehyde, when taken on weight per weight basis, are equivalent to 3, 4, 5 g. of the Bakelite plastic. (6) Sheets and discs containing the leather moulding powder have the following properties:

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

(B) The sheets and discs prepared can be bored with threads, milled and machined and can also be painted like wood.

(7) As regards the economic aspect, the leather based moulding composition is cheaper than the Bakelite plastic alone, because the cost of the former has been estimated to be Rs. 1.90 and that of the latter is Rs. 2.13 per pound.

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