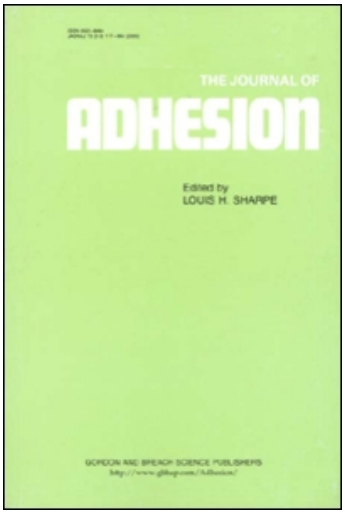

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BOOK REVIEWS

"Issledovaniya v oblasti poverkhnostnykh sil" ("Research on surface forces") B. V. Deryagin, editor. Nauka Publ., Moscow 1967. 544 pp. Rubles 3.00.

The third Russian conference on surface forces took place in 1966, and this is a collection of the papers presented to it. The proceedings of the conference of 1960 have been published in an English translation in 1962.

For several years, book reviewers have bemoaned publication of "no-books" which possess no more unity than an issue of, say, The Journal of Physical Chemistry. The semblance of unity which exists in the present collection is of a rather personal kind: the editor's work is referred to in almost every paper.

Five articles concern adhesion; four of them are by N. A. Krotova and her collaborators. They deal with the chemical activity of polymer fracture surfaces; with chemical treatment of poly(tetrafluoroethylene) (PTFE) for improving its adhesiveness; with the adhesion of polymers to germanium (2 papers); and with the electron emission during rupture of adhesive joints. It is hoped that they will be abstracted and thus made available, to an extent, to English-speaking scientists. In the meantime, it may be divulged that PTFE is treated in a corona discharge and then kept in a monomer (e.g., methyl methacrylate) at 80° for several hours. The thickness of the polymer film on the PTFE usually is of the order of 10 microns.

J. J. Bikerman

G. D. Andreevskaya, "Vysokoprochnye Orientirovannye Steklo-plastiki" ("High-strength Oriented Glass-Plastics"). Nauka Publ., Moscow 1966. 370 pp., Rubles 2.12.

The title refers to glass-reinforced plastics, especially to those in which the glass fibers are not woven but rather oriented in parallel directions, as in filament winding. However, the scope of the book is much wider. There are four chapters, namely "Glass fibers and their properties," "Polymer binders for reinforced plastics," "Adhesion phenomena at the interface between fibers and polymers and factors determining the adhesion strength" and "The structure peculiarities and the physico-mechanical properties of non-woven oriented glass-plastics."

Probably, Chapter IV is the most valuable in the book but the readers of this journal may be more interested in the second and the third chapters. The first half of Chapter II (46 pages) gives general information on the structure and mechanical properties of linear and cross-linked polymers. The majority of references is to Russian publications (e.g., Kargin and his school) but the result is not markedly different from what would be found in an analogous American publication. The treatment is almost entirely qualitative; the few equations reproduced are given without proof. The statistical theory of strength is clearly expounded but the author believes that it is insufficient to account for the time effect on strength. The main methods of testing for the degree of curing and the extent of cross-linking are reviewed. In the second half of Chapter II (52 pages) the main types of polymers used in reinforced plastics are considered; they range from epoxy resins to chains containing silicon, oxygen, aluminum and phosphorus.

Chapter III (108 pages, 264 references) is almost long enough to be a monograph on adhesion, although "hooking joints" (in which the adherend is fibrous

or porous) and the joints between two plastic materials are excluded from consideration. The impartiality noticeable also in the earlier chapters is particularly visible here. Different and often contradictory notions are presented with an almost equal sympathy. Only 10 to 20% of the active centers on the adherend surface take part in the formation of an adhesive bond; the strength of the latter is proportional to c^n, if c is the concentration of polar groups in the adhesive and n an exponent; the same strength depends on $d\gamma/d\eta$, γ being the surface tension of the adhesive solution and η, its specific viscosity; the electrostatic theory of adhesion "is supported by many electric effects occurring during the rupture of a joint"; many concepts of the chemical theory of adhesion "are fruitful." It is a relief to encounter some criticism: the author does not believe in the close relation between adhesion and friction and emphasizes that the diffusion theory of adhesion is not applicable to (impermeable) glass adherends. The reviewer's book ("The Science of Adhesive Joints") is listed among the references but his views on adhesive joints are not mentioned anywhere.

Description of the methods suggested for measuring the strength of joints is very welcome as it contains results of Russian work almost unknown abroad. The "factors influencing the adhesion of polymers" are presented chiefly from the viewpoint of the chemical theory of adhesion. When the turn of wetting comes along, the strength of a bond is said to be proportional to $\gamma\ (1 + \cos\theta)$, if θ is the contact angle between air, the adhesive and the adherend. The wealth of experimental data (especially of Russian origin) systematically presented in this chapter renders it highly useful in spite of the shortcomings indicated above.

A similar judgement seems to be valid for the whole book. It does not teach a doctrine as it contains too many mutually contradictory statements but it is a mine of information, neat and clearly marked, ready to enrich a skillful miner.

J. J. Bikerman

A. D. Zimon, "Adgeziya pyli i poroshkov" ("Adhesion of dust and powders") Khimiya Publ., Moscow 1967. 372 pp., Rubles 1.51.

This seems to be the first monograph on the adhesion of particulate matter to solids in any language. The first four chapters (General notions of particle adhesion, The methods of determining the adhesive force, Adhesion in gaseous (air) medium, and Adhesion in liquid media) are of a more general character, while the remaining seven chapters deal with special areas, namely dust adhesion to painted surfaces, in an air stream, in a water stream, in gas scrubbers, in miscellaneous industrial plants and in agriculture, and with the removal of adhering particles by an electric field. A list concluding the book contains about 550 references many of which are to patents.

Probably, it is permissible to state that several theories of adhesion hindered rather than advanced our understanding of the phenomenon. The author treats these theories more charitably than they deserve but comes to the conclusion (p. 39) that "at present, the forces of adhesion can be determined by the experiment only." The theories of electrostatic adhesion and of capillary attraction could have been a great help but their presentation is not rigorous enough; thus, the dielectric properties of the paint coat on a metal are not mentioned in the discussion of image forces (p. 74) and the liquid ring between a spherical particle and a plane surface is assumed (p. 79) to be a torus although it cannot be a torus and is likely to be a nodoid.

Adhesion of particles to a solid surface in an electrolyte solution is a phe-

nomenon particularly suitable for testing the theories of the mutual repulsion of electric double layers. Unfortunately, the presentation of these theories, although it is 11 pages long and contains 32 equations, cannot be termed perfect.

The absence of a guiding theory does not prevent a description of experimental observations, of which many have been made by the author himself and very many are interesting and/or important. Thus, the reader is informed that the adhesion of dust is almost independent of relative humidity as long as this is below 65%; that the sticking of minute glass spheres to iron and steel surfaces is greater when these surfaces are extremely smooth or extremely rough but has a minimum for a moderate rugosity; that adhesion may increase or decrease or remain unchanged on a change in the particle radius, and so on. A comparison of the adhesion in salt solutions with the predictions of the electrostatic theory is restricted by the fact that, instead of the force needed for separation, the investigators measured the relative number of particles which fell off the support when the latter was handled in a definite manner.

A wealth of information is contained in the "applied" chapters. An airplane flying through a radioactive dust cloud took up about 0.01 mg dust per cm^2. Adhesion of a glass powder to a polymer coating decreased for a few days after the coating application (presumably, as a result of the post-cure) but increased again after a year, presumably because the polymer became covered with cracks. A jet of water has to be propelled by a pressure of 15 atmospheres to remove gypsum or tar from an automobile surface.

Anyone concerned with the removing of dust from solids should consult this book to find out what people observed (or at least noticed) before.

J. J. Bikerman

J. J. Bikerman, "The Science of Adhesive Joints". Academic Press, New York 1968. 349 pages. $16.00.

This monograph is a fundamental summary of the physics and mechanics of adhesive joints with due regard to the contemporary concepts of surface physics and surface phenomena. This approach to the theory of formation and rupture of adhesive joints is the only one which is correct and sufficiently justified. The author correctly treats the adhesives as liquids in the moment of application and as elastic materials in completed joints, as the elastic rather than viscoelastic nature is characteristic for polymers in thin layers fixed between two solid surfaces.

The monograph is logically constructed and treats, step by step, all aspects of the formation and rupture problems of adhesive joints. From this point of view, it is the most objective of the monographs devoted to the subject. Moreover, the author does not confine himself to a compilation of known facts but considers them in the light of his original notions. Hence, the monograph has a highly distinct individuality and presents many ideas which may serve as a starting point for subsequent studies. The author's contention that, as long as a defect-less molecular contact exists along the geometrical boundary of the phases, the rupture of adhesive joints is in cohesion rather than in adhesion certainly deserves most concentrated attention. Solution of the problem of whether molecular contact is, or is not, sufficient to guarantee that adhesion strength exceeds cohesion strength, constitutes at present the main task of the science of adhesive joints. If the answer to this question is positive, the search after joints of high strength should be conducted in the direction of realization of a complete molecular contact. If the

answer is in the negative, then the effort should be directed toward synthesis of adhesives having active functional groups. As the two directions are basically different, a solution of the above problem will permit the best selection to be made.

The former point of view was suggested, and is being actively developed, by the author; and it finds its most complete description and argumentation in this monograph. In the reviewer's opinion, however, this viewpoint, supported by physical and mechanical considerations, requires a physico-chemical completion, that is, it needs a scrutiny of the mechanism of interaction in the contact zone with due regard to the chemical nature of the adhesive and the adherend and, of course, to the stress distribution across the adhesive joint in the presence of an external load. The stress distribution is important as a stress concentration along the geometrical phase boundary may overcome the excess of adhesive over cohesive strength even in an ideal adhesive joint.

In addition to the theoretical consideration of the formation and rupture processes of adhesive joints, the monograph contains the necessary complex of practically useful data and thus is a good combination of a theoretical and a practical text; it is undoubtedly valuable for both theoretical researchers and practical engineers. It must be emphasized that the monograph, as a whole, is a smooth combination of theoretical discussions with practical conclusions, while the majority of other relevant monographs are either theoretical textbooks or practical manuals. The inclusion of both aspects in one volume unavoidably leads to lacunes in the discussion of some branches of the science of adhesive joints, so that the monograph cannot be considered encyclopaedic and requires additions, in particular as far as the effect of the chemical nature of the adhesive and the adherend, the processes of structure formation, etc. are concerned; sufficient experimental data on these effects are available at present. However, the wealth of ideas and the new approach to many known experimental data together with the wide coverage of the theoretical and the practical aspects of the problem make the monograph one of the most interesting at present and one of the most fruitful in the future, as its many ideas will be gradually taken up. It may be added that the monograph completely covers the results obtained by the investigators in USSR.

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