

In the experiments of Gavis and Gill, no appreciable change of velocity or radius along the jet was observed; in all of their experiments, however,  $G$  was always negligible with respect to unity, and so eq. (4) is concordant with their observations but cannot be quantitatively tested thereby.

For other reports where expansion has been described no data are available for axial tensions. Further experiments in the region where  $G$  is comparable with unity are presently being pursued.

This work was carried out under a grant (#30180) from the National Science Foundation whom the authors wish to acknowledge and thank. One of us (SLG) wishes also to thank the National Science Foundation for receipt of a NSF Predoctoral Fellowship.

### References

1. Merrington, A. C., *Nature*, **152**, 663 (1943).
2. Clegg, P. L., *The Rheology of Elastomers*, Pergamon, New York, 1958, p. 174.
3. Mooney, M., *Rheology, Theory and Applications*, Academic Press, New York, 1958, Vol. 2, p. 181.
4. Lodge, A. S., *The Rheology of Elastomers*, Pergamon, New York, 1958, p. 70.
5. Truesdell, C., *J. Rational Mech. Anal.*, **1**, 173 (1952).
6. Braun, I., and M. Reiner, *Quart. J. Mech. Appl. Math.*, **5**, 42 (1952).
7. Gill, S. J., and J. Gavis, *J. Polymer Sci.*, **20**, 287 (1956).
8. Gavis, J., and S. J. Gill, *J. Polymer Sci.*, **21**, 353 (1956).

S. L. GOREN  
S. MIDDLEMAN  
J. GAVIS

Department of Chemical Engineering  
The Johns Hopkins University  
Baltimore, Maryland

Received February 28, 1960

### Ion Exchange Properties of Nitrocellulose-Coated Cellophane Membranes

It has been observed that nitrocellulose-coated cellophane membranes (M.S.A.T. 400) exhibit cation selective properties. These properties were first observed indirectly when cellophane membranes were used in conjunction with Permaplex permselective membranes in a three-compartment electro dialysis cell for the simultaneous electro dialysis and electrodecantation of ammoniated skim rubber latex.<sup>1</sup> Experiments with pure ammonia solutions were also carried out (see Fig. 1) and are reported below.

Figure 2 shows the current at constant voltage flowing across the cell plotted against time for three combinations of membranes;

- (1) Permaplex C.20 (cation-selective)-Permaplex A.20 (anion-selective), (no cellophane).
- (2) Permaplex C.20-(Permaplex A.20 together with cellophane M.S.A.T. 400) (Fig. 1).
- (3) (Permaplex C.20 together with cellophane M.S.A.T. 400)-Permaplex A.20.

The electrolytes used were identical in all cases.

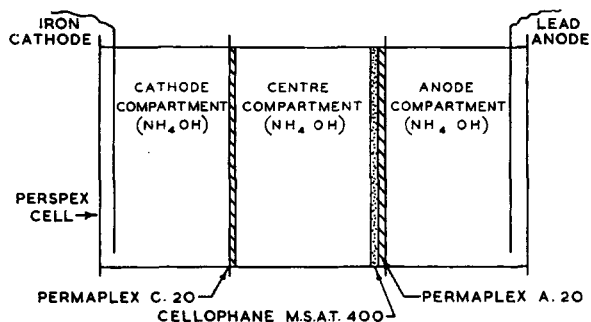


Fig. 1. A schematic representation of a three-compartment electro dialysis cell.

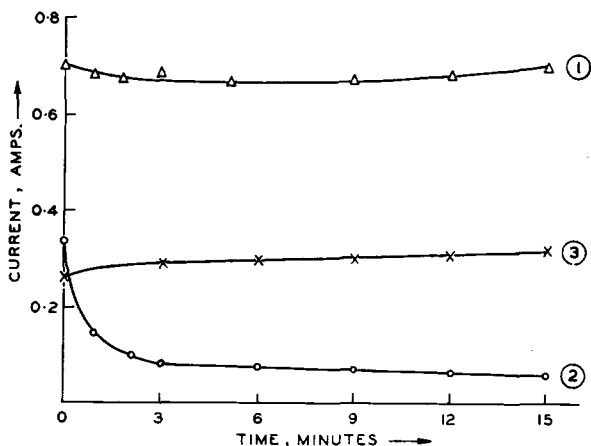


Fig. 2. The variation with time of current at constant voltage for three different combinations of membranes.

Curve 1 shows that without cellophane the current remains almost constant. If cellophane is used together with the anion-selective membrane (A.20), the current falls rapidly to a low level (Curve 2), but if the cellophane is used together with cation-selective membrane (C.20) the current, although lower than when no cellophane is used, again remains constant (Curve 3). A possible explanation is that the cellophane acts as a cation-selective membrane so that the film of liquid between the cellophane and Permaplex A.20 (condition 2) is deionized and the resistance rises. But in the case of condition 3 where the cellophane membrane is combined with the cation-selective membrane, C.20, the film of liquid between them is supplied with cations, and therefore no increased resistance results. In the case of condition 1, no such film is present. In all the experiments the cellophane membranes used were presoaked in the electrolytes used.

When the experiments were repeated with plain transparent cellophane (uncoated), P.T. 300, no increased resistance was found with time for the combination of Permaplex A.20 and cellophane, thus indicating no cation selectivity.

In order to find the degree of cation selectivity of the nitrocellulose-coated cellophane membrane, a few quantitative experiments were conducted in a two-compartment electro dialysis cell, using only a cellophane membrane. The transport number of the cations, which is directly related to

the current efficiency, was determined. The current efficiency is defined as the ratio of the equivalents of permeating ions actually transferred through the membrane to the number of equivalents of electricity passed. The electrolytes studied were KCl and  $\text{NH}_4\text{OH}$  solutions. The results obtained are given in Table I.

The results of this work support the theories of Neale and Standring,<sup>2</sup> who showed that nondiffusible ionogenic groups are present in a membrane such as a sheet or a strip of cellulose. The dissociation in aqueous medium of a portion of these groups causes the membrane to acquire a nega-

tive potential with respect to each of the contiguous solutions.

The author is grateful to Professor P. V. Danckwerts for helpful suggestions and to the British Council and the Board of the Rubber Research Institute of Malaya for their interest and support.

#### References

1. Sethu, S., M.Sc. (Eng.) Thesis, London, 1959, pp. 146-155.
2. Neale, S. M., and P. T. Standring, *Proc. Roy. Soc. London*, **213A**, 530 (1952).

S. SETHU\*

Department of Chemical Engineering  
Imperial College of Science and Technology  
London, S.W. 7, England

Received April 5, 1960

\* Present address: The Rubber Research Institute of Malaya, P. O. Box 150, Kuala Lumpur, Malaya.

TABLE I  
Cation Selectivity of Nitrocellulose-Coated Cellophane Membrane

Electrolyte	Transport number of cations at		
	0.05N	0.10N	0.20N
KCl	0.800	0.710	0.700
	0.720	0.760	0.690
$\text{NH}_4\text{OH}$	0.792	0.790	0.700