Table 1

Electrolyte used	$S \times 10^4$ in mhos	Values of ζ_a for the movement of boundary		Average ζ_a in milli- volts
		Upward	Downward	
KCl	75.60	44.32	48.48	46.4
BaCl ₂	3.70	23.83	26.63	25.2
MgCl ₂	8.87	26.03	26.20	26.1
AlCl ₃ (containing a little HCl)	6.75	31.98	32.08	32.0
AlCl ₃ (containing less HCl)	5.59	31.07	32.22	31.6
AlCl ₃ and KCl mixture	10.53	37.16	37.20	37.2
BaCl ₂ and KCl mixture	12.27	30.42	30.60	30.5
BaCl ₂ and KCl mixture	15.10	33.05	32.25	32.7

sol was separated from the sediment of large particles and the lower part of the *U*-tube was filled with it, the upper part being filled with a solution having the same specific conductivity as that of the intermicellar fluid of the sol occupying the lower part. The electric current, *i*, flowing through the system during electrophoresis was carefully measured. From the cross-section of the *U*-tube, the current, *i*, and the specific conductivity of the intermicellar fluid, the potential gradient was calculated. (In no case did the specific conductivity of the intermicellar fluid differ from that of the corresponding colloid-electrolyte mixture by more than 4 per cent. In the case of potassium chloride the difference was less than 1 per cent.) The results are recorded in Table 1.

From these results it was found that if $1/\zeta_a$ is plotted against $1/S$, two straight lines are obtained, one for the mixtures of aluminium chloride with hydrochloric acid and potassium chloride, and the other for magnesium chloride, barium chloride and mixtures of barium chloride and potassium chloride. These lines meet the $1/\zeta_a$ axis at two points very close to each other, giving the average value of $\zeta = 49 \pm 1$ mV. The different values of $\chi/\zeta r$ for the two straight lines are therefore to be attributed to the variation of either χ or r , or both, depending on the nature of the electrolytes used. Electro-osmotic data obtained with negatively charged silver iodide coagula⁵ indicate that χ does not depend on the nature of the electrolytes, and we are inclined to attribute the variation of $\chi/\zeta r$ to the change of r only.

The true ζ -potential found for the same arsenious sulphide sol under identical concentrations of the stated electrolytes by the electro-endosmotic method is 51 mV. The values of the true ζ -potential of arsenious sulphide particles in the region of slow coagulation in the presence of equicoagulating concentrations of the electrolytes, as measured by the electrophoretic and electro-osmotic methods, are thus in good agreement, and their mean is 50 mV. These results, therefore, confirm our previous conclusion that a given rate of coagulation of a colloid is characterized by a definite value of the ζ -potential independent of the valency of the counter ions used.

B. N. GHOSH
K. C. RAY

Physical Chemistry Laboratory,
University College of Science,
Calcutta 9. July 7.

¹ Bikerman, *Trans. Farad. Soc.*, **35**, 154 (1940).

² Henry, *Trans. Farad. Soc.*, **44**, 1021 (1948).

³ Booth, *Trans. Farad. Soc.*, **44**, 455 (1948).

⁴ Ghosh, *Trans. Farad. Soc.*, **49**, 1477 (1953).

⁵ Ghosh, Rakshit and Chatteraj, *Trans. Farad. Soc.*, **50**, 729 (1954).

⁶ Ghosh and Rakshit, *Sci. Culture*, **18**, 498 (1953).

Preparation of Aluminium Borohydride and its Applications in Organic Reductions

It was found that the reaction of aluminium chloride with calcium borohydride¹ in a tetrahydrofuranic solution gives a solution of aluminium borohydride:

Calcium chloride is precipitated and can be separated by centrifuging in sealed centrifuge tubes; the supernatant contains the tetrahydrofuranic adduct of aluminium borohydride. (By cooling to -50° this solution gives colourless crystals of this adduct.) Partial evaporation of such a solution at atmospheric pressure gives a residue the aluminium borohydride content of which is considerably greater. Since the boiling point of aluminium borohydride is about 20° lower than that of tetrahydrofuran, this shows that the aluminium borohydride adduct has considerable stability.

The tetrahydrofuranic solution of aluminium borohydride is not spontaneously inflammable in air (unlike undiluted $\text{Al}(\text{BH}_4)_3$), and thus it is relatively safely applicable for reductions of organic compounds.

It is interesting to note that aluminium chloride gives a good yield of the borohydride only with calcium borohydride; under similar conditions (tetrahydrofuranic solution) lithium borohydride gives a small yield, while sodium borohydride does not react.

With such solutions (or with solutions of distilled aluminium borohydride² in dry tetrahydrofuranic) carboxylic acid esters can be reduced selectively to the corresponding primary alcohols. For example, ethyl benzoate and ethyl-*p*-nitrobenzoate are at room temperature reduced to the corresponding carbinols; similarly the aldehydes and ketones, respectively.

Nitriles give the corresponding primary amines: benzyl cyanide and 3,4-dimethoxy benzyl cyanide give primary amines with a yield of about 50–60 per cent.

Nitriles are not reduced with the borohydrides of the alkaline metals; even calcium borohydride—which is a much stronger reducing agent—reduces nitriles only very slowly and with low yields.

Thus the reducing power of the complex borohydrides is lowest in the class of the borohydrides of the alkaline metals (which have a structure of ionic salt character) and highest in the case of aluminium borohydride, which represents a typical covalent structure (boiling point 44° (760 mm.)). The alkaline-earth metal borohydrides represent an intermediate grade in structure as well as in their reducing power.

These correlations between structure and reducing power have, in our opinion, a bearing on the mechanism of such reductions and indeed point to the importance of a molecular reducing mechanism.

Note added in proof. After submitting this paper, a communication appeared by H. C. Brown and B. C. Subba Rao (*J. Amer. Chem. Soc.*, **77**, 3164; 1955) dealing with applications of a solution of sodium borohydride and aluminium chloride in diethylene glycol-dimethyl-ether for reduction of organic compounds.

J. KOLLONTSCH
O. FUCHS

Research Institute of the
Pharmaceutical Industry,
Rottenbiller-u.26, Budapest, VII.

¹ Kollontsch, J., Fuchs, O., and Gábor, V., *Nature*, **175**, 346 (1955).

² Schlesinger, H. J., Brown, H. C., and Hyde, E. K., *J. Amer. Chem. Soc.*, **75**, 209 (1953).