

INELASTIC SCATTERING OF PROTONS BY MAGNESIUM AND ALUMINIUM

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THE inelastic scattering of protons by some light elements has been investigated experimentally, using 4.5-MeV. protons from the Cambridge cyclotron. The energy spectrum of the scattered protons was determined by using a proportional counter in conjunction with absorbing foils. The experimental arrangement was similar to that used by Dicke and Marshall, except that provision was made for observation of the scattered protons at angles between 20° and 160° at 10° intervals. Only proton groups corresponding to excited states less than 2.5 MeV. above the ground-state were able to reach the counter. The resolving power was improved by a factor of four over that obtained by Dicke and Marshall by the simple expedient of rotating the scattering foil through 90° from the position adopted by them, which minimizes the effect of target thickness. Under these conditions the resolving power was about 250 keV. for inelastic groups of equal amplitude.

The spectrum of the protons scattered by magnesium is shown in Fig. 1. The first inelastic group corresponds to a Q value of -1.36 ± 0.03 MeV., and in view of its large amplitude is almost certainly associated with the predominant isotope, magnesium-24. The excited state of the residual nucleus which is involved is probably that which is responsible for the 1.38-MeV. gamma-ray emitted following the beta-decay of sodium-24, which has been measured very accurately by Siegbahn². The Q value of this group remained constant with angle to within ± 0.015 MeV., which represents the relative error in the measurements at different angles. The second inelastic group corresponds to an excited state 1.82 ± 0.04 MeV. above the ground-state, and in view of its small amplitude may belong to an isotope other than magnesium-24. The presence of an inelastic group at this energy has recently been confirmed by Bush and Fulbright³, though these authors state that its amplitude is comparable with that of the first inelastic group for higher bombarding energy.

The spectra of the protons scattered through three different angles by aluminium are shown in Fig. 2, from which it is seen that the first inelastic group has a complex structure. At 90° the peak is nearly resolved into two groups, and can be well explained by the existence of excited states in aluminium-27 respectively 0.80 and 0.97 MeV. above the ground-

state. The shape of the peak varies considerably with angle, and in general is too indefinite to admit of such a precise interpretation as that given at 90° , though the left-hand component seems fairly well established at 0.97 ± 0.02 MeV. All that can be said with certainty is that this level is accompanied by at least one other level lying above 0.75 MeV. The second inelastic group was able to reach the counter only for scattering angles less than 90° , and corresponds to an excitation energy of 2.15 ± 0.05 MeV. There is little correlation between the excited states of aluminium-27 obtained in this way and existing information⁴ on the gamma-rays which follow the beta-decay of magnesium-27.

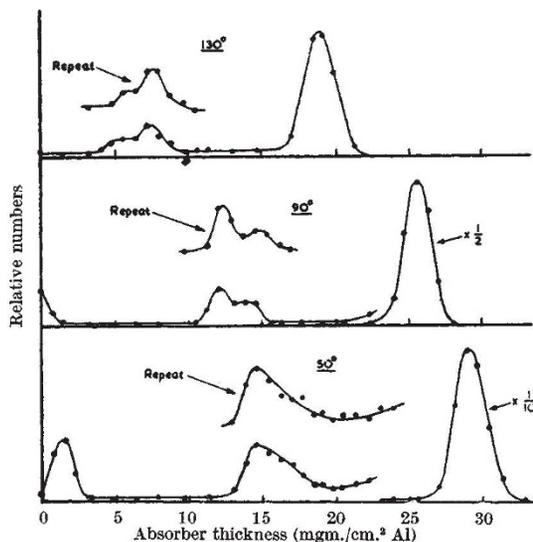


Fig. 2. Spectra of protons scattered by aluminium (incident proton energy = 4.56 MeV.). The vertical scale is not necessarily the same at all angles

The first inelastic group from magnesium is considerably larger than that from aluminium, and has a very different excitation function. The former increases sixfold on raising the incident proton energy from 4.2 to 4.7 MeV., whereas the latter is almost independent of energy in this region. This can be understood in terms of penetration of the potential barrier by the outgoing proton, since, in the case of aluminium, the proton emitted has almost enough energy to pass over the top of the barrier at the lowest bombarding energy used. This suggests that at these bombarding energies the reaction is predominantly a (p, p) process involving formation of a compound nucleus, which is interesting in view of suggestions^{5,6} that nuclear excitation might be effected by Coulomb interaction. The total cross-section for excitation of magnesium to the 1.38-MeV. state by 4.73-MeV. protons is about 8×10^{-25} cm.² (assuming it to be associated with magnesium-24),

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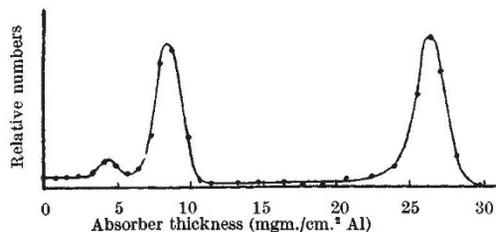


Fig. 1. Spectrum of protons scattered through 110° by magnesium (incident proton energy = 4.73 MeV.)

while that for excitation of aluminium to the 0.97-MeV. state by 4.4-MeV. protons is about 1.2×10^{-25} cm.². These figures were estimated by an indirect method, and are reliable only to within about 30 per cent.

The scattering of protons by beryllium was also investigated briefly, and an inelastic group observed corresponding to an excited state 2.39 ± 0.05 MeV. above the ground-state, in agreement with the results of Davis and Hafner⁷. This state is unstable with regard to neutron emission. No inelastic groups were observed from carbon, oxygen or copper.

I would like to thank Dr. A. E. Kempton and Mr. L. Coates for assistance in the experiments.

¹ Dicke and Marshall, *Phys. Rev.*, **63**, 86 (1943).

² Siegbahn, *Phys. Rev.*, **70**, 127 (1946).

³ Bush and Fulbright, *Phys. Rev.*, **74**, 1206 (1948).

⁴ Benes, Hedgran and Hole, *Ark. Mat. Ast. Fys.*, **35A**, Paper 12 (1948).

⁵ Weisskopf, *Phys. Rev.*, **53**, 1018 (1938).

⁶ Guth, *Phys. Rev.*, **68**, 280 (1945).

⁷ Davis and Hafner, *Phys. Rev.*, **73**, 1473 (1948).

MOLECULAR WEIGHT DETERMINATION ON THYMO- NUCLEIC ACID COMPOUNDS BY DIELECTRIC MEASUREMENTS

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Sodium Thymonucleate

THE molecular weight of a thread molecule with a permanent dipole moment such as desoxyribose nucleic acid can be calculated from the anomalous dispersion of the dielectric constant. By the so-called ellipsoid method¹ sodium thymonucleate was shown to have an extremely high dielectric increment, and the molecular weight was found to be very low (only about 16,000). This value, which was obtained only from measurements in 0.1 per cent aqueous solution, has since been found erroneous. In any event, it is quite clear that the dielectric method gives considerably lower values than those obtained by the ultracentrifuge, diffusion or streaming birefringence methods (200,000–1,500,000)²⁻⁴.

In continuing the investigations the ellipsoid method was considerably improved and attained a considerable degree of exactness, and was especially adapted to the unexpectedly high frequencies needed for desoxyribose nucleic acid. Fig. 1 shows examples of some anomalous dispersion curves of the sodium salt of the acid (prepared according to Hammarsten⁵) at different concentrations. The arrows indicate the inflexion points (critical wave-lengths), and the broken curves are the theoretical dispersion curves according to Debye. The smaller graph shows the dielectric increments at different concentrations and at a wave-length of 1,000 metres (0.3 Mc./s.).

The new measurements with 0.1 per cent solution agree well with those previously obtained, except at

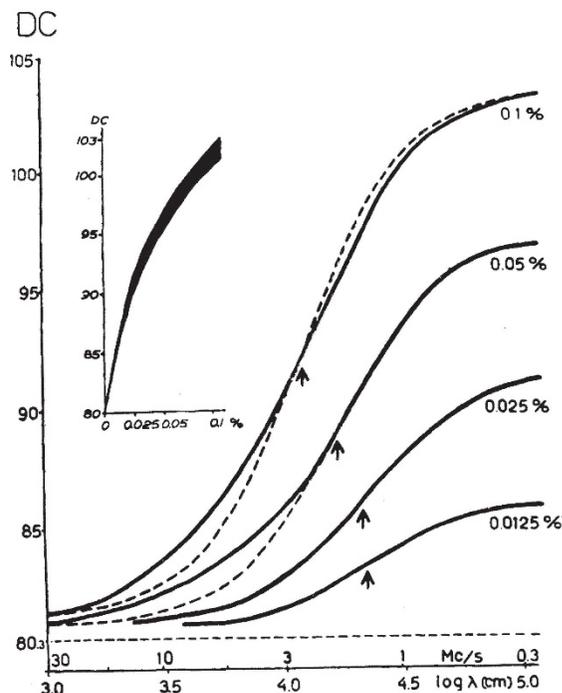


Fig. 1. Anomalous dispersion curves of sodium desoxyribose nucleate at different concentrations. Temperature 20° C. Concentrations in gm. of air-dried substance (moisture content 22.1 per cent) per 100-ml. solution

the highest frequencies, where the earlier results were misleading. Nevertheless, there still occurs a small but constant deviation from the theoretical curve according to Debye (see graph). This deviation can be explained by association, but it indicates that the 'molecular weight' thus obtained is not a true one.

An attempt to reduce the amount of association by measuring in even more diluted solutions revealed an unexpected effect, namely, that the apparent 'molecular weight' increased with the degree of dilution. This is evident from Fig. 1, which shows that the inflexion point advances towards longer wave-lengths. The reason for this advance is not clear, but we assume that in less dilute solutions a structure is formed (by non-polar association; cf. the smaller graph). In such a structure, the larger aggregates would be impeded in their orientation in the alternating field, and the polarization would be more dependent on smaller and easily movable parts. In very dilute solutions (less than 0.03 per cent) the experimental and theoretical dispersion curves coincide, the critical wave-length is nearly constant, and a dielectrically uniform molecular weight of about 135,000 is obtained.

The high tendency to association led us to doubt whether the new value of about 135,000 was a true molecular weight. It has now also been shown that the 'molecular weight' readily changes, for example, on the addition of small quantities of salts. The effect is completely reversible. It is remarkable, however, that only insignificant additions are needed for the 'molecular weight' to fall, and at a concentration of 0.002 M sodium chloride we get approximately 35,000. We have not been able to get lower values. Difficulties due to the method itself prevent measurements in strong salt solutions, and other treatments of desoxyribose nucleic acid (heating,