Lecture Demonstrations in Organic Chemistry

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Confronted with the problem of offering laboratory instruction to more students than our laboratories could accommodate, we resorted to the use of lecture demonstrations as a substitute for regular laboratory work in undergraduate organic laboratory chemistry.

These demonstrations are being offered to a group of beginning students in organic chemistry who are majoring in the field of home economics. With respect to this course, there are three points that deserve special emphasis: first, these demonstrations are intended for small groups of students, numbering about twenty to twenty-five to the section; second, two hours of outside preparation are required of the student before coming to class; and, third, these demonstrations are offered to students who are not majoring in chemistry and whose subsequent training will not be handicapped by the omission of this particular laboratory work.

In order to assure ourselves that the students do spend time in preparing for the exercise, reports on the topic under consideration are required to be handed in at the beginning of the demonstration hour. Further, to insure methodical preparation of this outside work, the reports are graded, and five to ten minute quizzes over the assignment are frequently given at the beginning of the demonstration hour. The lecture hour is devoted to the informal demonstration exercise and two hours to the preliminary outside preparation, meeting the usual requirement of three hours work for one hour of college credit.

The experiment selected as illustrative of the method is a comparatively simple one, namely, the preparation and properties of acetylene. The demonstration takes form somewhat as follows:

Acetylene is normally prepared by the action of water on calcium carbide;

$CaC_2 + 2\ H_2O \rightarrow H{\cdot}C{:}C{\cdot}H + Ca(OH)_2$.

Acetylene and other members of the series may be prepared by (a) the removal of two equivalents of "HX" from certain dihalogen compounds, as

$CH_3{\cdot}CH_2{\cdot}CHBr_2 + 2\ KOH$ (powdered) $\rightarrow CH_3{\cdot}CCH + 2\ KBr + 2\ H_2O$, (b) the removal of four equivalents of "X" from certain tetrahalogen compounds, as

$CH_3{\cdot}CBr_2{\cdot}CHBr_2 + 2\ Zn$ (ethyl alcohol and acetic acid) $\rightarrow CH_3{\cdot}CC{\cdot}H + 2\ ZnBr_2$,

or (c) by condensing metallic acetylides with alkyl halides as illustrated by the following equation;

$CH_3{\cdot}CC{\cdot}Na + X{\cdot}R \rightarrow CH_3{\cdot}CC{\cdot}R + NaX$.

From the laboratory viewpoint, the first method proves to be the most economical and satisfactory for the preparation of acetylene.

About five grams of calcium carbide are placed in a 50 cc.–distilling flask which is mounted on a ring stand and fitted with a dropping funnel. The side neck of the flask is connected with a bend of glass tubing in such a way that the gas may be collected by displacement of water from five-inch test tubes. After collecting samples of the gas, the following reactions are considered and the simpler ones illustrated.

The chemical properties of the "-yne" compounds may be characterized by:

1. Their tendency to burn with a smoky flame and to form explosive mix-

tures with air. Both of these properties are less pronounced in the case of "-ene" compounds, and still less observable in the case of the "-ane" compounds.

2. Their capacity to enter into addition reactions, as summarized below, when treated with (a) alkaline permanganate solution, halogens, or ozone, (b) molecular hydrogen in the presence of a catalyst or hydrogen from appropriate reducing agents, and (c) halogen acids, sulfuric acid, oxides of nitrogen, hypohalous acids, and similar compounds.

a. Oxidative addition		b. Reductive addition		c. Simple addition	
$CH_3 \cdot C \equiv$	$C \cdot H$	$CH_3 \cdot C \equiv$	$C \cdot H$	$CH_3 \cdot C \equiv$	$C \cdot H$
↓	↓	↓	↓	↓	↓
OH	OH	H	H	Cl	H
Cl	Cl			Br	H
Br	Br			I	H
I	I/(alcohol)			$HO \cdot SO_2 \cdot O$	H
O_3				ONO	NO
				OH	X

Only the initial stages of the reaction are indicated.

3. Polymerization, when passed through a hot tube, to give well defined derivatives;

3 H·C:C·H, passage through a hot tube → C_6H_6 (benzene)

4. Substitution reactions involving the hydrogen atom attached to a carbon atom, which is attached in turn to another carbon atom by a triple bond. Specific examples are;

H·CC·H+2 $Cu(NH_3)_2Cl$, aq.→Cu·CC·Cu+2 NH_4Cl+2 NH_3, and

H·CC·H+2 $Ag(NH_3)_2NO_3$, aq.→Ag·CC·Ag+2 NH_4NO_3+2 NH_3.

In conclusion, the "-yne" compounds may be prepared from calcium carbide, from dihalogen compounds, from tetrahalogen compounds, or from acetylides. The principal chemical properties of the "-yne" compounds, aside from burning, are characterized by (a) three types of addition reactions, (b) polymerization to give well defined derivatives, and (c) substitution to give acetylides.