Surface roughness measurements on both uncoated and film-coated tablets

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A knowledge of the surface roughness of a tablet is necessary in the interpretation of tablet/film adhesion results (Nadkarni et al 1975; Rowe 1977, 1978a). It is also useful in the optimization of both the film formulation and the coating process during product development (Rowe 1978b).

There are many ways of quantifying surface roughness. Normally the Ra (arithmetic mean roughness) value, defined as the arithmetic average value of the departure of a profile above and below the reference (centre or electrical mean) line (Fig. 1a), is used. Since this parameter is simply an arithmetic average value it cannot be used to fully describe the surface and more parameters are thus required. Accordingly, the British Standard (B.S. 1134, 1972) lists, in addition to the Ra value, the Rz (ten point height of irregularities) value defined as the average distance between the five highest peaks and the five deepest valleys within the sampling length measured from a line parallel to the reference line but not crossing the profile (Fig. 1b). Since this parameter can only be determined graphically and hence requires an analogue record of the surface profile, a similar parameter—the Rtm value, defined as the average of five peak to valley distances (Fig. 1c), and which can be measured by a machine, is often used. This parameter has been used by Nadkarni et al (1975) in describing tablet surfaces. Other parameters often used in the analysis of surface finish are the Rt value, defined as the distance between the highest peak and deepest valley, and the Rp value, defined as the distance between the highest peak and the centre line. This communication investigates the applicability of using Ra, Rtm, Rp and Rt in highlighting differences in the surface roughness of both uncoated and film-coated tablets.

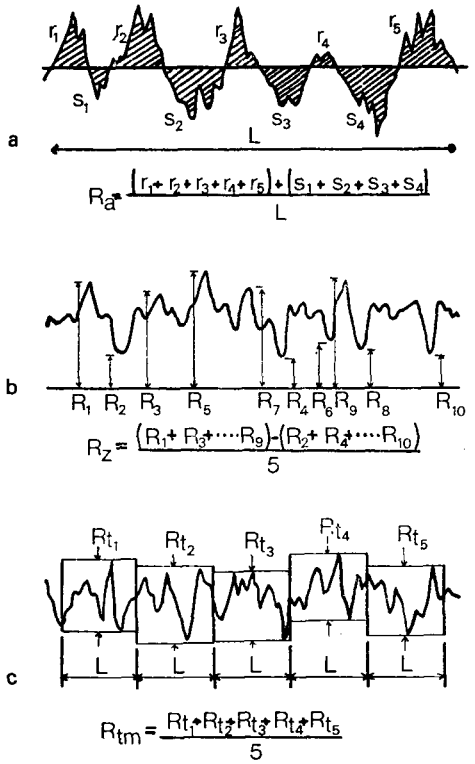

FIG. 1. The definition and graphical determination of Ra, Rz and Rtm values.

Uncoated tablets of varying surface roughness were prepared by compressing a standard placebo granule, consisting of lactose granulated with maize starch paste and lubricated with magnesium stearate, at a range of compaction pressures using an instrumented single punch tablet machine (Type F3, Manesty Machines Ltd., Liverpool) fitted with 11·1 mm diameter flat faced punches. A further batch of tablets was coated with a film formulation consisting of hydroxypropyl methylcellulose (Pharmacoat 606, Shinetsu Chemical Co. Ltd., Japan) dissolved in a dichloromethane–methanol (70:30% w/v) solvent mixture applied at polymer concentrations 1,2,5,8 and 10% w/v using an airless spray gun in a 24 inch Accelacota (Manesty Machines Ltd).

Surface roughness measurements were made on ten individual tablets using a standard surface measuring instrument (Hommel Type T10, Hommelwerke G.m.b.H., West Germany) using a 5 mm traverse length with a 0·8 mm cut off. The means and standard deviations of the Ra, Rtm, Rt and Rp values were calculated from data taken from a small computer

Table. 1. The effect of increasing compaction pressure on the porosity and surface roughness of uncoated tablets.

Compaction press. MPa	Porosity %	Surface roughness parameters (μm) Ra	Rtm	Rt μm	Rp
112	19·8	1·88 ± 0·34	13·52 ± 1·85	20·62 ± 9·01	9·38 ± 3·74
149	15·3	1·29 ± 0·29	10·94 ± 1·54	15·61 ± 2·75	6·22 ± 1·69
177	12·3	0·75 ± 0·05	5·79 ± 1·93	9·50 ± 1·70	3·56 ± 1·43
214	11·2	0·69 ± 0·11	5·88 ± 0·92	8·66 ± 1·56	3·12 ± 0·93
340	6·0	0·55 ± 0·15	4·11 ± 0·91	6·29 ± 1·49	2·32 ± 0·88

linked to the instrument. All measurements were taken across the diameters of the tablets.

The effect of increasing compaction pressure on the surface roughness parameters is shown in Table 1. In all cases there is a decrease in the values with increasing compaction pressure, a direct correlation existing between the tablet porosity and all four parameters ($P < 0.02$) confirming earlier results showing a direct correlation between the porosity and the Ra value (Rowe 1978a). Fig. 2 shows the effect of increasing the concentration of the polymer in the coating solution again confirming earlier results (Rowe 1978b.) While there are formulae for the calculation of the Ra and Rp values, any correlation between these and the other parameters will only hold for a specific surface profile. However, invariably Ra will be the smallest measurement, Rp will be greater than Ra and Rt will be the largest measurement: Rtm, because of its definition will always be a fraction of Rt. The ratio of Rtm to Ra gives an overall indication of the type of surface profile. In this study the ratios were 8·0 (range 7·2–8·5) for the uncoated tablets i.e. surfaces produced by the consolidation of a powder involving the fragmentation and deformation of particles, and 5·4 (range 4·9–5·7) for tablets coated with a polymer film formed by the evaporation of solvent from droplets of coating solution. The ratio of Rp to Rt is a useful guide to the nature of the 'peaks' in the profile e.g. if Rp $\simeq$ Rt then the peaks are high and narrow but if Rp $\ll$ Rt then the peaks are more rounded and broad based.

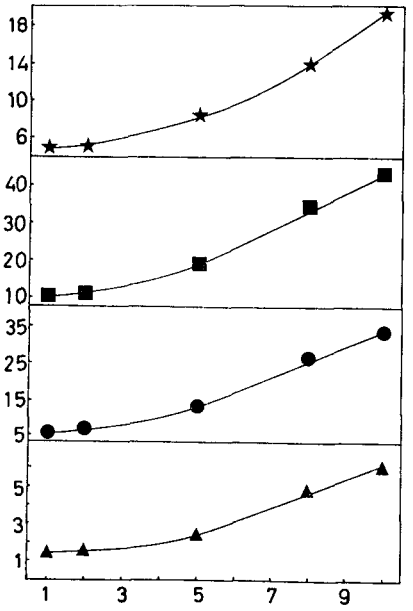

FIG. 2. The effect of solution concentration (% w/v) (abscissa) of the Rp(★) Rt(■) Rtm(●) and Ra(▲) values (μm) of tablets coated with hydroxypropyl methylcellulose.

Table 2. Ra values of tablets coated with varying solution concentrations measured on different instruments.

Polymer concn % w/v	Surface roughness Ra (μm) This study	Rowe (1978b)
1	1·26 ± 0·26	1·36 ± 0·18
2	1·42 ± 0·12	1·51 ± 0·11
5	2·34 ± 0·30	2·32 ± 0·26
8	4·86 ± 0·56	4·83 ± 0·13
10	5·99 ± 0·92	6·47 ± 0·52

For both surfaces in this study the ratio was 0·4 (range 0·35–0·5).

It can be seen, therefore, that a knowledge of all the parameters is necessary if surfaces are to be constructively compared. But, if only changes in the surface finish are to be assessed, e.g. in the optimization of film formulations or process conditions during product development, any one of the parameters can be used. Since the results (Table 1) show a direct relationship between all the measured parameters and the tablet porosity and it is known that a similar relationship exists between the porosity and the film/tablet adhesion as measured using a tensile tester (Rowe 1978a), then it would be expected that any one of the parameters could be used in analysing adhesion results. In this respect Ra values have already been shown to be directly related to the adhesion of polymer films to both metal substrates (Reegen & Ilkka 1962) and tablet surfaces (Rowe 1978a) but no such relationship was found for peak to valley values (Nadkarni et al 1975). It would appear advisable, therefore, to standardize on the Ra value since most surface finish measuring instruments have the capability of measuring this parameter and a comparison of the results obtained in this and a previous study using a different instrument (Rowe 1978b) on different samples of tablets from the same batch, show the good reproducibility between instruments (Table 2).

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