The need for water-insoluble nitrogen fertilizers that will release available nitrogen at rates approximating crop requirements has been recognized. Natural organics have been used to meet this need but are not ideal in two important respects. First, most of the available nitrogen is converted to mineral forms in a relatively short period. Second, a very substantial percentage of the total nitrogen is not available (9). Furthermore, most of the better grades of natural organics are used for livestock feed rather than for fertilizers and the unit price of nitrogen in natural organics is high. These considerations indicate the need for synthetic water-insoluble nitrogen fertilizers with controlled rates of availability and also high total availabilities.

Before World War II, urea-ammonia-liquor (3) was marketed for ammoniation of fertilizers. The liquor contained a small amount of formaldehyde for the purpose of forming water-insoluble nitrogen materials during ammoniation and subsequent storage of the product. The urea-formaldehyde compounds thus formed were sources of slowly available nitrogen (7). The present study relates to the preparation and properties of certain urea-formaldehyde products, with special reference to their value as sources of fertilizer nitrogen.

\[
\begin{align*}
\text{C} & = \text{O} \\
\text{N} & = \text{CH}_2 \\
\text{C} & = \text{O} \\
\text{N} & = \text{CH}_2
\end{align*}
\]

\[
\text{N} = \text{CH}_2 + \text{water} \xrightarrow{\text{weak acid}} \left[ \begin{array}{c} \\
\text{NH}_2 \\
\text{C} = \text{O} \\
\text{NH}_2 \\
\text{N} = \text{CH}_2 \end{array} \right]
\]

\[
\begin{align*}
\text{neutral or slightly alkaline} & \quad \text{NH} \cdot \text{CH}_2 \text{OH} \\
\text{C} & = \text{O} \\
\text{NH} \cdot \text{CH}_2 \text{OH}
\end{align*}
\]

\[
\begin{align*}
\text{C} & = \text{O} \\
\text{N} & = \text{CH}_2 \\
\text{N} & = \text{CH}_2 \\
\text{N} & = \text{CH}_2
\end{align*}
\]

\[
\text{- water} \quad \text{Molding Powder}
\]

\[
\text{Catalyst}
\]

\[
\text{NH} \cdot \text{CH}_2 \text{OH}
\]

**Figure 1.**—Urea-formaldehyde reactions.