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IDENTIFYING STUDENTS' MISCONCEPTION ABOUT INTERMOLECULAR FORCES TOPIC IN ORGANIC CHEMISTRY I COURSE

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Abstract

Intermolecular force is the topic in Organic Chemistry 1 course. Organic Chemistry 1 subject mainly involves abstractive and complex concepts. Therefore, many students face difficulties even get a misconception. This research aimed to identify the students' understanding and misconception in Organic Chemistry 1 lecturing especially about intermolecular forces topic. The study was a quantitative descriptive research. The research subjects were 50 fourth semester Chemistry Education students of 2015-2016 of State University of Malang that have taken Organic Chemistry 1 course. The research instruments were three-tier test namely multiple choices test with open reason and Certainty of Response Index of six items. The conclusion of research result is that 30% of the students still underwent misconception in Organic Chemistry 1 lecturing especially for intermolecular forces topic. The finding of some misconceptions encountered by the chemistry students were the strength of van der Waals forces of more electromagnetive element is more easily polarized; there is no electron withdrawing group in the organic molecules that have dipole-dipole forces so that there are no δ+ and δ-; there is a hydrogen bond in $CH_3(CH_2)_2CHO$ compound; the students did not understand the compound which can form hydrogen and water bond; the hydrogen bond is formed in polar compound; the bond between O-H in $CH_3(CH_2)_2COOH$ molecules is a hydrogen bond; and the strength of intermolecular forces of certain organic molecule is only influenced by electronegativity where the higher the electronegativity the greater the intermolecular forces.

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INTRODUCTION

The topic in Organic Chemistry I course provides students' basic knowledge of basic concepts in organic chemistry including the structure of organic compounds, conjugations and resonances, intermolecular forces, physical and chemical properties of organic compounds, isomers, and organic compound reactions (Catalog of Chemistry Department, 2016). All topics are very useful in further studying chemistry subjects such as Organic Chemistry II, Organic Chemistry III, and Physical Organic Chemistry. This basic organic chemistry course is obligatory for students of Chemistry Education and Chemistry Study Programs.

Organic Chemistry I or basic organic chemistry is part of the chemistry that specifically deals with carbon compounds. Intermolecular force is one of the topics in Organic Chemistry I lectures which involves many intermolecular interactions in organic compounds. Thus, if the chemical phenomenon is only explained through lectures at the macroscopic level without explanation at the molecular (submicroscopic) level, it will be hard to understand. The difficulties are not only experienced by high school students (SMA) but also by university students. Although the students have attained the basic concepts in Organic Chemistry I course in Senior High School and in Basic Chemistry course, they still face difficulty. This is in accordance with those reported by Anderson et al. (2008), that understanding organic chemistry well is not always determined by the students' success in understanding the basic chemistry well. Similarly, research conducted by Rushton et al. (2007) reported that fourth-year chemistry students still underwent misconception about basic organic chemistry topic. The misconception experienced is the same as that experienced by the first-year chemistry students. This indicates that misconceptions are firmly entrenched in students and difficult to remove.

The definition and research on misconception in chemistry have been conducted by some experts and researchers of education. According to Luoga et al. (2013), misconception is an inconsistency of understanding between the students' view and the experts' view, while according to Driver et al. (1994, in Pinarbasi et al., 2009) misconception or alternative conception is the students' inappropriate conception with the scientific conception. Students have their own thoughts about the chemical concepts that have been obtained in Senior High School before entering the Higher Education. This makes students often associate the improper connection between their newly acquired knowledge and their initial knowledge leading to a new understanding for students who are not in line with experts' expectations, or undergoing misconceptions. The results of Zoller's (1999) study concluded that the difficulties and misconceptions experienced by chemistry students were caused by abstract concepts that are not related to each other logically. Other researchers mentioned that the cause of misconception is the students' learning process or experience in the class and it is not because of the students' initial concept of students brought on the learning process in the classroom (Rushton et al., 2008). Students are often wrong in applying terms, concepts, and algorithms taught in the classroom.

The research related to misconception in organic chemistry has also been conducted by some experts to both high school and college students. The results of several studies show that Senior High School students and university students face difficulty and misconception in organic chemistry. The study of misconceptions of the second-semester students attending the organic chemistry course in one of the American universities in determining the acid/base strength of an organic compound has been undertaken by McClary et al. (2012). The students considered that the acid/base strength of an organic compound is determined by the functional group and stability. Misconceptions also happened to prospective teachers of Natural Sciences in one of Turkey's universities regarding the concept of alkenes such as geometrical isomers, structural isomers, Markovnikov and anti-Markovnikov rule applications, cycloalkene nomenclature, polymerization reactions, alkene synthesis of alcohols, and alkyl halides (Sendur, 2012).

Some prospective teachers of Natural Sciences thought that if the alkenes contain various four groups bound to C=C, they do not have geometrical isomers. This is due to the use of 1.2-dichloroethene as an example of geometric isomers so that the students assumed that only the alkene compound containing two halogen atoms bonund to the C=C bond has a geometric isomer.

Research on students' difficulties in organic chemistry has also been executed by Arellano et al. (2014), where their research results indicated that the students were hard in understanding the reaction of alkyl halides such as classifying a compound as a base and a nucleophile, determining the strength of a base and a nucleophile of a compound, describing the stage of the reaction mechanism of alkyl halide, and determining the reactive intermediates formed in the alkyl halides reaction. The same thing also happened in America in Organic Chemistry course, where resonance is one of the concepts in the Organic Chemistry lectures considered difficult by the students (Duis, 2011). The similar study related to the identification of chemistry prospective teachers' misconception about resonance topic has also been carried out by Widarti et al. (2017). Some of the misconceptions experienced by prospective chemistry teachers are resonance structures are in equilibrium with one another; the resonance structure is two or more Lewis structures having different atomic positions and electron arrangements; only the structure containing the charged atoms constituting the resonance structure; unrelate the formal charge to the resonance structure; do not understand the meaning of the curved arrows to indicate electron displacement; and the stability of the resonance structure is determined only by the location of the charge on the atoms in the resonance structure. The learning motivation of organic chemistry has also been found by Linenberger et al. (2011) reporting that although learning has used the media, Spartan Molecular Modeling software, students still found it difficult to understand the concept of resonance structure.

Research on the misconception about organic chemistry topic encountered by Senior High School students in Nigeria has been conducted by Omwirhiren et al. (2016). Their research results mentioned that misconceptions often experienced by Senior High School students in Nigeria related to organic chemistry topic are the definition of organic chemistry, polymerization, identifying the isomers, identifying aromatic compounds of compressed structure formulas, distinguishing substitution reactions and additions, unsaturated hydrocarbons, and applying IUPAC rules to give the name of an organic compound. The students also underwent the misconceptions about the physical properties of organic compounds. The research results indicated that the students believed that (i) the bonding degree depends only on the electronegativity of the atom, (ii) the student could not differentiate the concept of boiling and burning and assumed the breaking of covalent bond has happened when an organic compound boils, (iii) the students were unable to recognize the reaction type, and (iv) the students believed that hydrogen bonds involve covalent bond (Taagepera et al., 2000).

Based on some research results above, organic chemistry is a concept that is difficult to understand by students. The emergence of misconceptions will affect the students in understanding the concept of advanced organic chemistry. Interrelations of intermolecular forces have been reported by Cooper et al. (2015) which examined students' thinking about intermolecular forces (hydrogen bond, dipole-dipole interactions, and London dispersion forces) by asking chemistry students to describe their written comprehension and drawing representations. His research showed that most students still did not have a coherent and stable understanding of intermolecular forces as interactions between molecules. Students' representation of intermolecular forces varies. The students' written description of intermolecular forces is usually ambiguous enough, whether the student understands intermolecular forces as a bond or interaction. In this case, spatial information is very important, representations depicted in the free form are more likely to provide meaningful insight into students' thinking. In terms of intermolecular style materials, the same is true for Senior High School students in Germany, where 11th and 13th graders faced difficulty in predicting the boiling point of organic compounds (Schmidt et al., 2009). The common misconception was that covalent bonding causes organic compounds to boil, hydrogen bonds are only formed when organic molecules contain hydrogen and oxygen atoms, and polar molecules can form hydrogen bonds. The results showed that students' understanding of intermolecular forces was inadequate. Tarhan et al. (2008) have made a learning innovation on intermolecular forces topic with problem-based learning (PBL). The results of their research indicated that PBL is effective for students' achievement, can overcome the formation of alternative conceptions and also improve social skills. The concept of intermolecular forces is one of the concepts studied by prospective chemistry teachers in basic organic chemistry courses. This possibly causes the prospective chemistry teachers also experience difficulties and misconceptions when learning the concept.

The concept of intermolecular forces is a basic concept for studying the concepts of advanced organic chemistry such as predicting intermediate stability and reaction products in the organic reaction mechanism. In other words, misconceptions in lectures, especially in the basic organic chemistry course on intermolecular forces topic are a problem that must be solved immediately. The misconception will interfere if it is not addressed immediately because misconceptions can disturb the whole and true concept processing. The misconception of the intermolecular forces topic can destruct the formation of scientific conceptions by the prospective chemistry teachers in the next topic. In addition, the prospective teachers could bring such misconceptions until they teach later. Therefore, the objective of this work was to study the misconceptions about intermolecular forces topic in basic organic chemistry courses to be identified and solved as early as possible.

METHODS

This research employed the descriptive quantitative method. The research subjects were fourth-semester Chemistry Education students of 2015-2016 in the State University of Malang. They were 50 students who had taken Organic Chemistry I course. The instrument utilized for identifying misconceptions in this study was three-tier test, a multiple choices test with open reasons and Certainty of Response Index (CRI) scale technique developed by Hasan et al. (1999) and modified by Potgieter et al. (2005), and Hakim et al. (2012). According to Hakim et al. (20120, the data analysis technique is carried out by describing the students' answers. If the student's answer choices were correct, the reasons were right even though the level of confidence was low so it could be said that the students understood the concept but they were not confident.

CRI technique can be used to differentiate students who know the concept well but do not know the concept and experience misconception. In more detail, some of the possible CRI classifications from modification done by Potgieter et al. (2005) and Hakim et al. (2012) can be seen in Table 1. The research instrument used consisted of six items. The students' reasons are the reflection of students' thoughts and understanding of the concepts learned.

Table 1. Classification of CRI Modified in Every Answer

Answer	Reason	Score of CRI	Description
Right	Right	> 2	Understanding the concept well
Right	Right	<2	Understanding the concept but feeling unsure with the given answer
Right	Wrong	> 2	Misconception
Right	Wrong	<2	Do not understand the concept
Wrong	Right	> 2	Misconception
Wrong	Right	<2	Do not understand the concept
Wrong	Wrong	> 2	Misconception
Wrong	Wrong	<2	Do not understand the concept

RESULTS AND DISCUSSION

This study aimed to determine the levels of understanding and misconception experienced by prospective chemistry teachers related to the concept of intermolecular forces. Each prospective chemistry teacher has different capabilities to the concepts learned in the classroom, so that the levels of understanding of a concept is dissimilar as well. Research conducted by Cooper et al. (2015) reported that most students still did not have a coherent and stable understanding of intermolecular forces as interactions between molecules. The same thing was also reported by Schmidt et al. (2009) who concluded that misconception often occurred in intermolecular forces topic and students' understanding of intermolecular forces was insufficient. Taagepera et al. (2000) also reported students' misconceptions about physical properties of organic compounds topic experienced. From such reality, it is possible that the prospective chemistry teachers also face difficulty even experience misconceptions about the concept, even though the concept has been delivered during Senior High School and in Basic Chemistry courses. To determine the levels of understanding and misconception of prospective chemistry teachers related to the concept of intermolecular forces, a multiple choice test with open reason and CRI (three-tier test) were conducted. The distribution of items about the concept of intermolecular forces can be seen in Table 2. Meanwhile, the distribution of levels of understanding and misconceptions of prospective chemistry teachers to each item about intermolecular forces topic is presented in Table 3.

Table 2. Distribution of Item about Intermolecular Forces

No	Item
	Determining the strength of van der Waals forces
1	The **CORRECT** statement regarding the strength of van der Waals forces is …. A. The strength of van der Waals forces increases as the symmetry of certain molecule increases B. The strength of van der Waals of $CH_3C(CH_3)_2CH_2CH_3$ > $CH_3CH_2CH(CH_3)CH_2CH_3$ > $CH_3(CH_2)_4CH_3$ molecules due to the effect of polarizability. C. The strength of van der Waals forces of CCl_4 < CF_4 molecules since the chlorine atom is more easily polarized than F atom. D. Pentane molecule of ($CH_3(CH_2)_3CH_3$) and neopentane molecule of ($C(CH_3)_4$) have similar molecule weight but the strength of van der Waals of pentane molecule is smaller than that of neopentane. E. The strength of van der Waals forces of CH_3Br < CH_3I molecules since iodine atom is more easily polarized than bromine atom. Reason: CRI:
	Determining organic molecules having dipole-dipole forces if the molecular formulation is known
2	The following molecule that does not have dipole-dipole forces is …. A. $CH_3CH_2CH{=}CHCH_2Cl$ B. $(C_2H_5)_2O$ C. $(CH_3)_2C{=}C(CH_3)_2$ D. $(CH_3CH_2)_3N$ E. $CH_3(CH_2)_5OH$ Reason: CRI:
	Determining organic molecule that can form a hydrogen bond between the molecules if the molecular formula is known
3	The following organic molecule that **CAN** form the hydrogen bond between the molecules is …. A. $CH_3(CH_2)_2COCH(CH_3)_2$ B. $CH_3CH(CH_3)CH_2COOCH_2CH_3$ C. $(C_3H_7)_2O$ D. $(C_2H_5)_2NH$ E. $CH_3(CH_2)_2CHO$ Reason: CRI:

Determining the organic molecule that can form the bond of hydrogen and water if the molecular formula is known	
4	The following organic molecule that **CANNOT** form the bond of hydrogen and water is …. A. $(C_3H_7)_3N$ B. $CH_3CH(OH)CH_2CH(OH)CH_3$ C. $C_2H_5OCH_3$ D. CH_3F E. $CHCl_3$ Reason: CRI:
Predicting the type of intermolecular forces happening in organic molecules	
5	The **CORRECT** statement is …. A. CH_2Cl_2 molecule only has van der Waals forces. B. $CH_3(CH_2)_2COOH$ molecule has van der Waals forces, dipole-dipole forces, and the hydrogen bond between the molecules. C. $(CH_3)_3N$ molecule has van der Waals forces, dipole-dipole forces, and the hydrogen bond between the molecules. D. $CH_3CH_2CH{=}CHCH_2F$ has dipole-dipole forces and the hydrogen bond between the molecules. E. $CH_3COCH_2CH_3$ molecule only has dipole-dipole forces. Reason: CRI:
Ranking the strength of intermolecular forces of a certain organic molecule	
6	The **CORRECT** statement is …. A. The strength of intermolecular forces of $CH_3(CH_2)_4I > CH_3(CH_2)_4Cl > CH_3(CH_2)_4Br$ B. The strength of intermolecular forces of $(CH_3)_3N > (CH_3)_3NH > CH_3CH_2CH_2OH$ C. The strength of intermolecular forces of $CH_3CH(OH)(CH_2)_2CH(OH)CH_3 > CH(CH_3)_2(CH_2)_2CH_2(OH) > CH(CH_3)_2CH_2CH(OH)CH_3$ D. The strength of intermolecular forces of $CH_3(CH_2)_2CHO < CH_3(CH_2)_2COOH < CH_3CH_2COOCH_3$ E. The strength of intermolecular forces of $(CH_3)_3CCH_2COCH_3 > (CH_3)_3CCH_2CH_2(OH)CH_3 > CH_3(CH_2)_{10}CH_2$ Reason: CRI:

Table 3. Distribution of Levels of Understanding and Misconception of Prospective Chemistry Teachers for each Item about Intermolecular Forces (n = 50)

Number of Items	Percentage of Prospective Chemistry Teacher (%)		
	Do not understand	Understand	Misconception
1	56	22	22
2	16	50	34
3	14	40	46
4	34	46	20
5	4	68	28
6	24	26	50
Mean	**24.70**	**42.00**	**33.30**

Item number 1 is related to determining the strength of van der Waals forces. About 22% of prospective chemistry teachers experienced misconception. There were still many prospective chemistry teachers thinking that the strength of van der Waals forces is influenced by electronegativity. This is in line with the research of Schmidt et al. (2009). One example of the prospective chemistry teachers' answer is shown in Figure 1.

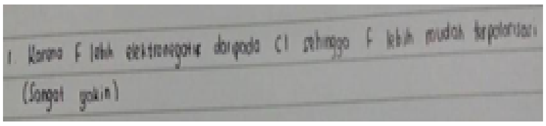

Figure 1. The Example of Students' Misconception Answer in Item Number 1

This case possibly occurred because the prospective chemistry teachers assumed that van der Waals forces are strongly influenced by the electronegativity of the elements. The correct concept is the electronegativity of an element is related to the ease in polarizing the other elements. In addition, some prospective chemistry teachers assumed that the longer the chain, the van der Waals forces become smaller as the following example answer:

"The longer the chain, the van der Waals will reduce"

This is not in accordance with the van der Waals forces theory stating that van der Waals forces are influenced by the touching surface of the molecule, thus affecting the tensile strength of its dipole-dipole forces (Smith, 2011). In other words, the larger the surface of a molecule, the stronger the van der Waals forces. Besides the molecule surface large, another factor that influences the strength of van der Waals forces is polarizability which is the ability of atomic electron cloud to respond to the changes in its environment. The size of the chlorine atom is greater than the fluorine atom, so the valence electron in the chlorine atom is more weakly bound by the nucleus than the fluorine atom. Hence, chlorine atoms are more easily polarized. As with chlorine atoms, the chlorine molecule has a stronger van der Waals forces than the fluorine molecule. Therefore, the correct answer is the strength of the van der Waals forces of the CH_3Br < CH_3I molecules because the iodine atom is more easily polarized than the bromine atom (E). Based on these findings, it can be concluded that prospective chemistry teachers had not fully understood the concept of intermolecular forces.

Item number 2 is related to determining organic molecules that have dipole-dipole forces if the molecular formulation is known. The result was 34% of the prospective chemistry teachers still experienced a misconception. In item number 2, several choices of molecular formulas are given, and prospective chemistry teacher were asked to determine molecules that do not have dipole-dipole forces. Some prospective chemistry teachers were wrong in giving reasons. The students assumed that in $(CH_3)_2C=C(CH_3)_2$ molecule, there is no electromagnetic withdrawing group, so there are no δ^+ and δ^-. The example of prospective chemistry teachers' answers can be seen in Figure 2.

The possibility of this answer is that in $(CH_3)_2C=C(CH_3)_2$ molecule, there is no element that has high electronegativity without seeing the great difference in electronegativity in a compound that causes the appearance of dipole-dipole. The prospective teachers also considered that there is no hydrogen bond in that compound as the following answer.

"Since in $(CH_3)_2C=C(CH_3)_2$ molecule, there is no hydrogen bond and it is not bound with halogen. It is similarly positive dipole"

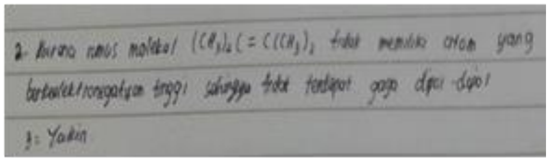

Figure 2. The Example of Students' Misconception Answer for Item Number 2

This is not in line with the theory stating that it is contrast to van der Waals forces caused by momentary dipole-dipole, the dipole-dipole interactions are caused by permanent dipole-dipole. The permanent dipoles are because both elements have big electronegative differences (Smith, J.G., 2011). In $(CH_3)_2C=C(CH_3)_2$ compound, the difference in electronegativity of H and C atoms is very small so that both C-C and C-H bonds are nonpolar bonds. Therefore, $(CH_3)_2C=C(CH_3)_2$ molecule is a nonpolar molecule and only has van der Waals forces.

Items number 3 and 4 are related to determining organic molecules that can form a hydrogen bond between their molecules. About 46% of students experienced misconception. In item number 3, there are several options of compounds and the students were asked to determine which compounds that can form a hydrogen bond between their molecules. Some students chose the answer E because they assumed that in the option E namely $CH_3(CH_2)_2CHO$ compound, there are free electrons in O that can bind to the hydrogen between the molecules. Some students chose the answer E as shown in Figure 3.

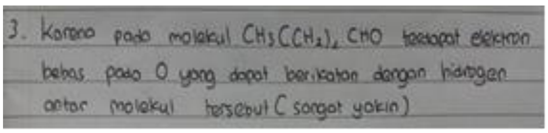

Figure 3. The Example of Students' Misconception Answer in Item Number 3

The choice of this answer possibly occurred because the students assumed that within the $CH_3(CH_2)_2CHO$ molecule there is an O atom that has a high electronegativity that can bind to the hydrogen atom between its molecules. In addition, the prospective teachers also assumed that CHO functional group in $CH_2(CH_2)_2CHO$ compounds can form hydrogen bonds. The same assumption also happened to $(C_3H_7)_2O$ molecules. This can be seen in the following samples of the answer.

"because there is no CHO functional group that can bind to hydrogen between molecules."

"in $(C_3H_7)_2O$ molecule, there is O that can form hydrogen bond"

In item number 4, only 20% of students who experienced misconception. This was because the prospective teachers still had not understood the compounds that can form hydrogen bonds based on the characteristics of the compounds. For example, misconceptions occurred because there were still students who answered C that is $C_2H_5OCH_3$ cannot form the bond of hydrogen and water due to the reasons as shown in Figure 4.

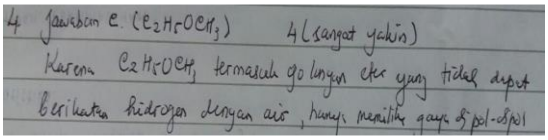

Figure 4. The Example of Students' Misconception Answer for Item Number 4

From these answers, we can see that students gave the reason that $C_2H_5OCH_3$ cannot form hydrogen bonds by assuming that ether compound does not have dipole-dipole. In fact, hydrogen bonds are formed from the O atoms in ether compounds with H atoms of water molecules. Another misconception that happened was that the prospective teachers also gave answer A, $(C_3H_7)_3N$, with the reason that the compound cannot form hydrogen bonds because it has a lipophilic group. In fact, hydrogen bonds are formed from N atoms in 3N (C_3H_7) compound with H atoms of water molecules. This can be seen in the following example of the answer.

"*$(C_3H_7)_3N$ cannot form hydrogen bonds since there are many lipophilic groups (waterproof)*"

The overall misconceptions that occurred were related to hydrogen bonds in item number 3 and 4 are essentially inconsistent with the theory stating that molecules that can bind to hydrogen are those that have hydrogen atoms bound to N/ O/ F atoms. The hydrogen bond happens in the hydrogen with the free electron pair on N/ O/ F atom of the other molecule (Smith, J.G., 2011). From all answers of prospective teachers, it seems that the students were basically wrong in understanding the concept of a hydrogen bond. The students also could not describe the structure correctly. This is in line with research conducted by Taagepera et al. (2000) reporting that students believed that hydrogen bonds involve covalent bond. This situation was also supported by the research results of Schmidt et al. (2009). The common misconception is that hydrogen bonds are only formed when organic molecules contain hydrogen and oxygen atoms, and polar molecules can form hydrogen bonds. These results showed that students' understanding of intermolecular forces is inadequate.

Items number 5 and 6 are related to statements about intermolecular forces. About 28% of chemistry teacher candidates still experienced misconceptions for number 5 and 50% of them underwent the similar thing for item number 6. Item number 5 gives some choices of statements related to the concept of intermolecular forces, and chemistry prospective teachers were required to choose the correct statement. The misconception of most prospective chemistry teachers happened when they chose answers C and E. The students chose the answer C because in $(CH_3)_3N$ the hydrogen bonds can be formed between molecules. The students assumed that N atom can always form a hydrogen bond, as seen in the following sample of the answer.

"because the dipole moment and N atom that can bind to hydrogen atom form the hydrogen bonds"

The possibility of such answer is that the students still did not understand the concept of intermolecular forces. In accordance with the conceptual theory of intermolecular forces, the choice B is the correct answer. $CH_3(CH_2)_2COOH$ molecule is a polar compound so it has van der Waals forces and dipole-dipole force. In addition, there is a hydrogen atom that is bound directly to the oxygen atom in the molecule so that it can form hydrogen bonds between the molecules. In molecular compounds, there are bonds in molecules and intermolecular forces. Intermolecular forces connect one molecule to the other molecules (Smith, 2011). Some students still considered that a compound only has one intermolecular force. This was apparent in students who chose E because he thought $CH_3COCH_2CH_3$ only has dipole-dipole force, as seen in the following example of the answer.

"do not understand that all molecules have van der Waals forces"

In item number 6, the prospective chemistry teachers were asked to sort the strength of intermolecular forces by giving statement related to intermolecular forces of some compounds. Prospective chemical teachers still faced difficulty in ordering the strength of intermolecular forces. One of the causes of students experiencing misconceptions in item number 6 was the students' inability to describe the structures of organic compounds and the lack of understanding of concepts related to intermolecular forces. This can be seen from the student's answer that did not describe the structure of each compound to facilitate knowing the strength of intermolecular forces. Therefore, many students got difficulties and misconceptions. This appeared in students who chose answer D that sees the strength of intermolecular forces based on the forces in a compound without regarding the characteristics of the forces, as shown in the following example of the answer.

"Intermolecular forces in each molecule are van der Waals forces, dipole-dipole force, and hydrogen bonds. However, the strength of intermolecular forces is more to the right and will increase"

From these answers, it appears that students did not pay attention to the significance of the figure of the compound structure which is very helpful in understanding what types of intermolecular forces existing in a compound. The students' inability to describe the structure is in line with the results of Cooper et al. (2010) which stated that some students were unable to apply the rules in structural representation and tended to memorize rather than understand the rules of structure depiction. The students also still thought that the strength of intermolecular forces is only influenced by electronegativity. This can be seen when the prospective chemistry teacher chooses the choice of answer A, like the example of the following answer.

"the greater the electronegativity, the greater the intermolecular forces"

This result is in accordance with the research results of Taagepera et al. (2000) reporting that the students experienced misconceptions about physical properties in organic compounds topic, including the polarity of bonds depends only on the electronegativity of atoms. In addition, students believe that hydrogen bonds involve covalent bonds. From several statements on item number 6 regarding the strength of intermolecular forces, it would be easier if prospective chemistry teacher students first drew the structure of each compound, so that they knew what type of force that exists and can compare the forces between the existing molecules. The strength of intermolecular forces can be seen from the type of bond that exists and the characteristics of the compound, whether the molecule has a momentary or permanent dipole, has an N-H, O-H, F-H bond, or the compound is an ionic bond. These characteristics would be easily seen if the prospective chemistry teachers understood the concept well and could describe its structure. This is in accordance with the results of Cooper et al (2015) research on intermolecular forces which showed that in understanding the intermolecular forces, spatial information is very important related to the representation of compound structure described as being more able to provide meaningful insights into students' thinking.

CONCLUSION

Based on the research findings, it can be concluded that there was still a misconception in the organic chemistry lectures, especially related to intermolecular forces topic. Some misconceptions experienced by chemistry prospective teachers included the more electronegative an element, it will be more easily polarized; in the organic molecules having dipole-dipole force there is no electron withdrawing group, so there are no δ^+ and δ^-; there is a hydrogen bond in $CH_3(CH_2)_2CHO$ compound; the students did not understand the compounds that can form the bond of hydrogen and water; the bond between the O-H in the $CH_3(CH_2)_2COOH$ molecule is a hydrogen bond; and the strength of intermolecular forces of an organic molecule is only influenced by the electronegativity, whereas the greater the electronegativity the greater the intermolecular forces.

Based on the research findings, the learning strategies of organic chemistry, especially for the intermolecular forces topic, need to be improved. Lecturers should provide more time to prospective chemistry teachers to practice describing molecular structure if the chemical formula is known. In addition, it is significant to emphasize the importance of hydrogen bond formation process, the strength of intermolecular forces, and the characteristics of intermolecular forces. One of the learning strategy innovations that can improve students' understanding and reduce students' misconceptions in basic organic chemistry lectures, especially the intermolecular forces topic is by using diverse representations (multiple representations). Various representations can be employed to clearly show a compound structure, the formation of hydrogen bonds, and some other types of intermolecular forces. The most important thing is to give the opportunity for prospective chemistry teachers to practice describing the molecular structure of which chemical formula has been known and to predict the strength of intermolecular forces of the compound structure that has been made.

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