

# Book Reviews

## Adhesion 2

Ed. K. W. Allen

Applied Science Publisher, £15

This is the second volume of papers to be published by Applied Science from the Annual Conference on Adhesion and Adhesives held at the City University, London. The Conference proceedings prior to 1975 were published under the title of 'Aspects of Adhesion' (Volumes 1 to 8) while the 1975 and 1976 proceedings were published in 'Adhesion 1'. However, 'Adhesion 2' contains one late paper from the 14th Conference held in 1976 and twelve papers from the 15th Conference held in 1977. The papers are not collected under any general headings but may be conveniently gathered under the headings of applications, environmental attack, non-destructive testing, stress-analysis of joints and surface chemistry.

Three papers from British industry illustrate how such diverse applications as the development of improved tyres, the solvent welding of plastics and an attempt to reduce oil leakage past rubber seals may benefit from a consideration of the basic adhesion principles involved. Indeed, this last paper from Shell Research Ltd outlines the results from the interesting idea of using an oleophobic layer (a highly fluorinated compound possessing a low critical surface tension) to reduce spreading and seepage of mineral oil past the shaft-seal interface.

The vitally important area of environmental attack by water on structural adhesive joints is discussed in two good papers. One, from Ciba-Geigy, is mainly concerned with theoretical aspects and is complemented by one from Air Force Materials Laboratories, USA which describes some novel concepts for improving joint durability by employing metal primers and electropriming techniques.

Another problem for the adhesive technologist is the non-destructive testing of adhesive joints and Dr Bijlmer of Fokker-VFW describes in detail the relation between surface potential difference measurements on treated aluminium-alloy surfaces and subsequent joint strengths and durability. A second paper is entitled 'Recent Developments in Non-Destructive Testing of Adhesive-Bonded Joints' which is rather misleading since the paper is strictly confined to 'Testing of Adhesive-Bonded Joints by Broad-Band Ultra-Sound', which in fact was the title used in the Conference programme.

The Bristol University group extend their finite-element analysis of joints to take into account non-linear elastic-plastic behaviour of the adhesive and show that this offers a significant improvement over previous studies which have assumed linear elastic behaviour. A paper from ICI Corporate Laboratory considers the mechanisms of failure of the commonly employed lap-joint geometry and develops an energy-balance argument to enable the failure force to be predicted.

Finally, four papers consider the role of surface forces in such diverse areas as cell

adhesion, liquid crystals, surface treatments for improving the adhesion to polyethylene and the adsorption of macromolecules from concentrated solutions.

The papers in this volume maintain a good standard but contain no really outstanding contribution. However, they should be of interest and value to research and development laboratories, technical service departments and university research groups.

A. J. Kinloch

## Durability of adhesive bonded structures

Ed. M. J. Bodnar

J. Appl. Polym. Sci. Applied Polymer Symposium No. 32  
Wiley, New York, 1977,  
443 pp. £13.40

This collection of papers is the third Picatinny Arsenal Symposium on Adhesives published in the Applied Polymer Symposia series and comes from the fourth symposium organised by the staff of the US Army Armament Research and Development Command. In a review of the previous (1972) collection<sup>1</sup> I had some very hard things to write about the presentation of some of the papers with graph paper reproduced, a plethora of uninformative photographs and a general appearance of an amateurish production. These features also disfigure the present book; nor is blatant advertising copy absent (*vide* p. 431) but, on the whole, the presentation has improved and it is fair to discuss the content rather than its presentation.

The organizers, as would be expected, have once again seized on the features of adhesive technology of most immediate concern to those dealing with structural adhesives. Recent accumulation of data on the behaviour of stressed bonded joints in adverse climates is leading to a new assessment of chemical treatments for aluminium and most of the earlier papers in this collection are concerned with this topic. A particularly interesting paper<sup>2</sup> of this group deals with the surface degradation of aluminium. It characterizes the surface produced by the standard treatment confirming that the sulphuric-chromic etch gives the structure suggested by Bijlmer<sup>3</sup>. The circumferential margins of the etch pits give the surface extremely reactive sites accounting both for its receptivity towards adhesive as well as the ease with which it can be contaminated or destroyed by high humidity. The techniques used were ellipsometry, Auger spectroscopy with ion etching, e.s.c.a. microscopy, surface potential difference measurements and contact angle measured with water. These techniques are used to follow changes in u.v. in air, moist air and so forth.

Several papers of this first group present evidence against the suitability of clad aluminium alloys for use as adherends. These modern techniques for examination of surfaces are also used in an attempt to charac-

terize the chemistry of the surface<sup>4</sup>, and Table 2 makes interesting reading with the various accepted treatments giving rise to a range of compounds from 'sub- $\alpha$  ides of  $Al_2O_3$ ' to mixtures of  $\gamma-Al_2O_3$  and  $Fe_3Si Al_2$ .

A second group of papers can be identified in which cyclical stressing in the tensile mode is used to construct Wöhler diagrams. Some of these papers omit to give the frequency employed and all quote number of cycles rather than the time. If the process is one of crack growth the number of cycles is relevant but if there is a continuous breaking of primary valency bonds as is implied in papers about joints subjected to static stress, then time becomes important. Moreover, frequency determines the temperature rise<sup>5</sup>. A continuation<sup>6</sup> of earlier work<sup>7</sup> on the prediction of the time-to-failure of a stressed joint shows how kinetic arguments can be supplemented by statistical ones.

One impression that arises from reading these papers with their enormous volume of work done, numbers of data collected and ingenuity shown, is that of the size of the US Aerospace industry. But need the reader be so overwhelmed by having to cope with a table of results extending over 7 pages (pp 278-84)? Do technologists only talk to themselves? This question is prompted by the first paper<sup>8</sup> but reoccurs to the reader at intervals throughout the book. The Newer Structural Adhesives of the title are given as M 1113, EA 9628, ADX 656.2 and PL 717B. Presumably all the participants in the meeting at the Picatinny Arsenal know which companies made these and what they are but that does not excuse the publisher who has put out the proceedings for international sale.

It is thus with mixed feelings that this book is recommended. With the exception of one or two papers its interest is only to the aerospace industry, for the shortcomings mentioned limit its usefulness over the range of adhesion science. On the other hand the topics have been well chosen and there are good papers contained in it. For its 443 pages it is inexpensive.

W. C. Wake

## REFERENCES

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- 4 Pattnaik, A. and Meakin, J. D. 'Characterization of Aluminum Adherent Surfaces', pp 145-158
- 5 Grimes, G. C. 'Durability of Composite Adherent Double Lap Bonded Joints Subjected to Tension-Tension Fatigue Loading', pp 261-290
- 6 Levi, D. W. 'Durability of Adhesive Bonds to Aluminum', pp 189-199
- 7 McAbee, E., Tanner, W. C. and Levi, D. W. *J. Adhesion* 1970, 2, 106-113
- 8 Wegman, R. F. 'Durability of Some Newer Structural Adhesives', pp 1-10