3. Rogovin, S. P., R. F. Anderson, and M. C. Cadmus, *J. Biochem. Microbiol. Technol. Eng.*, **3**, 51 (1961).

4. Wolff, I. A., H. A. Davis, J. E. Cluskey, L. J. Gundrum, and C. E. Rist, *Ind. Eng. Chem.*, **43**, 915 (1951).

PAUL R. WATSON
ALLENE JEANES
CARL E. RIST

Northern Regional Research Laboratory
Agricultural Research Service
U. S. Department of Agriculture
Peoria, Illinois

Received July 21, 1961

## Graphical Presentation of Copolymer Composition

The relationship between copolymer composition and monomer composition is often shown in graphic form by a plot of $F_1$ versus $f_1$, where $F_1$ is the mole fraction of monomer 1 in the copolymer being formed at the instant when $f_1$ is the mole fraction of monomer 1 in the unconverted monomer. In terms of relative reactivities,

$$\frac{F_1}{F_2} = \left(1 + \frac{r_1 f_1}{f_2}\right) \bigg/ \left(1 + \frac{r_2 f_2}{f_1}\right) \quad \text{or} \quad Y = r_1 X \frac{(1 + r_1 X)}{(r_1 r_2 + r_1 X)}$$

where $Y = F_1/(1 - F_1)$, $X = f_1/(1 - f_1)$, and $r_1$ and $r_2$ = relative reactivities.[1]

Usually the compositions are plotted as $F_1$ against $f_1$ on arithmetic coordinates similar to $x,y$ diagrams for vapor-liquid equilibria. However, a diagram of log $Y$ versus log $X$
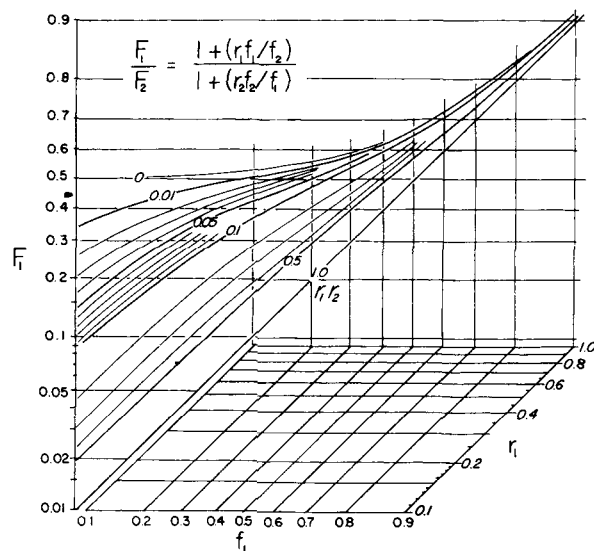


Figure 1

has several advantages. In the first place, "ideal" systems ($r_1 r_2 = 1$) plot as straight lines with a slope of 1. Even systems with $r_1 r_2 \neq 1$ show much less curvature and therefore require fewer calculated points to estimate completely. Moreover, since $r_1$ and $X$ appear together, a plot of log $Y$

versus log $X$ (when $r_1 = 1$) is changed (from that when $r_1 \neq 1$) merely by adding log $r_1$ to the abscissa.

In the second place, the log $X$, log $Y$ diagram can be used as a graphic solution for $F_1$ as a function of $f_1$, $r_1$, and $r_2$. In Figure 1, the abscissa and ordinate are labeled $f_1$ and $F_1$ although log $X$ and log $Y$ are actually plotted. The shifting of the $f_1$ axis is done graphically by a logarithmic scale of $r_1$. Example: Copolymer composition ($F_1$) desired when $f_1 = 0.4$ for vinyl acetate (monomer 1) and vinyl chloride (monomer 2); $r_1 = 0.23$, $r_1 r_2 = 0.39$. (a) Follow $f_1$ (at bottom of figure) to intersection with $r_1 = 0.23$. (b) Move vertically to line for $r_1 r_2 = 0.39$, read $F_1 = 0.24$.

### Reference

1. Flory, P. J., *Principles of Polymer Chemistry*, Cornell Univ. Press, Ithaca, New York, 1953, p. 180.

F. RODRIGUEZ

Geer Rubber and Plastics Laboratory
Cornell University
Ithaca, New York

Received February 27, 1961

## A Convenient Preparation of a Hydroquinone Redox Polymer

Many types of polymers have been described in the literature known as either redox polymers, electron-exchange polymers, or nondiffusible reducing agents. Examples of these are polyvinyl hydroquinone,[1,2] copolymers of vinyl hydroquinone,[3] polyvinyl gentisal,[3] polyacrylylascorbic acid,[3] and poly-3-(2,5-dihydroxyphenyl)propylene oxide.[4]

Recently we have had occasion to prepare polymers containing the monosubstituted hydroquinone structure, linked by a chemical bond stable to concentrated alkali. Most of the polymers listed above are tedious to prepare, and we now wish to report a convenient synthesis of polymeric hydroquinones. The method involves the reaction of a polymeric primary or secondary amine with 2,5-dihydroxyhydrocinnamic acid lactone. An optimum polyamine is polyethyleneimine because the amine equivalent weight is low, resulting in a high hydroquinone content on a weight basis, and also because the resulting tertiary amide structure is quite stable to alkali.
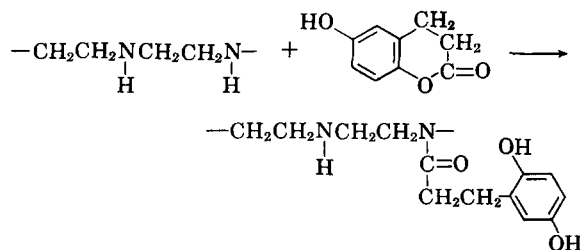


### Experimental

The 2,5-dihydroxyhydrocinnamic acid lactone was prepared by conventional methods from 2,5-dimethoxybenzaldehyde and malonic acid followed by reduction and simul-