J. Pharm. Pharmac., 1972, **24**, 815

LETTERS TO THE EDITOR

Cake thickness and deposition rate variation in a plate-and-frame filter press

In plate-and-frame filter presses, cake deposition is not uniform, and the non-uniformity may cause differences in particle size distribution between different regions of the same cake. Differences in deposition rate over the face of a growing filter cake are not readily accessible for measurement, but a technique is described here which renders them observable.

In the frames of a filter press, the slurry to be filtered enters a flat rectangular enclosure, the large faces of which are formed by the filter cloth. The water leaves the slurry through the cloths in a symmetrical fashion, and ideally the filter-cake should build up on each cloth uniformly over its entire area until sufficient solid has been deposited for the layers to meet on the centre plane of the frame. At this stage the press is full; this shows itself to the operator since the pressure required to force liquid through suddenly increases. The press is then opened and the filter cake removed.

A filter cake as it grows should be self-healing, in that if a thin zone or a crack should develop, the liquid flow will direct itself preferentially along the easy flow path so created. This leads to enhanced deposition on the thin area or in the crack and it is commonly thought that, because of this self-regulation, the cake builds up uniformly. We have now shown that this is not the case by changing the colour of the solid to be filtered halfway through the filtration, so that the position reached by the cake face at this stage would be marked by the change in colour. A number of cakes were dried and then dissected to display the cake face profile at the half-way stage; there proved to be some interesting variations in thickness.

The experiments were carried out on a stainless steel conventional filter press (S. H. Johnson & Co. Ltd., Carpenters Road, London, E.15), using 22 cm square frames and producing cakes 2·5 cm thick. The assembly was quite small, consisting of an end plate, a frame, a central washing plate, a second frame, and another end plate. Two cakes were made, one on each side of the washing plate, in each run. After preliminary runs to establish the slurry volume which had to pass through the press before it was completely filled with solid, further filtrations were carried out in which, for half the time, a slurry made up from a solid mixture containing 80% (by wt) of whiting and 20% of carbon, in the form of activated charcoal of approximately the same particle size, was filtered.* This could be either preceded or followed by a slurry containing whiting alone, until the press was full. The cakes were removed from the press, placed horizontally, and dried in an air oven at a slow rate to prevent cracking. They were then cut into slices in two directions at right angles, so that variations from the top to the bottom of the press, and from the inlet to the outlet side of each frame, would be exposed. The cutting was done with a 2 mm thick plain cutter running at 300 rev/min on a milling machine, taking an initial shallow cut about 3 mm deep across the top surface of the cake to prevent flaking, followed by a second cut, along the same line, to the full cake thickness to divide it. The cutter tended to carry some grey dust onto the white parts of the face, and, after cutting, gentle scraping with a palette knife was necessary to clean up the face.

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* Filtration rates and pressures were recorded but are not given here as this communication is a qualitative report only. Details are available from the senior author, K.R.

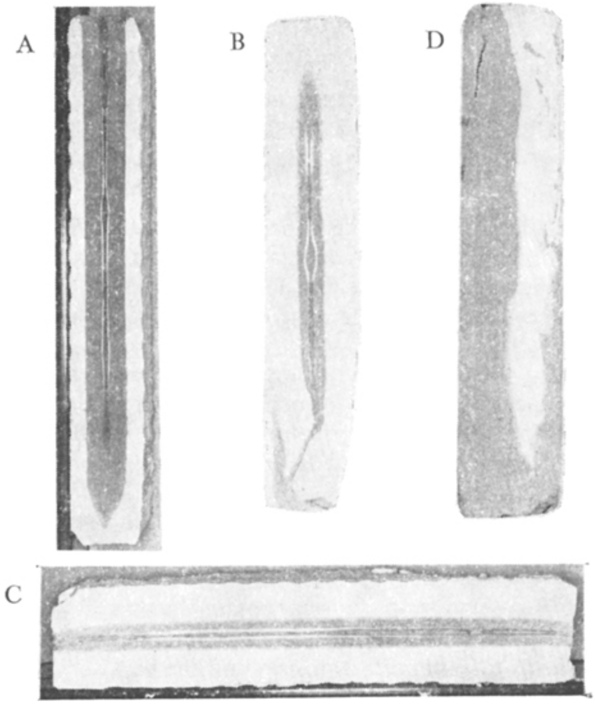

FIG. 1A, Cake formed in a 1·2 cm frame, whiting being deposited first. Some gravity-slumping of the white layer has occurred. B, A 2·5 cm cake cut vertically and C, horizontally. The vertical section shows non-uniformity due to the inlet launder, and the dark layer in the horizontal section a slight variation in thickness from left to right, the right hand, thicker, side being nearer to the inlet. D, A 2·5 cm thick cake in which carbon-whiting mixture was deposited first. Gravity-slumping is quite pronounced.

The face of each cut was photographed, and some of the resulting pictures are shown in the figures.

Ideally, the grey and white layers should be of equal thickness right across the width and depth of the filter. The nearest approach to this was attained when using the 1·2 cm thick frames and when the initial slurry contained whiting alone, which formed a more dense, cohesive and rigid cake. An example of such a cake is shown in Fig. 1A. It can be seen that there is a certain amount of slumping of the initial white layer at its lower edge.

When the cake thickness increases, the uniformity of structure is somewhat less. Cakes made in the 2·5 cm thick frames are shown in Fig. 1B, C. Here, besides the slumping of the initial layer, there is a non-uniformity from side to side of the press due to a more rapid cake build-up to the inlet launder.

Carbon and whiting together (two solid components in the initial slurry) did not give such a dense or cohesive cake as did the initial whiting slurry. The lack of cohesiveness of the initial cake layers allowed gravity sloughing of the cake to occur, as can be seen in Fig. 1D. Such sloughing results in an increased cake thickness near the base of the frame.

The sharpness of the slurry division lines in the cake which can be seen in all the figures is an indication that mixing is minimal in the slurry space between the opposing cake faces during cake build-up.

Due to the non-mixing conditions of fluid movement within the frame, and the net

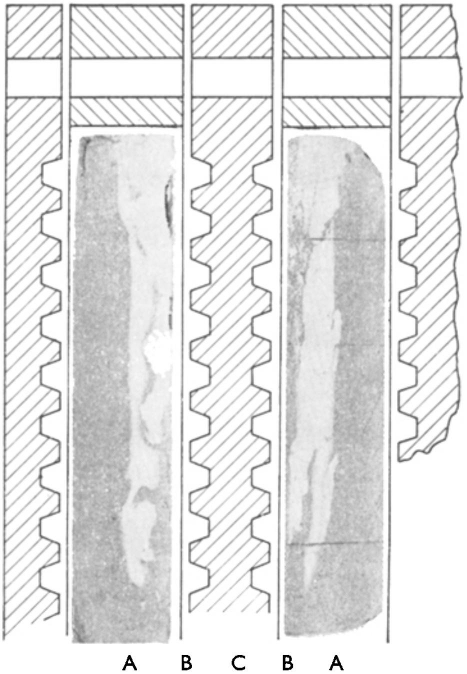

FIG. 2. A pair of 2·5 cm thick cakes in the relative positions they would occupy in the press, shown diagrammatically. The faces adjacent to the high-resistance cloth on the central plate have only a thin initial deposit, so that the white layers do not lie centrally in the cakes; mixing by the "load-casting" mechanism has occurred in the lower part of the left-hand cake.
A, Cake in frame. B, Cloth position. C, Washing plate.

flow of filtrate out through the cloths, particle segregation by size will occur in a pattern radiating from the inlet opening.

The net result of these effects is that the cake is thicker at the lower corners, particularly near to the outlet. In addition to this, however, there are other, less systematic, superposed variations in the thickness of the white layer, which may be due to the mixing of the layers. They have different physical properties, and the mixing, which must take place before the cake is completely consolidated to become rigid, is analogous to a known phenomenon: this is the geological formation called load-casting (Pettijohn, Potter & Siever, 1972). A sheet of sand overlying a layer of mud on the sea-bed tends to sink into it, being denser, but the sinking is localized where the mud is weaker or less dense and occurs by the downward movement of spherical or inverted mushroom shaped masses of sand, rather like bubbles in reverse. Such influxes of white material into the dark can be seen in the cake shown on the left.

The thickness of the white layer is not uniform, nor is it centrally placed within the cakes. There are several reasons for this divergence from the ideal pattern. Unless the resistance offered by the filter cloth to liquid flow is the same for each cloth, the rate of deposition will be greater on that side of the cake next to the least resistant cloth. This can be seen in Fig. 2, where the sides B are those adjacent to the high-resistance cloth, which covered the central washing plate. A possible contributory factor is that, on a washing plate, filtrate from two cloths has to pass through one hole at the plate corner to reach the outlet launder. On the two end plates, however, filtrate from only one side of one cake passes through one such hole.

We have thus shown a considerable degree of non-uniformity to exist during filter-cake formation. The practical importance of this is, firstly, that changes in particle-size distribution may well be introduced as well as the bulk inhomogeneities: for example, larger particles will have entered the lower parts of the cake under conditions where gravity settling has taken place. Secondly, it is quite possible that these same variations could occur when a filter is pre-coated with a filter-aid. Normally this is assumed to form a uniform coat, but it can be seen that this is not necessarily so.

We are grateful to Messrs, D. Hunt, L. Morris and D. J. Tulett for assistance with the cutting, and to Mr. J. Hardyman who took the photographs.

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PETTIJOHN, F. J., POTTER, P. E. & SIEVER, R. (1972). *Sand and Sandstone*, p. 370. N.Y.: Springer.

Relation between binding to plasma protein, apparent volume of distribution, and rate constants of disposition and elimination for chlorpromazine in three species

Several recent investigations from this and other laboratories have established that, for each unit of dose, wide interspecies differences occur in chlorpromazine concentrations in plasma after intravenous doses (Curry, Derr & Maling, 1970; Curry, D'Mello & Mould, 1971; Maxwell, Carrella, & others, 1972). Concentrations are highest in man, intermediate in dogs, and lowest in rats. Plasma protein binding of chlorpromazine is also highest in man and lowest in rats (Curry, 1970a). Binding of drugs to plasma proteins is thought to control drug localization in tissues (Curry, 1970b), so a pharmacokinetic analysis of chlorpromazine concentrations in plasma has been conducted, to quantify the relation implicit in the data. The calculations have also concerned disposition and elimination rate constants.

The data were taken from the original publications. The analysis involved comparison with a two-compartment model (Riegelman, Loo & Rowland, 1968a, b). The pharmacokinetics in man were discussed by Maxwell & others (1972). The treatment of the dog and rat data was methodologically identical with the treatment of the human data.

It was appropriate to calculate: (i) the apparent volume of distribution at steady-state (Vd_{ss}) as an assessment of tissue localization; (ii) the disposition rate constant (β), which is the same as the rate constant of the second phase of the double-exponential semilogarithmic plot of concentration against time, and which assesses the rate of removal from the body as a whole; and (iii) the elimination rate constant (k_{el}), which is the best assessment of the combined processes of metabolism and excretion. The elimination rate constant is greater than the disposition rate constant, because of continual replenishment of the drug concentration in plasma consequent on loss from tissue stores.

Vd_{ss} was highest in the rat and lowest in man (Table 1). The differences were significant ($P < 0{\cdot}05$), as were the differences in protein binding. Thus a high degree of tissue localization occurred in the species in which binding to plasma protein was low and *vice versa*. These data were further used to calculate the fractions of the body content of chlorpromazine occurring in plasma water. These were similar: rat,