difficulties. Prof. R. B. Mowat, in an interesting article, has pointed out that, from the French Revolution to the Battle of Waterloo, the whole of Europe was in the melting-pot before the impetus of that revolution was exhausted. In the same way it has been again in the melting-pot since 1914, and again we may expect the impetus of this revolution to die down. Then, as before, will come the period of reconstruction. What kind of world will arise depends much on our attitude now—it will decide whether the melting-pot is to be a witch's cauldron or a refiner's fire.

If we are to escape future disasters we must learn more about ourselves and our own nature. The ancient Greeks, and in our time Thomas Hardy, regarded man as the sport of inevitable fate; the modern psychologist shows us that fate is the outcome of individual and national temperament. The future is ours to redeem, and this can only be achieved by self-knowledge and mutual sympathy. One of the direst aftermaths of war is an inevitable hardening of the boundaries between nations and the withdrawal of feelings towards international sympathies. That is why the League of Nations failed, and why for the present federal union can only remain a dream. Nevertheless, it is an excellent thing to talk about federal union; it took years of talk to accustom men's minds to something so obviously right as the abolition of slavery.

Yet a more international spirit will have to arise if civilization is to be saved. Isolation in thought and ideals is absurd at the very time when wireless has joined up the whole world and it has become increasingly clear that even material prosperity depends on commerce being international. Peace must mean more than simply the cessation of war; it must be based on a new spirit of co-operation and we must hope for its emergence from the refiner's fire. H. G. Wells has said that the only chance of ever becoming more reasonable is by realizing how unreasonable we are; to which one might add—and by trying to understand why we are so unreasonable. Recent events have proved that, under the superficial crust of civilization, the age-long forces of savagery and brute instinct are still alive. To recognize their existence is the first step to canalizing their energy in right directions. "In man's very flesh and bones is the impulse towards closer and closer union in larger and larger fellowship. To-day he is fighting his way towards that goal." The path is difficult and will be fraught with many disappointments as in the past. It was recently remarked that the problem of the future is to combine individual freedom with collective responsibility. On whether we can achieve this or not depends the future of civilization. The world stands at the parting of the ways.

THE OIL/WATER INTERFACE

By DR. J. H. SCHULMAN,

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A JOINT meeting of the Faraday Society and the Physical Society was held in London on January 9 to discuss the oil/water interface. In spite of adverse conditions which prevail at the moment for such meetings, and the impossibility of the meeting taking on its usual international atmosphere, the room was quickly filled beyond capacity. There were also some of our Dutch, Belgian and Greek colleagues present to keep alive the spirit of international collaboration in science, fostered by the Faraday Society discussions. The discussion, which was opened by the president, Prof. E. K. Rideal, was at times very animated. The president stressed the implications this subject has on a very large number of scientific and industrial fields, and the papers read were divided into biological, physical, chemical (emulsions), and theoretical sections.

The chief aspects dealt with in the papers read were the influence of the chemistry and structure

of the interface on the adsorption and diffusion of ions and molecules on to and through the interface and on the kinetics of reactions taking place at the interface; likewise also, the influence the chemistry and structure of the ion or molecule has on the above factors.

Dr. A. E. Alexander (Cambridge) started the discussion by giving a review of the monolayer technique applied to both the air/water and oil/water interfaces, and stressed the use which a combination of the two methods has on elucidating and predicting phenomena occurring at the interfaces. Attention was directed to the fact that surface potential measurements at an oil/water interface can be made if the ionizing air electrode is in the air above, and not if the ionizing electrode is in the oil layer just above the interface. The oil layer has to be of the order of only 1 mm. or 2 mm. in thickness.

The discussion then centred on the fact that

at the oil/water or air/water interface the equation of state for substances examined by Alexander and Teorell gave $3/2 KT$ instead of KT as previously found by Langmuir.

It was pointed out by A. B. D. Cassie and R. C. Palmer (Leeds) in their paper that deriving a surface equation of state for strong electrolyte detergents by a combination of the Poisson, Boltzmann and Gibbs equation gave a factor of $3/2 KT$ for ionized films as compared with KT for unionized films. They actually used Alexander and Teorell's results to confirm their theoretical deductions. It would appear that the presence of the ionized polar group at the end of the hydrocarbon chain, as compared with an unionized polar group or dipole, is responsible for this 1.5 factor in the equation of state for monolayers at interfaces. A confirmation of this suggestion was considered important.

Dr. G. S. Hartley gave the first demonstration of how simple alterations in the structure of the adsorbing molecule can radically affect interfacial conditions. It is known that the lowering of interfacial tension at the oil/water interface is due to the ions of the paraffin chain salts, and the sudden break in the interfacial tension concentration curve coincides with the formation of micelles.

Hartley reasons, therefore, that by changing the structure of straight single-chain paraffin salt to that of a double-chain salt, two changes in the interfacial tension phenomena curves should take place. First, on changing the configuration of the non-polar portion of the molecule, one alters the adhesion balance of the molecule with the water molecules. Thus, with two chains there would be more accessibility for the water molecule to the hydrocarbon molecule than with one chain; hence the double-chain molecules would have less interfacial activity at identical concentrations. However, since steric factors with the two chains would alter the micelle packing, greater concentrations of the double-chain ions would be required before micelle formation can take place. Thus one should obtain with double-chain molecules a greater lowering of the interfacial tension than with a single-chain molecule containing an equal number of carbon atoms.

This theory is very prettily justified experimentally. Single-chain ions of sixteen carbon atoms, or double-chain ions with one long and one short chain, lower the interfacial tension at low concentrations to a greater extent than double-chain ions of eight carbons each. But at higher concentrations the double-chain ions lower the interfacial tension to much smaller values than the single-chain ions. This fact is well demonstrated by the spontaneous emulsifying properties of sodium dioctyl sulphate

(Tergitol) as the agent in an oil-in-water system as compared with sodium cetyl sulphate, showing that there must be a very low interfacial tension of the solution of the double-chain molecules.

A. C. Frazer (London), J. F. Danielli and J. H. Schulman (Cambridge) showed how physical chemical studies of interfacial phenomena can be applied to biological problems.

Frazer has established by a series of direct analogies with artificial systems that the particles which exhibit strong Brownian movement in blood plasma are fat emulsions, stabilized by a protein film around each particle. The particles consequently behave as a protected colloid and have all the physical chemical properties of the adsorbed protein and not of the fat of which they are essentially composed. Furthermore, the protein adsorption is specific, since the particles take on the characteristics of the globulin fraction of the serum. Strong support is given from the monolayer and electrophoretic techniques in establishing the fact that fats adsorb preferentially the globulin fraction of the serum and not the albumen fraction.

Discussion immediately centred around this important result. It was considered unlikely that the fats could participate in this specificity, and it was suggested that it was due to some difference in the chemical constitution of the proteins affecting their hydrophobic - hydrophilic balance. The globulins were supposed to have more CH_2 groups in their side chains than the albumens; but on the other hand the serum globulins are known to associate with lipoid substances specifically in the serum, which may account for their ability to adsorb on to fats, etc.

It has been shown by Frazer that this preferential adsorption of the important serum globulin which is associated with the immunity properties of serum, is given also by toxins (bacterial and snake venom) and hormones such as insulin. The biological activity of these substances is completely inhibited when they are in the adsorbed state. Apparently the phenomenon is reversible since, upon the emulsions being broken, the biological action of these substances returns. This is a very good example of how orientation of a molecule or certain components of the molecule at an interface can radically alter its chemical activity (as exemplified by its biological action). The significance of these results was fully appreciated by the meeting.

J. H. Schulman demonstrated how alterations in the structure and orientation of molecules composing the interface can also radically affect the course of a reaction taking place at the oil/water interface. From direct analogies as to the mutual orientation of the hydrocarbon chains attached to the acid and alcohol radical of an aliphatic ester

at an air/water interface, the adsorption of OH^- ions to the interface and the specificity of the digestion of aliphatic esters by ferments can be explained. Thus when the hydrocarbon chains are orientated parallel to one another (*cis* form) leaving unrestricted approach to the polar group from the water phase, adsorption of OH^- ions can take place together with digestion of the esters by lipoclastic ferments. If the chains are orientated opposite one another (*trans* position) adsorption of OH^- ions is greatly restricted and digestion is completely inhibited. It requires only a 5-carbon atom hydrocarbon chain on the acid radical to bring about complete indigestion of the ester; but 5-carbon atoms on an alcohol radical chain permit the molecule to orientate in the *cis* position and be easily digested. Thus, ethyl valerate is indigestible, but amyl propionate is readily digested by the lipoclastic ferment in pancreatin. The activity of the ferment itself is enhanced by the presence of most paraffin chain salts both positive and negative, except that of the long-chain sulphates, which cause complete inhibition of the ferment action in minute concentrations.

The adsorption of OH^- ions at oil/water interfaces was discussed in some detail following the presentation of results obtained by the school of Prof. W. C. McC. Lewis at Liverpool on the electrophoresis of emulsions or suspensions of oil in water (W. Dickinson and G. Growney).

It was shown that the adsorption varies markedly with a number of factors. In the first place, it varies with the physical nature of the surface, that is, liquid or solid. Discussion took place on the interesting fact that the increase of adsorption of OH^- ions in alkaline solution on the change from a solid to a liquid is gradual. The melting point gives no marked change. This was explained by the fact that X-ray diagrams of paraffins show no marked change over the melting point. Thus the change in area of the surface molecules in the neighbourhood of the melting point can be considered as changing gradually and not in a sharply defined manner as characterized by the melting point. This also gives an explanation for the apparent anomaly of the adsorption of OH^- ions on mixtures of ethyl laurate and stearic acid.

Stearic acid alone is a solid, but mixed in small concentrations with ethyl laurate it will give a liquid film of adsorbed stearic acid at the ethyl laurate/water interface. A liquid film of stearic acid will adsorb more OH^- ions than either a solid film of stearic acid or a liquid film of ethyl laurate.

The adsorption also varies with the stereochemical structure of the oil phase and hydrogen ion concentration. Thus aliphatic long-chain esters

fall into three groups: those that are solids which adsorb OH^- ions poorly; those in which the esters are orientated in the *cis* form, which absorb OH^- ions gradually with increasing *pH*, and those in which the esters are presumably orientated in the *trans* form, or in a form which only permits adsorption to take place at *pH* 9.

Discussion took place as to the reason why the electrophoretic mobility of ester (or other hydrocarbon compounds) suspensions changes with increasing *pH* until *pH* 9 is reached, and then remains nearly constant. There is no change in the curve over the region where hydrolysis is known to commence. There was no adequate explanation forthcoming for these interesting facts, which may have some bearing on the mechanism of hydrolysis in general.

J. F. Danielli (Cambridge) gave a theoretical interpretation of interfacial phenomena as related to a living cell. The cell membrane consists (to a first approximation) of a thin oil layer with a protein film adsorbed on its two surfaces. A molecule penetrating through the membrane must penetrate (a) the external interface, (b) diffuse through the thin oil layer, (c) penetrate the internal (cytoplasm-oil) interface. Attempts were made to plan the kinetics of diffusion through this system on a quantitative basis: this problem cannot yet be dealt with accurately owing to lack of a theory of diffusion which is cognizant of the influence of structure on diffusion. Some useful preliminary relationships between oil-water partition coefficients and permeability constants have been obtained, and approximate values calculated for the permeability of a thin oil layer to hydroxylic compounds. It was emphasized that with polar compounds the resistance to free penetration lies largely in the necessity of breaking hydrogen bonds between polar groups and water before penetration of the external oil-water interface can occur, and with non-polar compounds the principal resistance lies in the difficulty experienced by hydrocarbons in diffusing from oil into water.

The problem of emulsions was presented by R. C. Pink (Belfast) and A. King (London). The former pointed out that metallic soaps are poor emulsifiers unless they act as solid stabilizing agents. There are three essential functions attached to a solid stabilizing agent essential for emulsion stability. The agent must be insoluble in both phases, but must be wetted by both phases, and the particles must inter-associate to form a stable interfacial layer. A metallic soap which can be readily dispersed in oil acts as a solid stabilizing agent if the action of water precipitates it out of dispersion; thus magnesium oleate gives excellent water-in-oil emulsions, whereas zinc or nickel oleate give no emulsions.

A. King stressed the importance of the inter-

facial film on the stability of emulsions in general as measured by the change of area of the interface with time. Emulsions stabilized by agents such as soaps give much finer emulsions than those stabilized by solids such as alumina, but the former are easily influenced by the presence of salts and temperature, whereas the latter are stable against most conditions, such as salts, temperature and pH. The effect of salts of the lyotropic series on emulsions stabilized by saponin are interesting. Thus sulphates increase both stability and viscosity, whereas thiocyanates and iodides markedly reduce these properties of the emulsions.

J. Powney and L. J. Wood (London), in con-

clusion, brought to the attention of the meeting the interesting fact that whereas electrophoretic mobility of droplets and interfacial surface tension both depend on the formation of interfacial films, in a number of cases no correlation apparently exists between the two phenomena. Thus over very small concentrations of the salts of long-chain sulphates and amines, great changes in electrophoretic mobility (of oil droplets) are observed with no measurable change of interfacial tension. Only over the range of concentration where the electrophoretic mobility is nearly constant does the interfacial tension seem to change in any marked degree.

OBITUARIES

Mr. D. Ward Cutler

THE death of Donald Ward Cutler, head of the Microbiological Department at the Rothamsted Experimental Station, came as a sudden and unexpected shock to his colleagues. He had been at his work as usual, then was suddenly struck down with pneumonia and survived only a few days. He was trained in zoology at Cambridge under Prof. Stanley Gardiner, and after his happy and successful undergraduate years at Queens' College he went to the Marine Biological Station at Plymouth to investigate fish scales. In 1915 he joined Prof. S. J. Hickson's staff at Manchester, where his gift for lecturing and for teaching made him a useful member of the department; in his free time he studied the Protozoa of termites. A weak heart prevented his being accepted for active service, but he gave valuable help in the Pathological Department set up for the Manchester war hospitals and became an expert on amoebic dysentery.

After the War he transferred to Rothamsted to take charge of the microbiological work that had for some time been going on there. His first investigations were on the Protozoa of the soil which had been shown to play an active part in the microbiological processes, and he soon succeeded in clearing up many of the difficulties that had arisen in connexion with them. He confirmed Goodey's observation that the ciliates were probably not very active, and Martin and Lewin's observation that the amoebae were active, and he showed why amoebae could not easily be picked out from the soil. In conjunction with L. M. Crump he made daily counts of the numbers of bacteria and of certain Protozoa in the soil of one of the Rothamsted fields, carrying on the work without intermission for a whole year, and so obtained a rich mass of data which has since proved very valuable in soil microbiology. The numbers showed considerable fluctuations from day to day,

but the bacteria and the Protozoa fluctuated in opposite directions: when the Protozoan numbers were high those of bacteria were low, and vice versa. This accorded with the view that the Protozoa were acting detrimentally on soil bacteria. Later work, however, showed the operation of another factor: in culture solutions the bacteria generally proved to be more efficient when their numbers were low than when they were high, so that the amount of activity per head of bacterial population was actually increased by the action of the Protozoa.

He also studied the bacterial oxidation of ammonia to nitrate, and showed that this is a commoner property than had been supposed.

In recent years his chief work had been on the purification of effluents from sugar beet and milk factories, an investigation carried out at the request of the Department of Scientific and Industrial Research. He was in charge of the microbiological side and the late E. H. Richards of the chemical side, and the good personal relationships of the two leaders enabled them to bring the work to a satisfactory conclusion. During these investigations much valuable information was accumulated about the decomposition of organic matter by bacteria, and this is now being put together.

Ward Cutler's interests, however, were by no means confined to microbiology. He was an active member of the Councils of the Eugenics Society and of the British Social Hygiene Society, and he wrote two well-known books, "Heredity, Evolution and Adaptation" and "Some Problems in Soil Microbiology". He was also a good lecturer, giving generous service to the Workers' Educational Association and other bodies. For many years, too, he was an enthusiastic supporter of amateur theatricals, wherein he displayed no mean ability. Finally, he had an attractive personality and the great gift of winning the loyal support of his staff. E. J. RUSSELL.