TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 9, Sayı 3, Eylül 2012

Journal of
TURKISH SCIENCE EDUCATION
Volume 9, Issue 3, September 2012

http://www.tused.org

Prospective Science Teachers' Misconceptions in Organic Chemistry: The Case of Alkenes

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Received: 08.08.2011 **Revised:** 02.04.2012 **Accepted:** 21.05.2012

The original language of article is Turkish (v.9, n.3, September 2012, pp.160-185)

Keywords: Alkenes; Misconception; Chemistry Education; Organic Chemistry.

SYNOPSIS

INTRODUCTION

During the last three decades, with the effects of Constructivist learning theory, students' prior knowledge has gained importance in education. Many studies showed that students have some prior knowledge that is not scientifically correct (Driver &Easley, 1978; Driver &Erickson, 1983; Fleer, 1999; Taber, 2000; Palmer, 2001). Students' conceptions that are different from those accepted by the scientific community are labelled as misconceptions (Nussbaum, 1981; Nakhleh, 1992; Gonzalez, 1997).

In the literature, there are many studies on determining students' understanding levels and misconceptions in Chemistry (Gorodetsky & Gussarsky, 1986; Cakmakci, 2010; Ünal, Coştu & Ayas, 2010). On the other hand, these studies emphasized subjects in general Chemistry, such as chemical equilibrium, chemical bonding, chemical kinetics, and chemical reactions. There are very limited studies on understanding basic concepts and reactions in Organic Chemistry. Therefore, this study attempts to fill in this gap.

Organic Chemistry consists of many topics such as alkanes, alkenes, alkynes, and functional group compounds. Within these topics, alkenes are a central topic in Organic Chemistry since this topic is related to other organic compounds such as alkynes, and alcohols. Consequently, misconceptions about alkenes negatively affect students' further learning.

PURPOSE OF THE STUDY

The purpose of this study is to identify prospective science teachers' understanding levels and misconceptions about alkenes. Depending on this aim, following research questions were addressed as below:

1. What are the levels of understanding of prospective science teachers regarding alkenes?

2. What are the prospective science teachers' misconceptions about alkenes?

METHODOLOGY

This study adopted a case study research design because it provides much more detailed information and allows researchers to collect data with qualitative and quantitative methods (Yin, 1984; Çepni, 2007)

a) Sample

The sampling of the study consists of 73 prospective science teachers from Dokuz Eylul University, Buca Faculty of Education, in 2010-2011 academic term.

b) Instrument

In this study, two instruments were used to collect data. These are alkene concept test (ACT) and semi-structured interviews. ACT was developed by researcher to diagnose students' misconceptions and the level of understanding by the prospective teachers about alkenes. This test included 16 multiple-choice questions**.** Each question has only one correct answer and four distracters. These questions were prepared considering three categories. Similar categories were used by Abraham et al., 1992; Çalık, 2005; Ünal et al., 2010. The categories are below:

- Sound understanding (SU): Scientifically complete response and correct explanations take part in this category.
- Particular understanding with specific misconceptions (PUSM): This category includes scientifically complete response and unacceptable explanations.
- Specific misconceptions (SM): completely scientifically unacceptable response and explanations that match this category.

After the test was prepared, the test was piloted by the participation of 50 prospective teachers who were separate from the participants of the main study for the reliability. The reliability coefficient (Cronbach alpha) of the test was found to be 0.75.

In order to get deeper knowledge about prospective science teachers' understanding levels about alkenes, semi-structured interviews were conducted with participation of 18 prospective science teachers. These prospective science teachers were selected considering prospective science teachers' performance in the ACT. The interview form consisted of six questions.

c) Data Analysis

In analyzing test, following four categories were used: "sound understanding, partial understanding with specific misconception, specific misconception, no response". Also, data from interviews were analyzed according to these categories. But "partial understanding" category was used for interview analysis apart from test analysis.

Then, frequency and proportion of prospective science teachers' responses were calculated and presented in tables.

FINDINGS

The results of the study indicated that students had some misconceptions about important areas related to alkenes. These misconceptions are below:

Geometric/Cis-Trans Isomerism

- As long as there is C=C bond in the compound, the compound can display geometric isomerism.
- Two halogen atoms must be attached to double bonded carbons atoms for formation of geometric isomerism.
- If in a compound, all groups which are attached to C=C bound are different from each other, the compound cannot display geometric isomerism.
- Geometric isomerism is specific only for alkenes.

Physical Properties of Geometric/ Cis-Trans Isomers

- Boiling points of geometric isomers are the same because geometric isomers have the same chemical formulas.
- Trans- isomers have higher boiling points than their cis- counterparts.

Structural Isomerism

- The cyclic molecule and straight-branched compound are never structural isomers of each other.
- In alkene chains, the double bond can be located in different positions; these kinds of compounds are not structural isomers of each other.

Nomenclature of Alkenes

- When cycloalkenes are named, numbering is always counterclockwise.
- When cycloalkenes are named, the highest numbers are always given to alkyl groups attached to ring.

General Properties of Alkenes

- The general formula of all alkenes is $C_nH_{2n.}$
- To call a molecule as cycloalkene, it is enough that its general formula is C_nH_{2n-2}
- All compounds which have the general formula C_nH_{2n-2} are alkynes.

Chemical Reactions of Alkenes

- Only the compounds that include π bond are capable of undergoing addition reactions.
- In the addition of HX to an unsymmetrical alkene, Markovnikov's Rule can always be used to predict the product.
- The addition of water to an alkene in the presence of acid leads to the formation of ketone.
- The addition of water to an alkene in the presence of acid leads to the formation of ether.
- The addition of water to an alkene in the presence of acid leads to the formation of aldehyde.
- Only an alkene that has two carbon atoms undergoes polymerization reactions.
- Only alkenes that have six and more carbon atoms undergo polymerization reactions.

Synthesis of alkenes

- During dehydration of 2-Butanol as a secondary alcohol in the presence of acid at higher temperature, only 2-Butene is formed.

- During dehydration of 2-Butanol as a secondary alcohol in the presence of acid at higher temperature, only 1-Butene is formed.
- When alkyl halides are heated with strong bases such as KOH and NaOH in the presence of alcohols, alcohols are generated as major product.

DISCUSSION and RESULTS

From the findings, it was determined that prospective science teachers had misconceptions on some topics such as geometric isomerism, structural isomerism, application of Markovnikov's and anti-Markovnikov Rule, nomenclature of cycloalkenes, polymerization reaction, the synthesis of alkenes from the alcohols and alkyl halides. While some of these misconceptions are parallel to the ones in literature, some are identified for the first time in this research. One of the main reasons for the misconceptions is prospective science teachers' prior knowledge. Similar finding has also been observed in previous studies (McDermott, 1984; Driver, 1989). For example; some prospective science teachers believed that if in a compound all groups that are attached to C=C bound are different from each other, the compound cannot display geometric isomerism. It is likely that students interpret this statement according to their prior knowledge. In fact, the Turkish Secondary Chemistry Curriculum, and Chemistry textbooks did not contain more specific examples. Moreover, Chemistry teachers usually use specific examples such as 1,2– dichloroethene when they teach geometric isomerism. Thus, students may believe that only compounds where two halogen atoms are attached to double bonded carbons atoms shows geometric isomerism.

SUGGESTIONS

Some suggestions could be made based on the findings. These suggestions:

- This study was conducted with prospective science teachers who were trained in accordance with former high school chemistry curriculum. For this reason, future studies should be conducted with prospective science teachers or students who were trained in accordance with new high school chemistry curriculum.
- Similar studies can be conducted to investigate learners' understanding levels and misconceptions in other organic chemistry topics such as alkynes and alcohols.
- Further studies can be conducted to investigate the effectiveness of different teaching strategies such as conceptual change texts, 4E, 5E and 7E in remediation of these misconceptions.

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