

Table 1. ANALYSIS OF SYNTHETIC MIXTURES OF AMINO-SUGARS AND BLOOD-GROUP SUBSTANCES

Added		Found			
Glucosamine (per cent)	Galactosamine (per cent)	Glucosamine (per cent)		Galactosamine (per cent)	
0	100	0*		100*	
50	50	50		50	
76	24	74		26	
20	80	21		79	
37	63	35,35*		65,65*	
Blood-group substances		Analysis by Leskowitz and Kabat (ref. 2)		Found*	
Hog, 16		57	43	58,57	42,43
Horse, 6-15 per cent		69	31	67	33
Saliva, W.H., 2-10 per cent		61	39	55	45
Horse, 5-25 per cent		53	47	45	55

\* Samples were purified by adsorption on a 10-ml. column of 'Dowex 50' cation exchange resin (200-400 mesh, 12 per cent cross-linkage, H<sup>+</sup> form). The amino-sugars were completely adsorbed when placed on such columns in 2 ml. of 2 N hydrochloric acid. After washing the columns with water, the hexosamines were eluted with about 25 ml. of 0.75 N hydrochloric acid and lyophilized over silica gel-sodium hydroxide. The procedures described by Boas (ref. 8) and Roseman and Daffner (ref. 10) also should be adequate for this purpose. The blood group substances and the galactosamine sample initially were hydrolysed for 2 hr. in 2 N hydrochloric acid in a boiling-water bath

precision of the method apparently is the reproducibility of the Blix test. As a matter of routine, total hexosamines are determined in triplicate, and two aliquots of each sample are incubated with yeast and analysed in duplicate. 2-4  $\mu$ moles of total hexosamine (0.43-0.86 mgm. of the hydrochlorides) usually are sufficient for a complete analysis of each sample. This varies, of course, with the relative composition of the unknowns.

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<sup>3</sup> Eastoe, J. E., *Nature*, **178**, 540 (1954).

<sup>4</sup> Pigman, W. W., and Goepf, R. M., "Chemistry of the Carbohydrates", 146 (New York, 1948).

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<sup>7</sup> Blix, G., *Acta Chem. Scand.*, **2**, 467 (1948).

<sup>8</sup> Boas, N. F., *J. Biol. Chem.*, **204**, 553 (1953).

<sup>9</sup> Elson, L. A., and Morgan, W. T. J., *Biochem. J.*, **27**, 1824 (1933).

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### Contact Angles and Work of Adhesion

BECAUSE of frequent misunderstandings, we would like to emphasize that the work of adhesion  $W_{SL}$  in the equation,

$$W_{SL} = \gamma_L(1 + \cos \theta) \quad (1)$$

which one of us has recently pleaded<sup>1</sup> should be called Young's equation, is the reversible work required, per square centimetre, to separate the liquid from the solid, leaving an adsorbed film in equilibrium

with the saturated vapour of the liquid on the surface of the solid. This work is less than the work  $W_{SLO}$  required to separate the liquid from the solid, leaving a clean surface free from adsorbed vapour, by  $\pi_{SV^0}$ , the surface pressure of the adsorbed film of vapour on the solid. Calling  $W_{SL}$  in (1),  $W_{SLV^0}$ , to indicate the presence of the adsorbed film of saturated vapour,

$$W_{SLO} = W_{SLV^0} + \pi_{SV^0} \quad (2)$$

Harkins and Livingston's remark<sup>2</sup> that "it is extremely unfortunate that this equation came into notice at all" was made because Harkins had previously used  $W_{AB}$  for the work required to separate two liquids *A* and *B*, with clean surfaces and surface tensions undiminished by surface films of the other liquid. Later in the same paper<sup>3</sup> Harkins and Livingston stated that equation (1) is correct provided that  $W_{SL}$  means  $W_{SLV^0}$ , not  $W_{SLO}$ . The importance of the adsorbed film of vapour for the magnitude of the work of adhesion is usually greater for solid-liquid than for liquid-liquid systems; and attention has frequently been directed to it, first by Harkins and Dahlstrom<sup>4</sup>, later by Bangham and Razouk<sup>5</sup>, Harkins and Livingston<sup>6</sup>, and by others.

$\pi_{SV^0}$ , the difference between the work of adhesion to the clean and to the film-covered surface, cannot be measured directly; but  $\pi_{SV^0}$  can be calculated if the adsorption isotherm of the vapour on the solid can be measured. If  $\Gamma$  is the amount adsorbed when the pressure of the vapour of the liquid is *p*, the Gibbs adsorption equation,

$$\Gamma = \partial\pi/RT\partial\ln p \quad (3)$$

can be integrated to

$$\pi_{SV^0} = RT \int_0^{p^0} \Gamma d\ln p \quad (4)$$

as was shown by Bangham and Fakhoury<sup>6</sup>, and Bangham<sup>7</sup>;  $p^0$  is the saturated vapour pressure of the liquid.

$W_{SLV^0}$  is probably the work of adhesion of greatest practical importance and is by far the easiest to measure, since the part of the solid surface of importance for determining the contact angle is that immediately adjacent to the edge of the liquid, and must therefore be in equilibrium with vapour which is saturated, or nearly saturated. If  $W_{SLO}$ , which may be of greater theoretical interest, is required, the amount  $\Gamma$  adsorbed at a series of pressures of the vapour of the liquid must be measured and equations (2) and (4) used. On surfaces smooth enough to permit easy measurement of the contact angle, however,  $\Gamma$  will be so small that its measurement will usually be difficult.

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