

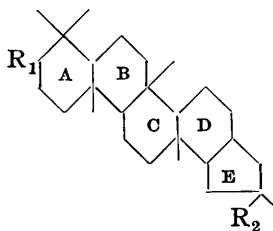
136. Surface Films of Lupane Derivatives.

By P. BILHAM, E. R. H. JONES, and R. J. MEAKINS.

Surface-film measurements on a number of lupane derivatives are described. The small limiting area values observed, particularly with bisnorlupanic acid and ψ -lupenol, and the large area values with lupenediol and lupanetriol monoacetate, in conjunction with chemical data, furnish evidence that in lupeol the *isopropenyl* group is situated at the opposite extremity of the ring system from the hydroxyl group.

MANY sterols (Adam, Askew, and Danielli, *Biochem. J.*, 1935, **29**, 1786), and triterpenes (Askew, J., 1936, 1585) containing water-attracting groups form stable unimolecular films when spread on water, or in some cases, dilute acid or alkali. The degree of compressibility of the films and comparison of the limiting area per molecule (found by extrapolation of the pressure-area curve to zero) with the cross-sectional area measured on scale models yield information regarding the position of the water-attracting group relative to the polycyclic system. Sterols and triterpenes with hydroxyl groups at the extremities of the ring system form almost incompressible films with limiting areas of 38–42 A.² and 45–50 A.², respectively.

Although much information is available concerning the chemistry of the hydroxyl and the *isopropenyl* group of the triterpene alcohol lupeol, there is almost a complete lack of evidence as to their relative positions in the molecule. It has been suggested, partly on chemical evidence and partly by analogy with other triterpenes, that this alcohol can be represented by the accompanying structure ($R_1 = OH$; $R_2 = CMe:CH_2$) (Jones and Meakins, this vol., p. 757; Ruzicka and Rosenkranz, *Helv. Chim. Acta*, 1940, **23**, 1311). The isolation of 6-hydroxy-1 : 2 : 5-trimethylnaphthalene from the products of selenium dehydrogenation of lupeol (Ruzicka, Furter, Pieth, and Schellenberg, *ibid.*, 1937, **20**, 1564; Heilbron, Kennedy, and Spring, J., 1938, 329) and of other triterpenes (for summary, see Haworth, *Ann. Reports*, 1937, **34**, 329) suggests the location of the hydroxyl group in ring A, a conclusion which receives support from the limiting area of 50 A.² for lupeol films measured by Askew (*loc. cit.*). The available chemical evidence makes it highly improbable that the *isopropenyl* group also could be situated in this ring. Surface-film measurements of lupane derivatives containing water-attracting groups in, or replacing, the *isopropenyl* group seemed to offer an opportunity of establishing the position of



this unsaturated centre. The results obtained with such lupane derivatives are indicated in the following table and accompanying figures.

Curve.	Substance.	R ₁ .	R ₂ .	Limiting value of area and μ at that area.	
				Area (A. ²).	μ (e.s.u. $\times 10^{-21}$).
Fig. 1	1 Lupanol	OH	CHMe ₂	50	324
	2 ψ -Lupenol	H	C(CH ₂ ·OH):CH ₂	50	212
	3 Bisnorlupanic acid	H	CO ₂ H	48	239
Fig. 2	4 Lupanediol	H	CMe(OH)·CH ₂ ·OH	57·5	217
	5 Acetylbisnorlupanic acid	OAc	CO ₂ H	46	543
	6 Bisnorlupanic acid	OH	CO ₂ H	55	452
Fig. 3	7 Lupanetriol monoacetate	OAc	CMe(OH)·CH ₂ ·OH	{ 124 55	{ 955 650
	8 Lupenediol	OH	C(CH ₂ ·OH):CH ₂	{ 138 63	{ 400 470
	9 Norlupanol	H	CH(OH)Me	74	227
	10 Norlupanediol	OH	CH(OH)Me	88	672

The small limiting areas and the incompressible nature of the films of bisnorlupanic acid and ψ -lupenol (in close agreement with those of lupanol, lupeol, and the amyryns), in conjunction with chemical evidence, lead to the conclusion that the R₂ groups in these compounds, and consequently the *isopropenyl* group in lupeol, are situated in ring E at the extremity of the cyclic system. This conclusion is supported by the value for acetyl-bisnorlupanic acid, where the carboxyl group is probably attracted to the aqueous surface in preference to the acetoxy-group. A somewhat larger molecular area was observed with a film of the free acid, and here it is probable that the molecule is sited on the hydroxyl group. [Askew (*loc. cit.*) concluded that the oleanolic acid molecule was also sited on the hydroxyl group.] Location of these R₂ groups in other positions in ring E, particularly on the carbon atoms joining rings D and E, would undoubtedly give rise to films with greater limiting areas than those observed.

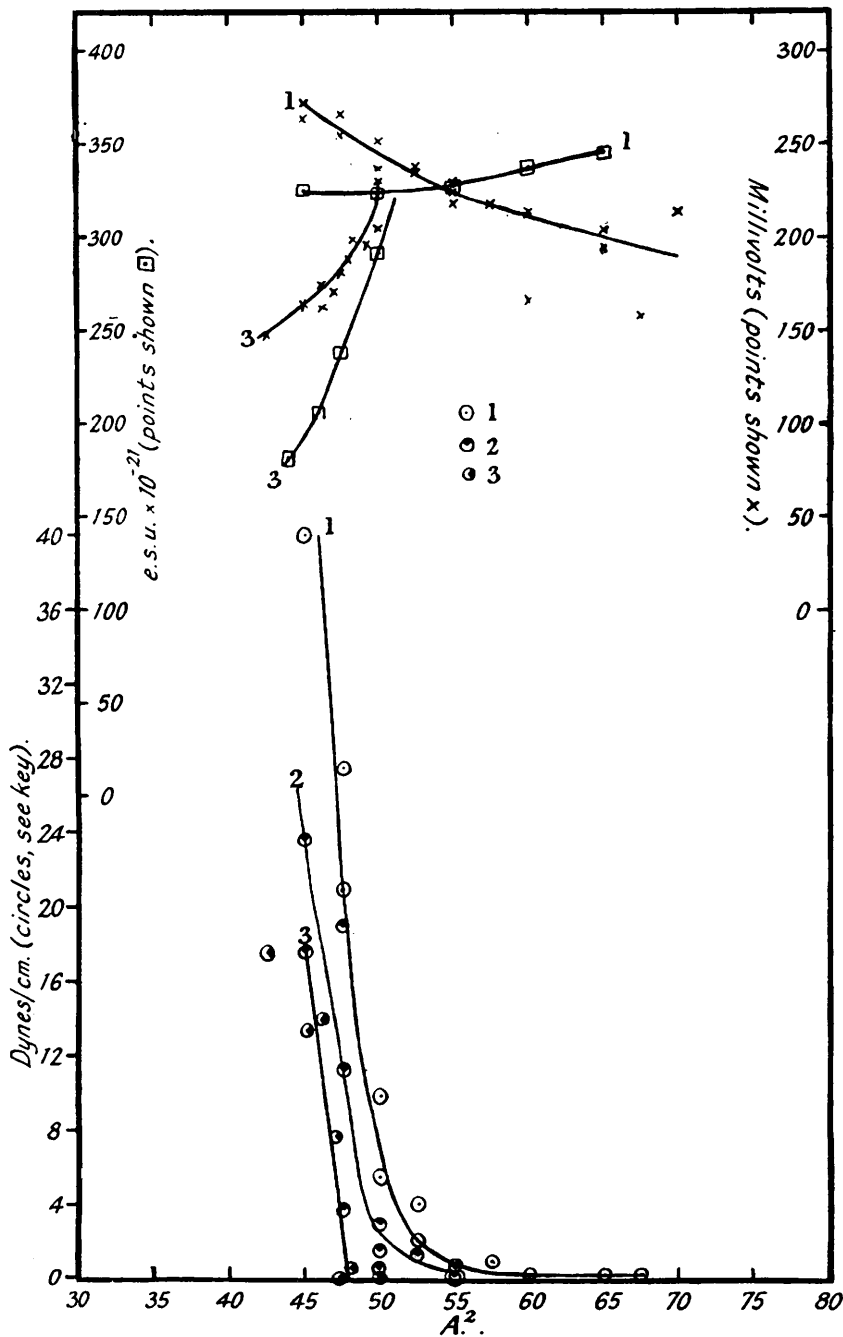
The larger area and the greater compressibility of the lupanediol film (9·5 A.² greater than for bisnorlupanic acid) may be due to a tilting of the molecule caused by simultaneous water-attraction of the adjacent hydroxyl groups, and the same effect is found with lupanetriol monoacetate, the second area value being correspondingly greater (9 A.²) than that of acetylbisnorlupanic acid.

Lupanetriol monoacetate and lupenediol gave results which indicate definitely that the *isopropenyl* group is situated at the opposite end of the ring system to the hydroxyl group, the limiting areas agreeing well with that (120 A.²) from measurement of a molecular model oriented in such a way that both the R₁ and the R₂ group are in the water surface. The curves are dealt with here in some detail since they illustrate clearly the phenomenon of the raising of one of two water-attracting groups from the surface. The curve for lupanetriol monoacetate shows at 128 A.² the first indication of a close-packed film which offers resistance to further compression until a pressure of 6 dynes/cm. is imposed. The extrapolated limiting area of this portion gives a value of 124 A.², which shows that the cyclic system is pinned down on to the water surface. The value of μ is slightly enhanced over this region. A further increase in pressure of only 3 dynes/cm. produced a reduction of the area over the very large range from 110 to 60 A.², but during this phase the μ value fell markedly, corresponding to a profound change in the orientation of the molecules. Finally, the formation of a second incompressible film capable of withstanding high pressures (up to 33 dynes/cm.) was observed. The limiting area observed on extrapolation of the second compressibility curve is 55 A.² (*cf.* lupanediol), as would be expected if the group of lesser hydrophilic character, *i.e.*, the acetoxy-group, were removed from the surface. The film was perfectly reproducible, and the surface potentials did not vary more than 10 mv. over the whole surface. Only very slight indications of spontaneous contraction were observed in the first compression region.

The same three phases, although not so clearly defined, are discernible in the curve of lupenediol. The initial close-packed film is formed at 138 A.², and the point of inflexion occurs at 124 A.² at a pressure of 3·6 dynes/cm. The area can then be reduced to 60 A.²

before any greater pressure than 6 dynes/cm. need be applied, but at this point a highly incompressible film is formed which is not stable at pressures above 14 dynes/cm. It is

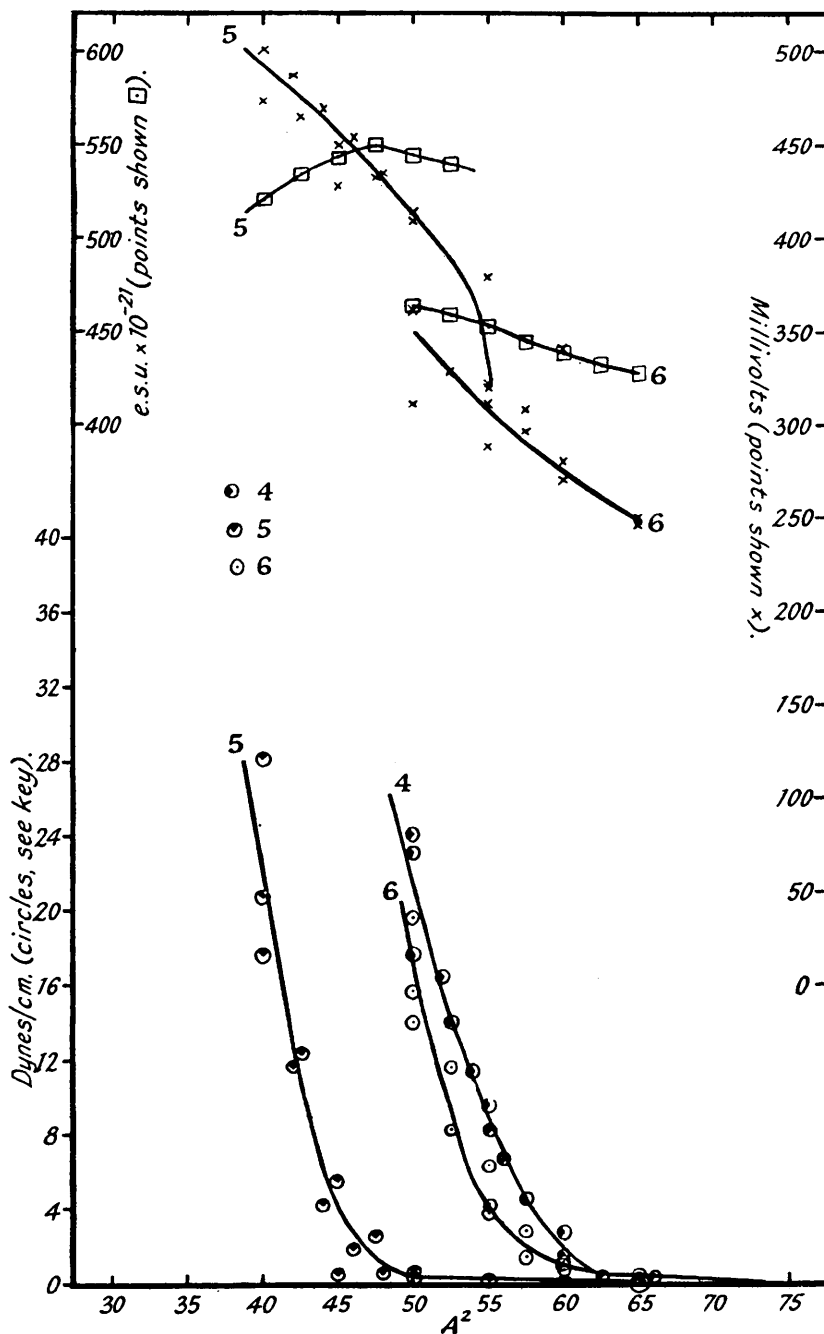
FIG. 1.



evident that at this stage the molecules are oriented so that only one of the two hydroxyl groups is in the water surface, but it is impossible to decide which has the stronger water-attracting properties. The limiting area here is ill-defined but is approximately 63 A^2 ,

which is markedly higher than the areas of 50 \AA^2 for ψ -lupenol and lupanol. An explanation of this is probably to be found in a slight residual attraction of the free hydroxyl

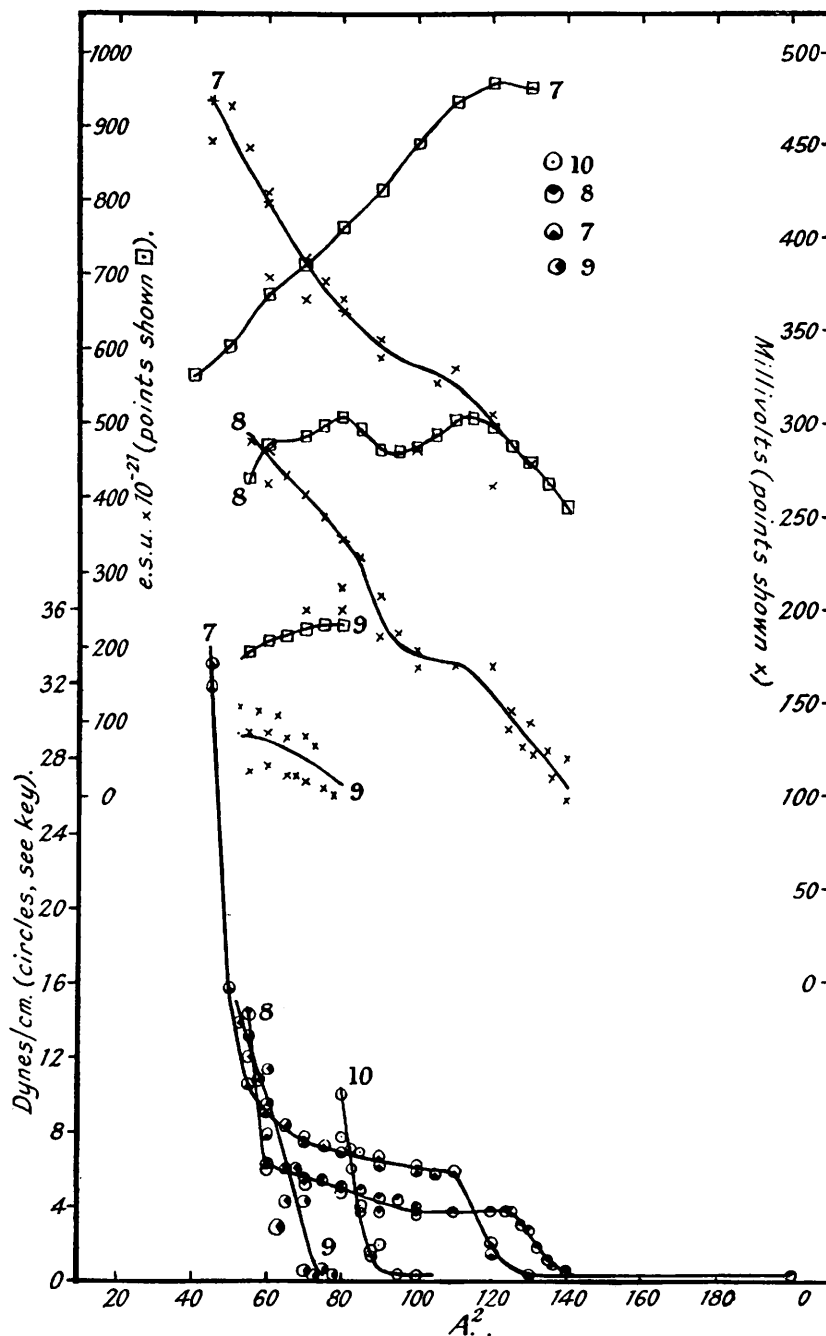
FIG. 2.



groups towards the water surface, thus causing tilting of the molecules. The value of μ follows a complex course, and it is probable that both the distortion of the isopropenyl group and the general rearrangement of the molecules in the film are responsible for the variations.

In contrast to the remaining lupane derivatives, which all gave "solid" films, norlupanol and norlupanediol both yielded easily compressible films of the "liquid" type

FIG. 3.



and exhibited larger areas than would be expected for molecules sited on the R_2 group. The only explanation which can be offered for this anomaly is that a steric effect of the adjacent methyl groups tends to prevent the hydroxyl group reaching the water surface,

and consequently causes tilting of the molecule which, in the case of norlupanediol, may be accentuated by the attraction of the second hydroxyl group towards the water surface. Of the lupane derivatives which yield "solid" films, only bisnorlupanic and bisnorlupanic acids do not exhibit the phenomenon of "spontaneous contraction" (Askew, *loc. cit.*).

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IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, S.W. 7.

LABORATORIES OF J. LYONS & CO., LTD., 149, HAMMERSMITH ROAD, LONDON, W. 14.

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