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Research Article

Review of Chemistry Learning Modules on the Impact of Students' Literacy

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Abstract.
This study aimed to review the chemistry learning module that impacts students' literacy. The method used was document analysis and included articles between 2012 –2022. 20 articles, consisting of 17 journals and three proceedings, were analyzed. Eight articles were indexed by Scopus, and SINTA accredited 12. The main variables analyzed included module development methods, types of literacy skills, and the relationship between development methods and literacy skills. The results indicated nine methods: multi-representation-based modules, natural sciences, STEM, green chemistry, context-based learning, socio-scientific issues, cooperative learning, inquiry, and literacy-based. The types of literacy skills were grouped based on the competencies published by PISA, which included explaining phenomena (about 19 articles), designing investigations (about 18 articles), and evaluating contextual investigations (about 19 articles). The relationship between the development method and the type of literacy skills training shows a connection at each step. The modules developed have the impact of training and improving student literacy.

Keywords: chemistry, module, literacy

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1. INTRODUCTION

Chemistry is one of the subjects of science studied at the high school level in Indonesia. Chemistry is a science that studies matter in terms of properties, composition, structure, bonds, formation and energy changes involved [1]. Chemistry can explain many phenomena around us. For example, rusting iron, forming stalactite and stalagmite in caves, acid rain, etc. Science has succeeded in developing a set of explanatory theories that have changed our understanding of the world around us [2]. This understanding will then lead to many benefits for life, such as the prevention and treatment of disease, the use of sunlight as alternative energy, the manufacture of polymers (including rubber and nylon), ceramics (such as cookware), coatings (for example, latex paints), and advances in food and agriculture sector [1]. The ability to use knowledge and information interactively to change how a person interacts with the world to achieve broader goals is called scientific literacy (including chemical literacy) [3].

People are said to be scientifically literate if they can use scientific knowledge, identify questions and draw conclusions based on evidence to understand and make decisions about the universe [4]. Chemical literacy means that someone can solve problems in life related to concepts by using existing chemical concepts. Based on the 2018 PISA Indonesia report, the level of scientific competence in PISA Indonesia is still relatively low. The PISA science competency assessment consists of the lowest (1b: score = 261) to the highest (6: score = 768). The minimum level of competence in the PISA assessment is level 2. The minimum level of competence is the level that shows that students can solve problems that require minimum abilities according to international standards and display the characteristics of independent thinking [5]. Indonesian students who score below level 2 (level 1a) are still 35%. It means that students can only use basic or everyday content and procedural knowledge to recognize or identify explanations of simple scientific phenomena, not the ability of content knowledge to recognize complex phenomena or use abstract knowledge. A total of 17% scored below (level 1b). This percentage is still quite a lot when compared to OECD countries. In OECD countries, only 15.7% of students are in the 335 grade, and 5.5% are below it [5]. This fact means that there are still more than 50% of students who have scientific literacy scores below the minimum competency.

To make someone chemically literate, basic knowledge is needed, starting from education. In learning at school, students need to know the relevance of subject matter to everyday life. This can make students aware of the importance of chemistry in determining careers and members of society. Holbrook suggested that learning in schools should pay attention to the relevance of actual subject matter to people's lives and directly involve students [6]. One way that can be used is to provide teaching materials to students. Teaching materials that can be used independently will be more helpful, it is a module.

Module is a teaching material that are made systematically based on the curriculum and packaged in the smallest learning units so that they can be used independently [7]. The use of modules that do not depend on other people or other media makes it very appropriate to use today. The post-covid-19 pandemic is a time for the resumption of face-to-face learning. However, many chemical materials were missed or left behind during the previous pandemic. Therefore, the development of chemistry learning modules needs to be considered in terms of module development method and also the impact of their use.

Several modules were developed using a method approach, such as intertextual, contextual, socio-scientific issues, and so on [8–14]. This method is applied as a basis for compiling the module's content, which is expected to have an impact on students' chemical literacy. Aspects of chemical literacy are 1) the main idea of chemistry, 2) chemistry in context, 3) High Order Learning Skills (HOLS), and 4) affective [15]. Meanwhile, competence in literacy includes 1) explaining phenomena scientifically, 2) designing scientific inquiries, and 3) evaluating contextual investigations [2].

Based on the description above, reviewing the chemistry learning module is necessary. Information from the results of this review can help teachers/instructors or developers develop chemistry modules. The study of the chemistry learning module that has been developed has been reviewed previously, it explains about the type of module, the chemistry topics discussed in the module, the pedagogical approach used, and the results obtained after using the module [16]. The review does not discuss the impact of chemical literacy after using the module. Based on this, there is no review of chemical modules to improve chemical literacy. The importance of literacy, as discussed earlier, leads us to the importance of developing modules that impact literacy. This review will analyze the method used in module development, literacy skills type, and their impact on student literacy. This study aims to review the chemistry learning module that impacts on student literacy.

2. RESEARCH METHOD

2.1. Participants

This study identifies and analyzes articles published in chemistry and science education journals. The article is on the development of chemistry learning modules that have an impact on students' literacy. Data collection was done by searching for articles digitally with the keywords "scientific literacy module" or "chemistry module development". Identify the article seen from the title, keywords, and abstract. There were 20 selected articles, consisting of 17 journals and three proceedings. They are both Scopus indexed journals and SINTA accredited, while the proceedings are publications from IOP and AIP. The module development method of modules with certain methods that impact literacy (or contain aspects of literacy) are the identification keys. After that, a thorough analysis of the journal's contents was carried out to find the module development method and the impact of its use on student literacy. In addition, classifying the improvement of literacy skills based on PISA.

3. RESULT AND DISCUSSION

3.1. Module Development Method

Based on the reviewed articles, the modules are developed by a type of method. They are grouped into nine types. One of them was designed with a multi-representation method type, four articles with Nature of Science (NoS), three articles with STEM, three articles with green chemistry, four articles with context-based learning, two articles with the socio-scientific issues, and one article with each with cooperative learning, inquiry, and literacy. The grouping of the module development method can be seen in Table 1.

Table 1: Module development method.

Method Types	References
Module based on Multi-representation	[8]
Module based on Nature of Science (NoS)	[7, 17–19]
Module based on STEM	[20–22]
Module based on Green Chemistry	[23–25]
Module based on Context Based Learning	[11–14]
Module based on Socio-scientific Issue	[9, 10]
Module based on Cooperative Learning	[26]
Module based on Inquiry	[27]
Module based on Literacy	[28]

The module development method is very commonly used as the basis for designing module content. The stages in the module are adapted to the content development method, as in the multi-representation-based module, which is based on macro, sub-micro, and symbol representations. The NoS-based module is based on six learning steps, namely 1) background readings, 2) case study discussions, 3) inquiry learning, 4) inquiry labs, 5) historical studies, and 6) multiple assessments. The STEM-based module is based on aspects of Science, Technology, Engineering, and Mathematics. The green chemistry-based module is based on the contexts of pollution, prevention, and pollution minimization. The context-based learning module is based on providing everyday contexts at the beginning of the module. The module based on socio-scientific issues is based on providing the latest issues around science and society as problems in the module. The cooperative learning-based module is based on eight learning steps, namely 1) material description, 2) questions, 3) problem identification, 4) problem formulation & hypothesis generation, 5) designing experiments, 6) data analysis, 7) making conclusions, and 8) self-evaluation. The inquiry-based module is based on 1) observation, 2) manipulation, 3) verification, and 4) application. The literacy-based module is based on three competencies, 1) explaining phenomena scientifically, 2) designing investigation, and 3) Interpreting data and evidence scientifically.

3.2. Type of Literacy Skills

Type of literacy skills from the 20 articles reviewed are grouped into three basic competencies, they are explaining phenomena, designing investigations, and evaluating contextual investigations. A total of 19 articles contain competence in explaining phenomena, 18 contain competence in designing investigation, and 19 contain competence in evaluating contextual investigation. The types of chemical literacy competencies based on the developed modules can be seen in Table 2 below.

Table 2: Science literacy basic competences.

Basic competences	**References**
Explaining phenomena	[7–14, 17–20, 22–28]
Designing investigation	[7, 9–13, 17–28]
Evaluating contextual investigation	[7, 9–14, 17–28]

Demonstrating the competency of *explaining phenomena scientifically* requires students to recall the appropriate content knowledge in a given situation and use it to interpret and provide an explanation for the phenomenon of interest [2]. *Designing investigations*, this competency requires students to have procedural and epistemic knowledge but can also utilize their knowledge of science content [2]. *Evaluating contextual investigation,* this competency requires students to evaluate alternative conclusions using evidence; give reasons or conclusions given, and determine the assumptions made in reaching conclusions [2].

3.3. The Impact of Module Development Method on Literacy Skills

Multi-representation Module on Literacy Skills

Module development with a multi-representation type uses an inter-textual approach that contains macro, sub-micro, and symbol representations. Macro is representations of real things that can be physically observed, such as chemical phenomena in everyday life [29]. One of the literacy skills aspects is chemistry in context, where students are asked to use their understanding of chemistry in their lives daily [30]. The context used in this module is the combustion of gas C_2H_2, $Ca(OH)_2$, and the formation of Al_2O_3 [8]. Sub-micro is a representation to explain the cause of phenomena [29]. In the aspect of literacy skills, the Sub-micro representation, namely High Order Learning Skills (HOLS), asks students to explain phenomena scientifically. [16]. On this module students are asked to explain the process of exothermic and endothermic reactions and their enthalpy [8]. Symbolic is a representation of chemical reaction [9]. In addition to explaining phenomena, students are asked to explain and write down related chemical reactions. Based on this developed module, multi-representation has an impact on literacy skills. Both macro, micro, and symbolic are well developed in the module to be used to train students' literacy.

Nature of Science (NoS) module on Literacy Skills

Nature of science is an approach that invites students to carry out scientific investigations to act as scientists. They have a sense of interest and confidence in studying science. Besides, they are able to understand and acquire scientific concepts [18]. Module-based on NoS follows six learning steps they are 1) background reading, 2) case study discussion, 3) inquiry lessons, 4) inquiry labs, 5) historical study, and 6) multiple assessments [7, 17–19].

In the background reading step, students are asked to read the article or discourse about phenomena [7, 17–19]. In this case, students will get information about chemistry's main ideas, such as those in the literacy aspect put forward by Swartz. [15]. In the second step, case study discussion, students are asked to discuss and provide an overview of the information to be studied [7, 17–19]. Explaining phenomena is a competency that can be trained in this step. In the third step, inquiry lessons, students are asked to learn and understand content [17] through primary literature [7]. In the fourth step, inquiry labs, students are asked to conduct simple experiments to prove the facts they learned [7, 17–19]. Both inquiry lessons and inquiry labs have an impact on literacy skills, such as explaining phenomena and designing investigations. In the fifth step, historical study, students are asked to make an experimental report [17, 18], present it, and communicate it [7, 19]. The historical study relates to literacy skills, namely epistemic knowledge, where students can understand their role in procedural justification [21]. Procedural justification is an indicator of the fulfillment of evaluating contextual investigation. In the last step, multiple assessments, students are asked to evaluate by answering questions related to what they have learned [7, 17–19]. Based on the six steps, the Nature of Science (NoS)-based module can train students' literacy skills. The results obtained after testing the module can be used to grow [17, 18] and improve students' scientific literacy [7, 19].

STEM Module on Literacy Skills

STEM-based modules include Science, Technology, Engineering, and Mathematics. Science is a learning material that is outlined in modules, such as general chemistry

[20], pressure [21], and environmental pollution [22]. Technology will constantly change and develop, in this case, the manufacture of modules adapted to today's technology. Technology and Engineering are used to do electronic modules (e-module) or interactive modules [21, 22]. In addition, a discussion of materials related to the latest technology can also be carried out, such as machines in the industrial sector [20]. Mathematics cannot be separated from chemistry, such as stoichiometry [20], pressure calculations [21], and the calculation of pollution levels in water [22]. STEM has impacts on student literacy, such as improving cognitive, problem solving, thinking skills, and application in life [20–22]. Cognitive includes recalling information about facts, theories, and concepts used to explain phenomena [20, 21]. It included competence in explaining phenomena. Problem-solving includes conducting experiments and observations [20–22]. This is included in the competence of designing investigations. Thinking ability includes empirical abilities, namely, describing assumptions and giving cause and effect [22]. This ability is included in the competence to explain phenomena. Application in life is the ultimate goal of chemical literacy skills. According to Prasetyo, Marianti, and Alimah [22], students can relate the content to problems in everyday life and solve problems through the STEM-based module [20–22]. This is included in the competence of evaluating contextual investigation. Based on the explanation above, the STEM-based module can increase students' literacy.

Green Chemistry Module on Literacy Skills

Green chemistry is a chemical concept in designing, developing, and implementing products and processes that have a small level of pollution or do not pollute the environment and human health [23]. This learning aims to foster a sense of environmental care in students. This aim is in accordance with how literacy asks students to be able to use knowledge to make decisions in solving problems. This green chemistry-based module contains various contexts related to the environment. The literacy skills contained in it include explaining phenomena, such as explaining chemical solvents in making paint standards [25]. Designing investigations is also one of the competencies being trained, namely making "green" paint to make a painting on green chemistry [25] and conducting chemical synthesis that does not produce toxins for waste treatment [20]. Furthermore, evaluating contextual investigations, these competencies are fulfilled in each module, such as evaluating ideas for dealing with B3 waste, using renewable raw materials, and testing concepts [23–25]. Based on the description above, green chemistry-based modules have an impact on growing and improving students' chemical literacy.

Context Based Learning Module on Literacy Skills

Context-based Learning (CBL) uses a contextual approach that makes it easier for students to relate phenomena in life to chemical concepts [11]. Chemistry in context means using and acknowledging chemical knowledge to explain phenomena [15]. By using a context-based approach, chemical literacy competencies can be fulfilled. The context used was adding natural and artificial dyes and preservatives to food [11], organic photochemical [12], car engines [13], and phenomena in life [14]. Students were asked to explain whether adding dyes and preservatives was harmful or not (explaining the phenomena). In addition, students were also asked to look for the threshold for food coloring and preservatives to be safe for consumption (investigation design). Finally, students are asked to choose what colorants and preservatives are suitable for food (evaluating contextual investigations) [11].

In other journals, students are asked to explain the relationship between the structure of the model with nature and function based on the phenomenon of organic photochemicals. In Designing Investigation Competence, Students are asked to predict, calculate, analyze, record data, and make conclusions. Furthermore, in Evaluating Contextual Investigations, Students are asked to make decisions [12]. All CBL-based modules can train and improve students' literacy.

Socio-Scientific Issue Module on Literacy Skills

The use of socio-scientific issues can contextualize content to be used across scope and develop literacy competencies in science [9, 10]. The use of socio-scientific issues covers aspects of scientific literacy, such as 1) chemistry in context, showing how hydrogen fuel cell cars work [10] or use issues that are controversial and subject to debate in the community [9]; 2) chemical ideas, showing the concepts of fuel cells, half-reactions, voltaic cells, free energy, and batteries; and 3) HOLS competencies such as explaining phenomena, designing investigations, and evaluating contextual investigations. Based on the description above, the module developed with a socio-scientific issue method can trigger and improve students' literacy.

Cooperative Learning Module on Literacy Skills

Cooperative is a learning model by forming small groups (heterogeneous) to solve problems to achieve common goals. The steps of cooperative learning in the module are 1) reading discourse about phenomena, 2) asking questions, 3) identifying problems, 4) formulating problems and hypotheses, 5) designing workflows, 6) analyzing data, 7) making conclusions, and 8) evaluating [26]. In this case, the aspects of literacy that are improved are content knowledge, procedural knowledge, cognitive, and attitudes. The discourse presented is from phenomena and experimental videos regarding salt hydrolysis. This step is a practical scientific literacy aspect, namely chemistry in context.

Steps 2 to 6 are suitable literacy competencies for designing investigations. Students are asked to observe the video, formulate problems, design experiments, conduct experiments, and analyze data. Step 7 is suitable for explaining phenomena and evaluating contextual investigation. In competence explaining the phenomenon, students are asked to explain the phenomenon of salt hydrolysis content in the daily context [26]. Students are asked to write conclusions and conduct self-evaluation in evaluating contextual investigation competence. Based on the explanation above, cooperative learning-based modules can improve students' literacy.

Inquiry Module on Literacy Skills

In this module, the use of inquiry development methods can improve student literacy. The inquiry learning model integrated into the module consists of observation, manipulation, verification, and application [27]. Observing, manipulating, and generalizing will train students' literacy competence to designing investigations. Verification and application will train to evaluate contextual investigations. In explaining phenomena competence, students are asked to explain phenomena scientifically.

Literacy Module on Literacy Skills

Literacy-based module developed by scientific context, process, content, and attitude [28]. Aspects of chemical literacy include 1) the main idea of chemistry, 2) chemistry in context, 3) high-level learning skills (HOLS), and 4) attitude [15]. The chemical context is given in videos or pictures related to colligative properties, such as a video about melting snow with salt [28]. The competency measured in this aspect is explaining phenomena, where students are asked to explain the phenomenon of freezing point depression with salt.

The development of the process aspect is in the form of the prediction of freezing point depression [28]. Competence measured in this aspect is designing investigations, where students use a scientific context to develop aspects of the process of how an event occurs [28]. The development of the attitude aspect is providing problems in terms of social, economic, and environmental aspects. Competence measured in this aspect is evaluating contextual investigation. This module development module can improve students' literacy.

4. CONCLUSION

The students' low level of chemical literacy indicates that more innovation is needed in learning. One of them is by providing teaching materials that are in accordance with the latest technological developments and can be used independently. One of the most common teaching materials used in learning is the module. The development of this module requires methods according to the learning objectives. Nine module developing methods were identified in the review. They are multi-representation-based module, nature of science-based module, STEM-based module, green chemistry-based module, cooperative learning-based module, inquiry-based module, socio-scientific issue-based module, CBL-based module, and literacy-based module—all that methods in their development present phenomena related to everyday life. Using an appropriate method to the module can improve literacy skills in three competencies, explaining phenomena, designing investigation, and evaluating contextual investigation. Impact of Module development methods on literacy skills students conclude that nine methods can be a trigger, train, and improve students' literacy.

References

[1] Chang R, Goldsby KA. Reactions in aqueous solutions. Chemistry. 10th ed. New York: McGraw-Hill; 2010.

[2] Harlen W. "The assessment of scientific literacy in the OECD/PISA project.," p. 2001. https://doi.org/10.1007/0-306-47639-8_5.

[3] Rychen DS, Salganik LH. Key competencies for a successful life and well-functioning society. Hogrefe Publishing GmbH; 2003.

[4] OECD. Assessment and analytical framework. 2009.

[5] Pusat Penilaian Pendidikan Balitbang Kemendikbud. Laporan PISA Indonesia, pendidikan di Indonesia belajar dari hasil PISA. Jakarta; 2018.

[6] Permanasari A. Menyiapkan anak Indonesia menghadapi '21^{st} century skills' melalui penelitian berbasis literasi kimia. *Prosiding Seminar Nasional Kimia dan Pendidikan Kimia*. 2017 pp. 1–5.

[7] Wardhana SO, Nabilah S, Dewitasari AP, Hidayah R. E-Modul interaktif berbasis nature of science (nos) perkembagan teori atom guna meningkatkan level kognitif literasi sains peserta didik. UNESA Journal of Chemical Education. 2022;11(1):34–43.

[8] Yuliana IF, Sholichah N. Pengembangan modul termokimia berbasis multi representasi untuk melatih literasi kimia mahasiswa pada materi termokimia. Chemistry Education Practice. 2021;4(2):179–85.

[9] El Shinta Z, Sunyono S, Setyorini M. The validity of the online module of flipped classroom based on socioscientific issues towards students' literacy skills. IOSR Journal of Research & Method in Education. 2020;10(2):51–56.

[10] Cigdemoglu C. Flipping the use of science-technology and society issues as triggering students' motivation and chemical literacy. Science Education International. 2020;31(1):74–83.

[11] Wiyarsi A, Pratomo H, Priyambodo E, Kusumaningtyas H. Chemistry enrichment in tourism vocational school: The development and validation of food additives module. *Journal of Physics: Conference Series*. 2019: 012015. https://doi.org/10.1088/1742-6596/1156/1/012015.

[12] Hoover GC, Dicks AP, Seferos DS. Upper-year materials chemistry computational modeling module for organic display technologies. J Chem Educ. 2021;98(3):805–11.

[13] Cigdemoglu C, Geban O. Improving students' chemical literacy levels on thermochemical and thermodynamics concepts through a context-based approach. Chem Educ Res Pract. 2015;16(2):302–17.

[14] Vaino K, Holbrook J, Rannikmäe M. Stimulating students' intrinsic motivation for learning chemistry through the use of context-based learning modules. Chem Educ Res Pract. 2012;13(4):410–9.

[15] Shwartz Y, Ben-Zvi R, Hofstein A. Chemical literacy: what does this mean to scientists and school teachers? J Chem Educ. 2006;83(10):1557.

[16] Yuliani E, Wiji W, Mulyani S. Review of learning modules in chemistry education. *Journal of Physics: Conference Series*. 2021. https://doi.org/10.1088/1742-6596/1806/1/012207.

[17] Accraf LB, Suryati S, Khery Y. Pengembangan e-modul interaktif berbasis android dan nature of science pada materi ikatan kimia dan gaya antar molekul untuk menumbuhkan literasi sains siswa. Hydrogen: Jurnal kependidikan kimia. 2018;6(2):133–141.

[18] Nurwanti H, Khery Y, Nufida BA. Pengembangan modul ikatan kimia dan bentuk molekul berorientasi nature of science untuk menumbuhkan literasi sains siswa. Hydrogen: Jurnal Kependidikan Kimia. 2018;6(2):81–99.

[19] Wardhana SO, Hidayah R. Interactive chemical bond electronic module based on Nature of Science (NOS) to improve scientific literacy knowledge. Journal of Science Education Research. 2022;6(1):15–23.

[20] Pane EP, Siahaan FE. Pengembangan modul pembelajaran berbasis STEM untuk meningkatkan kemampuan literasi sains mahasiswa pada mata kuliah kimia umum. *Eksakta: Jurnal Penelitian dan Pembelajaran MIPA*. 2022;7(1): 154–161.

[21] Hutomo BA, Saptono S, Subali B. Development of e-module based on science, technology, engineering, and mathematics (stem) to improve science literacy of junior high school students. Journal of Innovative Science Education. 2022;11(2):241–9.

[22] Prasetyo D, Marianti A, Alimah S. Improvement of Students' science literacy skills using STEM-based e-modules. Journal of Innovative Science Education. 2021;10(2):216–21.

[23] Ahmadi HP, Suryati S, Khery Y. Pengembangan modul contextual teaching and learning (CTL) berorientasi green chemistry untuk pertumbuhan literasi sains siswa. Hydrogen: Jurnal Kependidikan Kimia. 2016;4(1):17–25.

[24] Kimianti F, Suryati S, Dewi CA. Pengembangan modul learning cycle 5E berorientasi green chemistry pada materi sistem koloid untuk peningkatkan literasi sains siswa. Hydrogen: Jurnal Kependidikan Kimia. 2016;4(2):70–9.

[25] Ballard J, Mooring SR. Cleaning our world through green chemistry: introducing high school students to the principles of green chemistry using a case-based learning module. J Chem Educ. 2021;98(4):1290–5.

[26] Luthfiana AD, Hidayah R. E-Module of chemistry practicum based on cooperative learning on salt hydrolysis material to improve students' scientific literacy Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram. 2022;10(1):36–47. https://doi.org/10.33394/j-ps.v10i1.4763.

[27] ArdinaTP, Retno, Saputro S, Ulfa M. Properness test: Development of an inquiry-based learning module to improve science literacy in thermochemistry subject. The 8th annual basic science international conference: Coverage of Basic Sciences toward the World's Sustainability challenges;202. East Java: AIP Publishing; 2021.

[28] Irwansyah FS, Lubab I, Farida I, Ramdhani MA. Designing interactive electronic module in chemistry lessons. *Journal of Physics: Conference Series*. 2017. https://doi.org/10.1088/1742-6596/895/1/012009.

[29] Gilbert JK, Treagust DF. Introduction: macro, submicro and symbolic representations and the relationship between them: Key models in chemical education. *Multiple representations in chemical education*. Springer; 2009. p. 1–8. https://doi.org/10.1007/978-1-4020-8872-8_1.

[30] Rahayu S. Mengoptimalkan aspek literasi dalam pembelajaran kimia abad 21. *Prosiding Seminar Nasional Kimia UNY*. pp. 183–188 (2017).