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# Development of student worksheets through study chitosan as corrosion inhibitor on metal

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**ABSTRACT**

This research aims to develop student worksheets (SW) through the study of the effectiveness of chitosan as a coating of corrosion on the metal Zn, Fe, and Al in acidic media, which are valid based on the feasibility aspect of content, language, presentation and graphic. This type of research is the development of research with reference to the development process of the 4-D model of development. Instrument data collection sheet validation is given to three validators, and from analysis of the data obtained on the validity of the feasibility aspects of content, language, presentation and graphic row is equal to 93.88%, 96.67%, 95.83%, and 93.75% with a valid category. Based on the results of limited trials conducted on teachers and students, each obtained an average score of 92.50% and 87.90% with good criteria. It can be concluded that SW developed based on the study of the effectiveness of chitosan as a corrosion coating on metals in acidic media is stated to be valid and can be used in high school chemistry subjects in the subject of reduction–oxidation (redox) reactions and corrosion.

**Keywords:** chitosan, corrosion, redox reactions, student worksheet

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## INTRODUCTION

Understanding the concept of corrosion and its prevention in senior high school needs to be done so that students are more aware of the problem of corrosion because losses due to corrosion in Indonesia are estimated at trillions of rupiah per year or 1.00% to 5.00% of national domestic revenue. It is necessary for the research development making of student worksheets (SW) are also defined as facilitating basic activities as regards learning science, gaining research method and techniques, helping students to be active and to make learning permanent (Karsli & Ayas, 2011).

SW include teaching materials and learning media that contain a set of basic activity that must be done by learners (Erna et al., 2021). SW also includes work to be done by learners sheets are typically in the form of instructions or steps to complete a task. Basic competencies to be achieved must be clear. SW should increase students' interest in learning. Government regulation of Indonesia number 19 of 2005 section 20, hinted that teachers are expected to develop learning materials, which are then reinforced through government regulation number 41 in 2007 on the standard process, which among other things regulates the planning of the learning process that requires the educator in the educational unit to develop a lesson plan. One element of the lesson plan is a source of learning. Thus, teachers are expected to develop teaching materials as a source of the learning (Ian & Popp, 2013). For instance, the language used in the current study may have been too difficult for students to understand. In addition, teachers can identify their students' prior knowledge using SW. It could see when students conducting experiment and each group used their time to complete their student sheet (Astra et al., 2015). A lot of time and research are required for teachers to develop for a topic to be taught. Therefore as an alternative solution, teachers may have to rely on research to design and develop for more topics on chemistry (Chong et al., 2013). The topic of oxidation-reduction reactions and corrosion was studied in class XII senior high school students.

Preparation and application of SW in learning can be used as a medium for active learning and as a means or a reference to guide the implementation of learning activities. It is necessary for innovation in manufacturing SW namely SW based research laboratory. In this the development of SW to be used in high school chemistry laboratory-based experimental research to study the effectiveness of chitosan as a coating corrosion of the Zn, Fe, and Al in acidic media was explained. Based on interviews with chemistry teachers in Pekanbaru, Indonesia, information was obtained that SW used so far was still theoretical and not based on laboratory experiments. SW used by teachers does not support the implementation of the 2013 curriculum that applies in Indonesia. The 2013 curriculum emphasizes student activity of

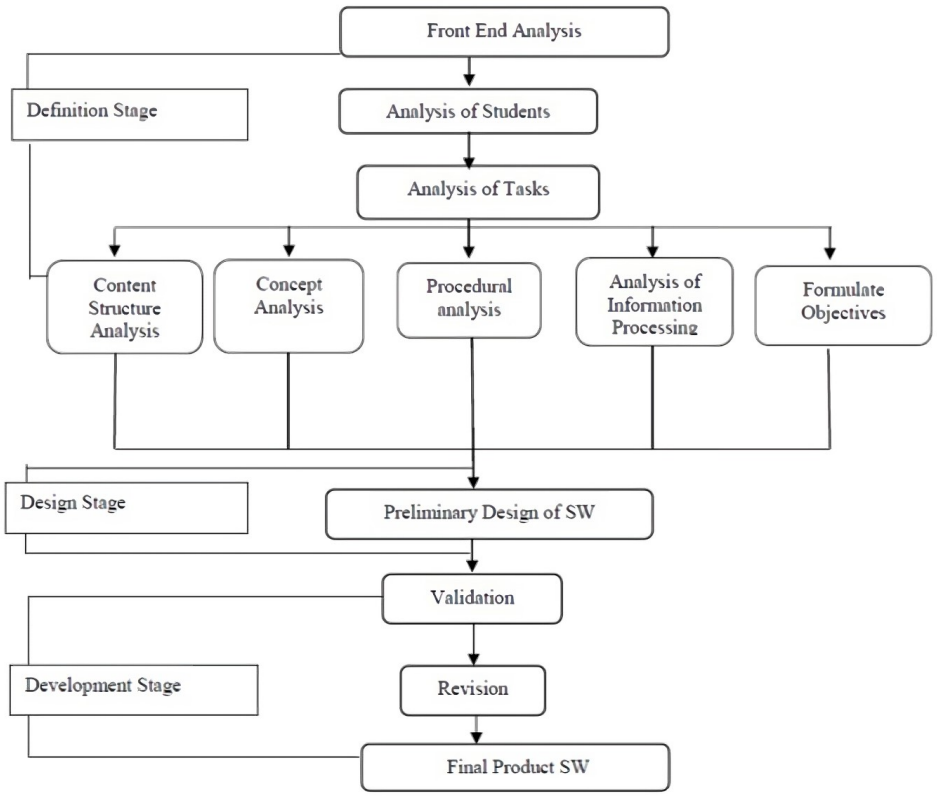


**Figure 1.** Flow chart development SW instruments used in this research (Adapted from Thiagarajan et al., 1974)

observing, asking, linking the phenomena, do trial and present the knowledge obtained in learning. For that making of SW corresponding to high school chemistry syllabus that students are able to analyze the factors influence the occurrence of corrosion and submit ideas to address them. The phenomenon of corrosion on metals is studied through the corrosion process on Zn, Fe, and Al metals, because they are often found in everyday life. While the method used to inhibit the corrosion process on the metal used chitosan compounds as corrosion inhibitors (Erna et al., 2017).

## LITERATURE REVIEW

Corrosion process consists of cathodic and anodic reactions. When a metal atom experiences an oxidation reaction, which is the release of electrons, the atom is turned into an ion through a reaction with chemical compounds found in its environment. To understand the redox reaction and the corrosion process as well as its prevention in this research, the development of SW is based on the study of the effectiveness of chitosan as a corrosion coating on several metals in acidic media. SW is a form of learning guide used in learning environtment that makes easier for students and teachers to carry out teaching and learning activities. In addition, SW allows students to do real activities with the objects and problems being studied. SW is also a student's guide that is used to carry out investigation or problem solving activities. SW can improve the students competence in building their knowedge in teaching science subject (Yustina & Kapsin, 2017).

Chitosan is derived from chitin compounds including organic compounds, which are abundant biopolymer in nature after cellulose and environmentally friendly. Chitosan is used because it contains hydroxyl groups and primary amine has a pair of electrons that can bind directly to metal surfaces. Based on Zheludkevich et al. (2011), the chitosan-based inhibitor-containing active anticorrosive coating with self-healing ability is reported for the first time in the present work. Chitosan as the organics corrosion inhibitor have both action anodic and cathodic the protective by a film adsorption (Dariva & Galio, 2014). Chitosan corrosion prevention techniques in this study by coating (coating) that coat the metal with a solution of chitosan such as using paints in general. This technique is done because it is very simple and can be applied in teaching chemistry in schools. SW products, which are valid in this study expected to provide a significant contribution in improving the ability of learners on the oxidation-reduction chemistry in particular corrosion and its prevention. The efficiency of inhibiting chitosan can be improved by modifying the hydrophobic structure (Alsabagh et al., 2014). Chitosan derivatives namely carboxymethyl chitosan are also effective in inhibiting corrosion in steel (Erna et al., 2010).

## METHOD

Experiment-based research was carried out at the Chemistry Education Laboratory, University of Riau in the 2016/2017 academic year and SW product development research was carried out in 2020/2021. This research is the development of a product. This research aims to develop high school chemistry SW through the study of the effectiveness of chitosan as a coating of corrosion on the metal Zn, Fe, and Al in acidic media, namely HCl.

The method used in this research is the method of research and development with 4-D model of development raised by Thiagarajan et al. (1974). 4-D model consists of four stages, namely define, design, develop, and disseminate. At this research the stage disseminate was not

**Table 1.** Validation sheet

| No | Assessment indicators | 4 | 3 | 2 | 1 | C%S |
|---|---|---|---|---|---|---|
| 1 | SW according to the learning objectives | | | | | |
| 2 | SW according to the ability of learners | | | | | |
| 3 | SW accordance with the substance of the redox and electrochemistry | | | | | |
| 4 | Guided inquiry stage in coherent SW | | | | | |
| 5 | The orientation stage in SW stimulates learners to think about solving problems | | | | | |
| 6 | The formulation of the problem presented is in accordance with the objectives to be achieved | | | | | |
| 7 | The hypothesis stage in SW encourages learners to formulate possible temporary answers to problems | | | | | |
| 8 | The stage of collecting data at SW directs learners to find the information needed | | | | | |
| 9 | The hypothesis testing stage in SW directs students to determine the accepted answer based on data collection | | | | | |
| 10 | Conclusions in SW encourage learners to describe the findings obtained based on the results of hypothesis testing | | | | | |
| 11 | SW provides illustrations or discourses of problems related to everyday life | | | | | |
| 12 | SW has clear information | | | | | |
| 13 | Images that are in SW can foster curiosity in learners. | | | | | |
| 14 | SW has activities that enable learners to communicate opinions and work results | | | | | |
| 15 | The questions in SW provide clues to find concepts independently | | | | | |
| 16 | The language used in communicative and interactive SW | | | | | |
| 17 | SW in accordance with the rules of Indonesian standard | | | | | |
| 18 | SW using clear sentence structure | | | | | |
| 19 | SW use language appropriate to the level of ability of learners | | | | | |
| 20 | SW consistent in the use of terms and abbreviations | | | | | |
| 21 | Completeness of SW format (title, objectives, study instructions, supporting information, work steps, questions, & assessments) | | | | | |
| 22 | SW provides enough space to provide breadth for learners to write what learners want to convey | | | | | |
| 23 | SW already has a coherent systematics | | | | | |
| 24 | SW has illustrations/picturess/photos related to the concept | | | | | |
| 25 | SW uses a good and attractive typeface and size | | | | | |
| 26 | SW has an attractive layout | | | | | |
| 27 | SW has clear illustrations/pictures/photos | | | | | |
| 28 | SW has an attractive display design | | | | | |

Note. C&S: Comments and suggestions

**Table 2.** Questionnaire sheet

| No | Statement | SA | A | D | SD |
|---|---|---|---|---|---|
| 1 | Worksheet help me understand redox and electrochemistry material in the learning process. | | | | |
| 2 | The language used in communicative chemistry worksheets makes it easier for me to understand redox & electrochemistry material. | | | | |
| 3 | Design, writing, and drawings in worksheets look attractive. | | | | |
| 4 | The guidance steps given in the worksheet are clear and easy to understand. | | | | |
| 5 | The orientation stage on worksheets motivates me to seek and find concepts. | | | | |
| 6 | The problem formulation stage on the worksheet relates with daily life. | | | | |
| 7 | The hypothesis stage on the worksheet led me to formulate a temporary answer to the problem. | | | | |
| 8 | The data gathering stage of the worksheet led me to gather information. | | | | |
| 9 | The hypothesis testing stage on the worksheet led me to determine the accepted answer based on data collection. | | | | |
| 10 | The conclusion stage on the worksheet encouraged me to conclude the findings and concepts obtained. | | | | |
| 11 | Chemistry worksheets require me to always be active so that learning is not only teacher-centered. | | | | |
| 12 | Sentences used in worksheets can be read clearly, structured and do not cause double meanings. | | | | |
| 13 | The presentation of the worksheets is very interesting and makes me more enthusiastic about learning chemistry. | | | | |
| 14 | Worksheets build my knowledge little by little so that I understand the material presented. | | | | |
| 15 | Delivery of material in worksheet is adjusted to my previous abilities so that it makes it easier for me to understand the material presented. | | | | |

Note. SA: Strongly agree; A: Agree; D: Disagree; & SD: Strongly disagree

done. The steps of development of SW in this study can be described in the form of a flow chart, as follows (**Figure 1**).

### Validation Sheet

This validation sheet serves as a research instrument that aims to determine whether or not valid SW criteria being developed by researchers. This validation sheet will be given to three validator, which are three lecturers for the improvement of development SW on redox reactions and corrosion materials in high school class XII. The validation sheet used can be seen in **Table 1**.

### Questionnaire

The questionnaire used to support for the response or responses of learners and teachers to the development SW during limited testing. The questionnaire sheets used can be seen in **Table 2**.

Data were analyzed using descriptive statistical analysis. The purpose of descriptive analysis is to describe the results of the validity of a given validator after being validated.

**Table 3.** Category rating by validator

| Score assessment | Category |
|---|---|
| 4 | Good/valid |
| 3 | Pretty good/fair valid |
| 2 | Not good/less valid |
| 1 | No good/invalid |

**Table 4.** Eligibility criteria

| Average validation sheet value (%) | Criteria |
|---|---|
| 80.00-100.00 | Good/valid/worth |
| 60.00-79.99 | Pretty good/fair valid/self worth |
| 50.00-59.99 | Not good/less invalid/less worthy |
| 0.00-49.99 | No good (replaced) |

**Table 5.** Assessment of eligibility of contents by validator I, II, & III

| No | Components score | Ratings validator | | | Eligibility value (%) | Remarks |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | SW according to the learning objectives | 4 | 4 | 3 | 91.67% | Valid |
| 2 | SW according to the ability of learners | 4 | 4 | 4 | 100.00% | Valid |
| 3 | SW accordance with the substance of the redox and corrosion | 4 | 4 | 4 | 100.00% | Valid |
| 4 | SW provide illustrations or discourse problems related to everyday life | 4 | 4 | 4 | 100.00% | Valid |
| 5 | SW have clear information | 4 | 4 | 4 | 100.00% | Valid |
| 6 | Images that are in SW can foster curiosity in learners. | 4 | 3 | 4 | 91.67% | Valid |
| 7 | SW have activities that enable learners to communicate their opinions and work | 3 | 4 | 3 | 83.33% | Valid |
| 8 | The questions in SW provide clues to find the concept independently | 4 | 3 | 3 | 83.33% | Valid |
| Average scores | | 3.93 | 3.80 | 3.53 | 93.83% | Valid |

Validation aspects are assessed by experts or practitioners made in the form of the scale. Type of scale used is a Likert scale with a score of 1-4. This scale provides flexibility to the validator in assessing learning tools such as activity sheet students who have developed. Validation activity sheet students determined by the value of the average score given by validator. Category rate is shown in **Table 3**.

Eligibility criteria in making decisions to validate SW can be seen in **Table 4**. The worksheet produced from this study if the average value of the validation sheet meets the good/valid/worth criteria.

After validation process of SW was tested. Limited trial using questionnaires and conducted to look at the use of one SW that have been developed and to evaluate the response of students and teachers to SW that have been developed. Data limited trial results will be analyzed in accordance with the guidelines that have been developed rating.

## FINDINGS AND DISCUSSION

Development of SW the effectiveness of chitosan as a coating corrosion for metals Zn, Fe, and Al in acidic media was performed by using the 4-D model. The stages of research development SW includes the step of defining, designing stage, and the stage of development. Define phase was to identify and study about the front end analysis, analysis of learners, and analysis tasks (Tompo et al., 2016). The results of the analysis front end SW conditions on the ground, which did not facilitate learners to enrich the experience, build knowledge and active learners, and support problem solving abilities. While the analysis of learners shows that learners are still passive in learning, are still not capable of reasoning well and have not been accustomed to high-level thinking, especially in understanding abstract concepts.

The results of the task analysis produced some results of the analysis are analysis of content structure, concept analysis, procedural analysis, analysis of information processing and formulation of learning objectives. Analysis of content structure is based on the content analysis of curriculum materials developed is redox materials and corrosion. Redox and corrosion material development and based on core competence and basic competences. Analysis of the concept of making the concepts systematically arranged in the form of maps concept redox and corrosion. While the results of the analysis of procedural stages completion of tasks used in SW orientation, formulation of the problem, hypothesis, collect data, test hypotheses and conclusions. Procedural stage in SW based on inquiry method. Method of inquiry learning activities deeply engaged and challenged students in all of steps of the activities process their conceptual comprehension was enhanced (Suparsorn & Promarak, 2015). The analysis resulted in an analysis of information processing in the form of learning implementation plan. While the formulation of the goal of producing the learning objectives are formulated based on basic competencies and learning indicators, which refer to the syllabus. The model was expected to have valid, practical and effective criteria (Tompo et al., 2016).

Stage design and produce the preliminary draft SW, SW validation sheet. SW developed draft contains SW structure in accordance with the instructional materials development guide (Suparsorn & Promarak, 2015), which includes the title SW, SW instructions, SW material, and writing an answer key SW (SW teacher guides). Develop phase SW produce initial draft, the chemistry activity sheet students based effectiveness of chitosan as a coating corrosion. Products SW the initial draft is consulted with the supervisor to get inputs for the development and improvement SW prior to validation. Validation SW aims to determine the feasibility of SW be used in learning. Validation carried out by validator, therefore, three people lecturer in chemical education at University of Riau. Validation SW includes four aspects, namely the feasibility of the content, language, presentation and graphic. In this study we have conducted, the responses obtained from the learning impact questionnaire showed that the tutor was rated as being more significant for students' learning and not the worksheet (Choo et al., 2011). SW are practical, useful and economic materials to use in educational activities. Regarding Turkish educational system, worksheet is a new topic and subject area for scholars to explore. As it can be seen in many other educational subjects, worksheets entered Turkish educational system after the reorganization policies of national education in 1990s. At this point, number of studies on worksheets started to increase during 1990 (Kaymakci, 2012).

### Aspects of Content Eligibility

The eligibility aspect contents have eight component assessments that aim to assess the accuracy of chemical concepts in SW. The average score of content validation of eligibility aspects can be seen in **Table 5**.

**Table 6.** Linguistic assessment of eligibility

| No | Components score | Ratings validator | | | Eligibility value (%) | Remarks |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | The language used in communicative and interactive SW | 4 | 4 | 3 | 91.67% | Valid |
| 2 | SW in accordance with the rules of Indonesian standard | 4 | 3 | 4 | 91.67% | Valid |
| 3 | SW using clear sentence structure | 4 | 4 | 4 | 100.00% | Valid |
| 4 | SW use language appropriate to the level of ability of learners | 4 | 4 | 4 | 100.00% | Valid |
| 5 | SW consistent in the use of terms and abbreviations | 4 | 4 | 4 | 100.00% | Valid |
| Average scores | | 4.00 | 3.80 | 3.80 | 96.67% | Valid |

**Table 7.** Assessment of eligibility presentation

| No | Components score | Ratings validator | | | Eligibility value (%) | Remarks |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | Completeness format SW (title, objectives, hints learning information support, steps to work, questions, & assessment) | 4 | 4 | 3 | 91.67% | Valid |
| 2 | SW provides sufficient room to provide breadth for the learners to write to be conveyed by learners | 4 | 4 | 4 | 100.00% | Valid |
| 3 | SW own systematic coherent | 4 | 4 | 4 | 100.00% | Valid |
| 4 | SW own illustrations/pictures/photos related to the concept | 4 | 4 | 3 | 91.67% | Valid |
| Average scores | | 4.00 | 4.00 | 3.50 | 95.83% | Valid |

**Table 8.** Assessment of graphic eligibility

| No | Components score | Ratings validator | | | Eligibility value (%) | Remarks |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | SW use a type and size of letters was good and interesting | 4 | 4 | 4 | 100.00% | Valid |
| 2 | SW has the layout (layout) of interest | 4 | 4 | 3 | 91.67% | Valid |
| 3 | SW own illustrations/pictures/photos are clear | 4 | 3 | 4 | 91.67% | Valid |
| 4 | SW design has an attractive display | 4 | 4 | 3 | 91.67% | Valid |
| Average scores | | 4.00 | 3.75 | 3.50 | 93.75% | Valid |

**Table 9.** Average score recap fourth assessment feasibility aspects SW

| No | Rated aspect | Average score validator 1 | Average score validator 2 | Average score validator 3 | Average score validation | Information |
|---|---|---|---|---|---|---|
| 1 | Eligibility of contents | 98.30% | 95.00% | 88.33% | 93.88% | Valid |
| 2 | Linguistic eligibility | 100.00% | 95.00% | 95.00% | 96.67% | Valid |
| 3 | Eligibility of presentation | 100.00% | 100.00% | 87.50% | 95.83% | Valid |
| 4 | Eligibility of graphics | 100.00% | 93.75% | 87.50% | 93.75% | Valid |
| The overall average score validation | | | | | 95.03% | Valid |

The average score of validation of the feasibility aspects the contents is 93.83%. Based on the eligibility criteria learning devices in **Table 4**, the eligibility criteria analysis of the percentage of 93.83% are valid.

### Aspects of Linguistic Eligibility

The eligibility aspect of language has five component ratings that aim to assess the level of legibility or the use of language in SW. The average score of validation of the feasibility aspect of language can be seen in **Table 6**.

The average score of validation on aspects of language was 96.67%. Based on the eligibility criteria learning devices in **Table 4**, the eligibility criteria analysis of the percentage of 96.67% are valid.

### Aspects of Presentation Eligibility

The presentation of the feasibility aspect has four components that aim to assess the quality of the presentation on SW. The average score of the validation aspects of the feasibility of the presentation can be seen in **Table 7**.

The average score of validation on the presentation aspect is 95.83%. Based on the eligibility criteria learning devices in **Table 4**, the eligibility criteria analysis of the percentage of 95.83% are valid.

### Aspect of Graphic Eligibility

Graphic feasibility aspect has four components that aim to assess the accuracy of the layout (layout), text, pictures/photos, and designs SW. The average score graphic validation of the eligibility aspects can be seen in **Table 8**.

The average score on the aspect graphics validation is 93.75%. Based on the eligibility criteria learning devices in **Table 4**, the eligibility criteria analysis of the percentage of 93.75% are valid. Recap the average score of the four aspects of the feasibility assessment SW (**Table 9**).

Recap average score of four aspects of the feasibility assessment by a team SW validator, the feasibility of the content, language, presentation, and graphics row to have the feasibility value 93.88%, 96.67%, 95.83%, and 93.75%. Thus, the overall average score SW validation redox and corrosion based effectiveness of chitosan as a coating corrosion on metals Zn, Fe, and Al in acidic media is 95.03%.

Based on the eligibility criteria learning devices in **Table 4**, the eligibility criteria analysis of the percentage of 95.03% and included valid. This students questionnaire responses given to the students to determine the external validity of students' activity sheet developed.

**Figure 2.** Shrimp shells, chitosan, & metal plate (Source: Authors)

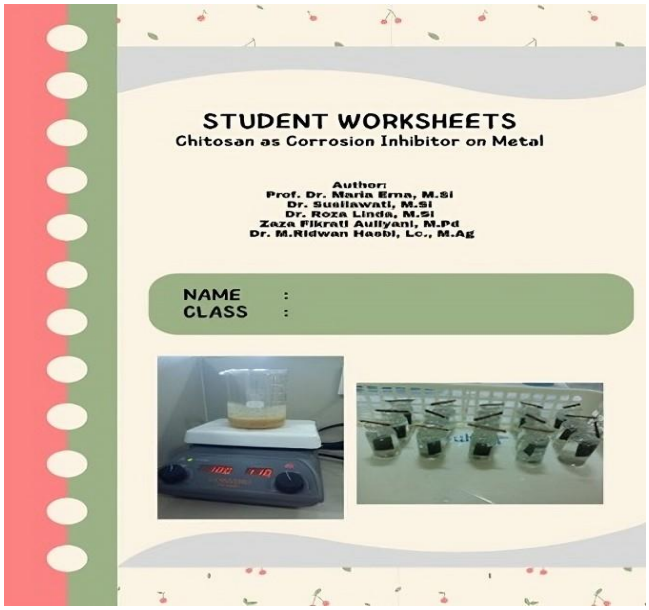


**Figure 3.** Student worksheet cover (Source: Authors)

The student questionnaire responses carried out by answering the number of questions with the answer "yes" or "no" (Damayanti & Dian, 2017). Based on questionnaire response student can participants to these lessons by inquiry instruction. Students overall would have more receptive to it. According to the research given the participant of the students about inquiry instruction can be interest for them (Ian & Popp, 2013). Based on the results of limited testing done to teachers in high school Riau province the average scores, which obtained 92.50% with a good criteria and the results of limited testing done to students, which has 21 people obtained an average score of 87.90% with a good criteria. Overall students activities sheet based on the study of the effectiveness of chitosan as a coating of corrosion on the metal Zn, Fe, and Al in acidic media declared valid and can be used on subjects of high school chemistry subject of redox reactions and corrosion. This result is supported by research results (Arwati, 2018), which also prove chitosan can inhibit corrosion on aluminum.

Chitosan produced from this research came from shrimp shell waste through four stages, namely deproteination, washing and filtering, demineralization and decolorization. Shrimp shells and chitosan can be seen in **Figure 2**. The stages of chitosan isolation included in SW developed in this study.

SW product cover produced in this study, which were declared valid and had good responses can be seen in **Figure 3**.

## CONCLUSIONS

Based on the results of this study concluded that SW based the study of the effectiveness of chitosan as a coating of corrosion on the metal Zn, Fe, and Al in acidic media on the subject redox reaction and corrosion is valid according to the feasibility aspects of content, linguistic appropriateness, feasibility and feasibility presentation graphics with an average score of three validator amounted to 95.03%. While the results of limited testing performed teachers to SW is 92.50% with a good criteria and results of limited testing to students is 87.90% with a good criteria. The results of this study are suggested to be applied by chemistry teachers in learning as a guide for students in carrying out structured and logical activities.

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**Data availability:** Data generated or analyzed during this study are available from the authors on request.

## REFERENCES

Alsabagh, A. M., Elsabee, M. Z., Moustafa, Y. M., Elfky, A., & Morsi, R. E. (2014). Corrosion inhibition efficiency of some hydrophobically modifified chitosan surfactants in relation to their surface active properties. *Egyptian Journal of Petroleum, 23*(4), 349-359. https://doi.org/10.1016/j.ejpe.2014.09.001

Arwati, I. N. A. (2018). Effect of chitosan on the corrosion protection of aluminumin $H_2SO_4$. *World Chemical Engineering Journal, 2*(1), 1-5. https://doi.org/10.48181/wcej.v6i1.14377

Astra, I. M., Nasbey, H., & Muharramah, N. D. (2015). Development of student worksheet by using discovery learning approach for senior high school student. *Journal of Education in Muslim Society, 2*(1), 91-96. https://doi.org/10.15408/tjems.v2i1.1749

Chong, V. D., Salleh, S. M., & Aicheong, I. P. (2013). Using an activity worksheet to remediate student's alternative conceptions of metallic bonding. *American International Journal of Contemporary Research, 3*(11), 39-52.

Choo, S. S., Rotgans, J. I., Yew, E. H., & Schmidt, H. G. (2011). Effect of worksheet scaffolds on student learning in problem-based learning. *Advances in Health Sciences Education, 16*, 517-528. https://doi.org/10.1007/s10459-011-9288-1

Damayanti, M., & Dian, N. (2017). The development of student activity sheet oriented guided discovery learning model to practice science process skills on redox reaction subject for tenth grade denior high school student. *UNESA Journal of Chemistry Education, 6*(1), 89-97.

Dariva, C. G., & Galio, A. F. (2014). Corrosion inhibitors–Principles, mechanisms and applications. In M. Aliofkhazraei (Ed.), *Developments in corrosion protection* (pp. 365-379). IntechOpen. https://doi.org/10.5772/57255

Erna, M., Elfizar, & Dewi, C. A. (2021). The development of e-worksheet using Kvisoft Flipbook Maker Software based on lesson study to improve teacher's critical thinking ability. *International Journal of Interactive Mobile Technologies, 15*(1), 39-55. https://doi.org/10.3991/ijim.v15i01.15679

Erna, M., Emriadi, Alif, A., Arief, S., & Noordin, M. J. (2009). Sintesis dan aplikasi karboksimetil kitosan sebagai inhibitor korosi pada baja karbon dalam air [Synthesis and application of carboxymethyl chitosan as a corrosion inhibitor on carbon steel in water]. *Jurnal Natur Indonesia* [*Journal of Indonesian Nature*], *12*(1), 87-92. https://doi.org/10.31258/jnat.12.1.87-92

Erna, M., Susilawati, Linda, R., Herdini, Auliyani, Z. F., & Dharma, E. S. (2017). Efektivitas kitosan sebagai pelapis (coating) korosi pada logam Zn, Fe, Al dalam media HCl Dan $H_2SO_4$ [The effectiveness of chitosan as a corrosion coating on Zn, Fe, Al metals in HCl and $H_2SO_4$ media]. *EduChemia (Jurnal Kimia dan Pendidikan Kimia)* [*EduChemia (Journal of Chemistry and Chemistry Education)*], *2*(2), 119-129. https://doi.org/10.30870/educhemia.v2i2.950

Ian, C. B., & Popp, S. (2013). Learning to teach science through inquiry: Experience of preservice teachers. *Electronic Journal of Science Education, 17*(1), 1-24.

Karsli, F., & Ayas, A. (2011). Developing a laboratory activity on electrochemical cell by using 5E learning model for teaching and improving science process skills. *Western Anatolia Journal of Educational Sciences*, 121-130.

Kaymakci, S. (2012). A review of studies on worksheets in Turkey. *US-China Education Review, 1*, 57-64.

Suparsorn, S., & Promarak, V. (2015). Implementation of 5E inquiry incorporate with analogy learning approach to enhance conceptual understanding of chemical reaction rate for grade 1 students. *Chemistry Education Research and Practice, 16*(1), 121-132. https://doi.org/10.1039/C4RP00190G

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teacher of exceptional children: A sourcebook*. Center for Innovation on Teaching the Handicape.

Tompo, B., Ahmad, A., & Muris, M. (2016). The development of discovery-inquiry learning model to reduce the science & of junior high school students. *International Journal of Environment & Science Education, 11*(12), 5676-5686.

Yustina, Y., & Kapsin, K. (2017). The implementation of constructivism-based student worksheets within the theme 'the prevention of land and forest fire' in science education for seventh graders in Riau. *Jurnal Pendidikan IPA Indonesia* [*Journal of Indonesian Science Education*], *6*(2), 298-305. https://doi.org/10.15294/jpii.v6i2.10573

Zheludkevich, M. L., Tedim, J., Freire, C. S., Fernandes, S. C., Kallip, S., Lisenkov, A. D., Gandini, A., & Ferreira, M. G. (2011). Self-healing protective coatings with "green" chitosan based pre-layer reservoir of corrosion inhibitor. *Journal of Materials Chemistry, 21*, 4805-4812. https://doi.org/10.1039/c1jm10304k

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