CE – 02

Construction of Chemistry Teaching Material Using Organic-LED (OLED) Context for High School Students

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Abstract— Science education should really be able to project students not only to obtain knowledge, but also to apply those knowledge. This is triggered by the establishment of the AEC, which challenges Indonesian resources to compete with foreign resources. In addition, young generation faces major challenges in providing sufficient water, food and energy as environment continue changing. But in fact, the ability of students' scientific literacy is still very low, indicated by PISA 2012 study. Content-oriented curriculum and learning process is one of the reason. Meanwhile, many countries that have implemented contexts-oriented instruction project such as Finland (Phenomenon teaching), Germany (Chemie im Kontext), US (ChemComm) and UK (Salters) are considered as successful educational system countries according to PISA. Therefore, this study focused on the construction of Chemistry teaching material using OLED as context. OLED is chosen because it is up-to-date, relevant to real life even for the next decade and closely related to the process competence. This study used Model of Educational Reconstruction that combined students' preconceptions and scientists' perspectives on OLED and high school curriculum objectives. Students' preconception is obtained through interviews, while scientist's perspective is obtained through the analysis of OLED and related chemical contents from textbooks and journals. Both data were analyzed for compliance with high school curriculum. The results of this study stated that OLED-context teaching material includes chemical concepts as follows: Bohr's Theory of energy level, Electromagnetic Radiation, Chemical Bonds (in Solids), Electrolysis, Alkenes, Redox, Aromatics and Polymers.

Keywords: *chemistry, construction, context-based, OLED, teaching material*

I. INTRODUCTION

On this day, education is an important key in the development of human resources. With the establishment of the AEC (ASEAN Economic Community) at the end of 2015, the quality of Indonesian resources in Indonesia should be increased in order to compete with foreign resources. On the other hand, changes in the world continue to occur and followed by the challenges that accompany it. Emerging challenges such as providing sufficient water and food, controlling diseases, generating sufficient energy and adapting to climate change should be capable to be faced by young people. To face these challenges, it required a large contribution of science and technology. Therefore, the purpose of science education should be both broad and applied..

The study of PISA (Programme for International Student Assessment), which organized by OECD (Organization for Economic Cooperation and Development) since 2000 to 2012 show things that are not in line with the expectations declared before. Indonesian students' performance in scientific literacy in year 2000-2012 remained at low levels.

According to the Firman (2007), and Hayat and Yusuf (2010), a low level of Indonesian students performance in scientific literacy is suspected caused by the content of curriculum (experimental activities and teaching materials), learning process and assessment conducted that does not support the exploration of scientific literacy. All of them are too focused on the dimensions of the content (knowledge of science) whilst ignoring other dimentions, e.g. knowledge about science, process / competence (thinking skills) and the context of science application (such as technology).

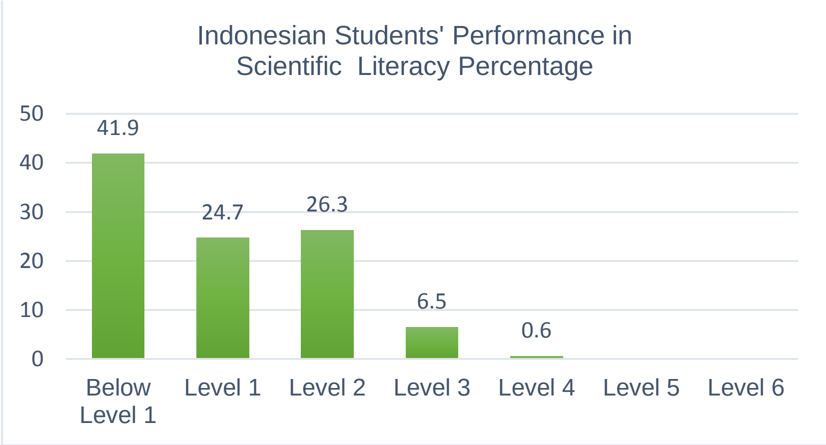

FIGURE 1. INDONESIAN STUDENTS' PERFORMANCE IN SCIENTIFIC LITERACY PERCENTAGE ACCORDING TO PISA 2012 RESULT

Meanwhile in some advanced countries, the trend of learning has shifted from conventional learning into context based learning / topic. The goal is to prepare students to face the world of work is considered important for the industry and modern society. Finland is one of many countries that implementing this learning trend. The result, based on PISA study, revealed that Finland education system is considered successful (OECD, 2010).

From the 1980s, context-based curriculum projects were implemented in mainstream chemistry courses, for instance, the USA project of 'Chemistry in the Community' (ChemCom) and the UK project of 'Salters Chemistry'. Quite recently, new projects were implemented, such as the USA project of 'Chemistry in Contexts: Applying Chemistry to Society' (CiC), and the German project of 'Chemie im Kontext' (ChiK) (de Jong, 2006). According to Otter (2011), the use of context-based teaching materials is guided by several studies such as the lack of interest of students towards science subjects (Ramsden, 2003), the declining interest of students in science at secondary school level (Reiss, 2004; Simpson and Oliver, 1990) and students' asumption that science has no relevance to their lives (Reiss, 2000). Revealed by De Jong (2006), meta-analyzes have been performed by Bennett, Hogarth and Lubben (2003) in 66 studies on the effect of context-based learning approach and the results show that the context-based approach has been successfully motivate students to study science and be able to increase positive attitudes towards science in general.

Based on the explanation above, innovation in science learning content in Indonesia can also be performed by using some particular topics as the context for studying Chemistry. One topic that is considered as up-to-date theme is the Organic Light-Emitting Diode (OLED). Topic OLED is chosen based on three principles of learning science in PISA: relevant to real life situations, still relevant at least for the next decade and closely related to the process competency (Hayat and Yusuf, 2010).

II. PURPOSE OF THE STUDY

Based on all the explanations above, this research focused on the development of Chemistry teaching materials based on modernization of scientific content using OLED topics to be used in the science literacy-based on learning process.

III. METHODOLOGY

The research model used in this study is the Model of Educational Reconstruction (MER) developed by Duit, *et.al.* (2012). The model was designed with the specific purpose of providing a "theoretical framework for studies as to whether it is worthwhile and possible to teach particular areas of science" (Duit, 2007, p. 5). Accordingly, the model has previously been employed in scrutinising comparatively novel fields of science – ones that are not yet in the school curriculum. One basic idea of this model is that the structure of the content for learning can not only be taken directly from the structure of science content, but also must be specially reconstructed by paying attention to education goal and students' cognitive and affective perspective.

MER consists of three components, namely: 1) clarification and analysis of science content; 2) research on teaching & learning; and 3) design and evaluation of teaching and learning environments. The relationship between one components with the other components is not rigid, but recursive.

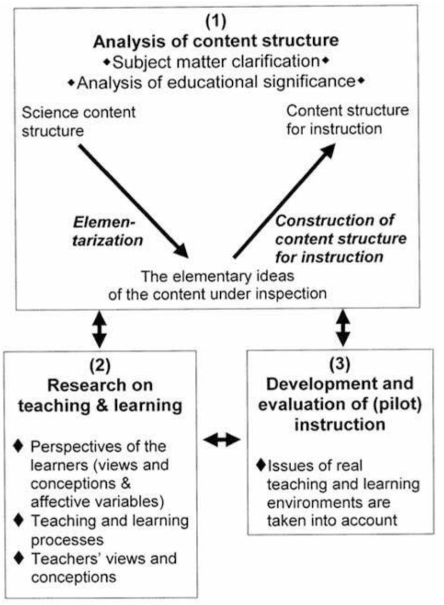

FIGURE 2. THE MODEL OF EDUCATIONAL RECONSTRUCTION (DUIT, 2007, P. 6). REPRINTED BY PERMISSION OF THE EURASIA JOURNAL

The steps being taken in this study are:

1. Analysis of scientist perspective about OLED and Chemistry concepts that related to OLED.
2. Analysis of learner and teacher preconceptions through interview. In general, the content questions include: 1) knowledge of OLED, 2) knowledge of the Chemistry concepts related to OLED, 3) the importance of relating context OLED in learning Chemistry, 4) the urgency of context OLED-based teaching materials and 5) the interest of learner and teacher in using context OLED-based teaching materials.
3. Analysis of curriculum (contents) refered to Kurikulum 2013.

IV. RESULT AND DISCUSSION

A. *Analysis of scientist perspective about OLED*

Definition of OLED

According to Pereira (2012), OLED is defined as light-emitting semiconductor based om organic compounds which have a thickness of 100-200 nm. This thickness is on average a thousand times thinner than a human hair. Overall, the OLED device is about a few millimeters in total thickness. It already includes a substrate (medium that supports the work OLED) and encapsulation structure (organic layer closure to protect them from dust and water). OLED is a self-emitter, meaning that it is not require backlite. Broadly speaking, OLED is divided into two types, namely Small Molecule OLED (SMOLED) and polymerOLED (PLED).

OLED has some advantages compared to the previous light-emitting technologies like LED (Light-Emitting Diode) and LCD (Liquid-Crystal Display). According to Mitschke dan Bäuerle (2000), those advantages are:

1. Can be made to be very thin, thus allowing it to be used in roll-up television
2. It is cheaper to be produced
3. More efficient in energy consumption than LED and LCD
4. Tunability of color emission is better than LCD

Stucture of OLED

The basic structure of OLED is an organic material which is positioned between the cathode and the anode made from transparent conductive glass, ITO (indium tin oxide). The organic material consists of several thin layers, including *Hole Transporting Layer* (HTL), *Emission Layer* (EL) and *Electron Transporting Layer* (ETL).

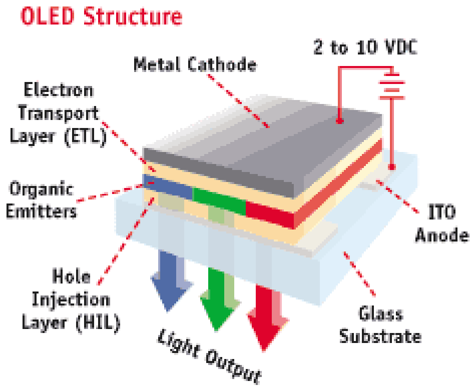

FIGURE 3. BASIC STRUCTURE OF OLED

a. Substrate, glass or plastic foil. Its function is to support the workings of the OLED.
b. Transparent anode. The anode removes electrons (adds "holes" or electron defect) when a current flows through the device.
c. *Organic layer*. This layer consists of organic molecules or polymers.
d. *Emissive layer*, this layer is made of organic plastic molecules (different ones from the conducting layer) that transport electrons from the cathode; this is where light is made. One polymer used in the emissive layer is polyfluorene
e. Cathode (may or may not be transparent depending on the type of OLED). The cathode injects electrons when a current flows through the device.

Characteristic of OLED

As was mentioned above, OLED is a semiconductor device that use organic compound, usually a polymer, as basic materials. So far, the polymer which we know is an electrical insulator. However, the polymer used in OLEDs are conductive polymers that can conduct electricity.

In 2000, A.Heeger, H.Shirakawa da nA.McDiarmid received the Nobel Prize in Chemistry for the discovery and development of conductive polymers. The key in electrical conductivity of the polymer is the presence of conjugated system. Conjugated system is a state where the position of double bonds and single bonds between carbon atoms is conjugated. With the presence of conjugated system, the energy gap in the organic molecules decrease so that polymers turns into a semiconductor.

The presence of conjugated system in polymer does not automatically make the polymer becomes an electrical conductor. To become electrically conductive, the plastic has to be disturbed - either by removing electrons from (oxidation), or inserting them into (reduction), the material. The process is known as doping.Through the redox principle, electrons will be easy to move and flow through the molecule to creates an electric current.

There are two types of doping, oxidation or reduction. In the case of polyacetylene the reactions are written like this:

Oxidation with halogen (*p*-doping): $[CH]_n + 3x/2\ I_2 \rightarrow [CH]_n^{x+} + x\ I_3^-$
Reduction with alkali metal (*n*-doping): $[CH]_n + x\ Na \rightarrow [CH]_n^{x-} + x\ Na^+$

In the first of the above reactions, oxidation, the iodine molecule attracts an electron from the polyacetylene chain and becomes I_3^- . The polyacetylene molecule, now positively charged, is termed a radical cation, or *polaron*.

The doped polymer is a salt. However, it is not the iodide or sodium ions that move to create the current, but the electrons from the conjugated double bonds. Furthermore, if a strong enough electrical field is applied, the iodide and sodium ions can move either towards or away from the polymer. This means that the direction of the doping reaction can be controlled and the conductive polymer can easily be switched on or off.

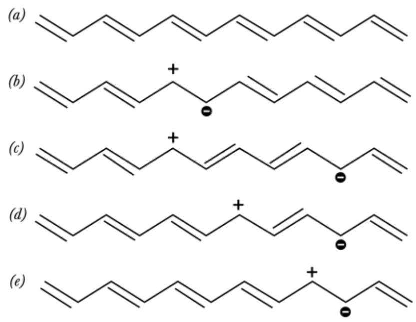

FIGURE 4. FORMATION AND MOVEMENT OF POLARON

How OLED work

Emission of light in the OLED occurs through a process called electroluminesence. In their study, Mitschke dan Bäuerle (2000, hlm. 1471) stated the definiton of electroluminesence (EL) as a non-thermal generation of light resulting from the application of an electric field to a substrate. In the latter case, excitation is accomplished by recombination of charge carriers of contrary sign (electron and hole) injected into an inorganic or organic semiconductor in the presence of an external circuit.

When the electron-hole recombine (merge) in the organic molecules, it formed exciton. Exciton have the same nature as single molecules, but in higher energy. This exciton produce light after its period of lifetime. The wavelength of the light emission produced depends on the exciton energy. Therefore, we can control the color produced by regulating the energy through the selection of the organic material. This is the advantage of OLED displays (Tsujimura, 2012).

Here is an overview of the basic principles of electroluminesence process that occurs in OLED (Banerji, *et. al.*, 2012).

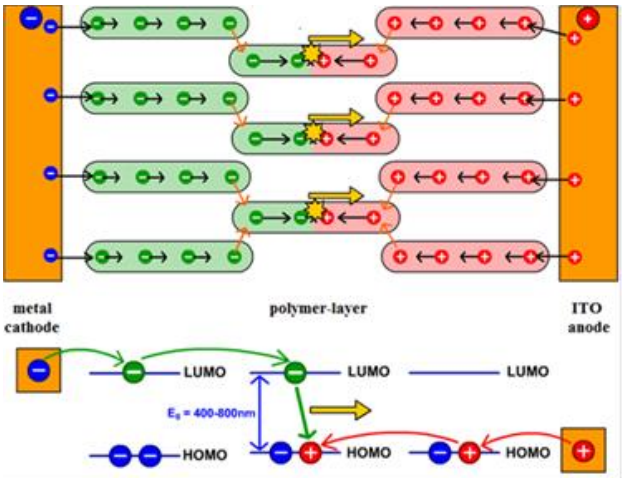

FIGURE 5. PRINCIPLE OF ELECTROLUMINESCENCE IN AN OLED (BANERJI, TAUSCH & SCHERF, 2012)

a. Charge Injection
   In a first step electrons are injected into the LUMO1 of molecules close to the cathode and holes are injected into the HOMO1 of molecules close to the anode.
b. Charge transport
   Via hopping processes (red arrows in Figure 5) the injected charges drift through the polymer layer from molecule to molecule in opposite directions.
c. Charge recombination and decay of excitons
   When electron and hole meet inside a molecule they recombine to give an exciton.

B. Analysis of Chemistry concepts related to OLED

Based on the analysis of context OLED, Chemistry concepts related to OLED can be illustrated in the following figure.

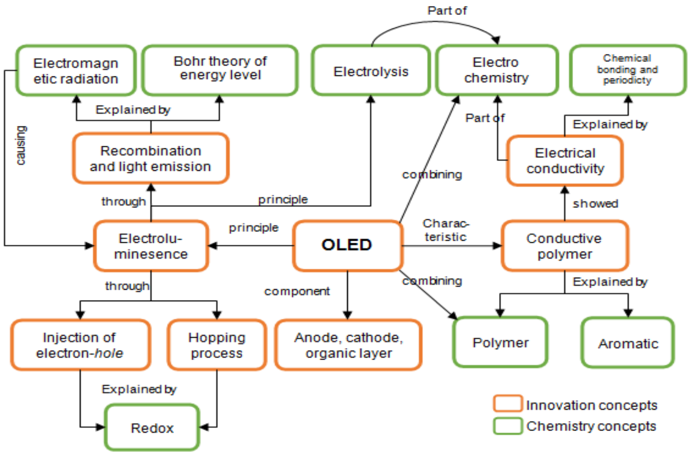

FIGURE 6. SCHEME OF CONTEXT OLED AND RELATED CHEMISTRY CONCEPT

According to the scheme above, chemistry concepts related to OLED are:

1. Bohr's Theory about energy level, to describe light emission process
2. Periodicity, to describe electrical conductivity of semiconductor
3. Organic compound, related to basic material of OLED
4. Polymer, especially conductive polymer
5. Alkene and aromatic compound to describe conjugated system
6. Redox and electrolysis, to describe principle of OLED that makes conductive polymer can emitt lights.

All of those high school Chemistry concepts are adapted to Kompetensi Inti and Kompetensi Dasar Kurikulum 2013 to make it appropriate with national education goals.

C. Analysis of learner and teacher preconceptions about OLED and related Chemistry concepts

The study was conducted through interviews adapted from Laherto (2012). Interviews were conducted on 10 students and three teachers of High School Chemistry. The interview consist of 14 items with a free answer format. The aim is to explore preconceptions that exist in respondents mind. Interview items divided into four parts. Items 1-7 explores the knowledge of the context OLED. Items 8-9 explores the knowledge of chemistry concepts related to the context OLED. Items 10 explore the opinions of respondents on the importance of linking the context OLED in learning Chemistry. Meanwhile, the fourth part consists of items 11-14, explores the respondents' opinions on the urgency of using OLED context-based teaching materials.

Comparison between the preconceptions of students and teachers with scientist's perspective can be seen in the chart below:

TABEL 1. COMPARISON BETWEEN THE PRECONCEPTIONS OF STUDENTS AND TEACHERS WITH SCIENTIST'S PERSPECTIVE

	Students	**Teacher**	**Scientist's perspective**
Knowledge about OLED	Sophisticated technology on TV that makes it has better features	Developments technology of organic-based light emitting material that makes it has better features	Diodes from organic materials that can emit light which have thinner structures and better quality than LED
Principle of OLED	Most do not know, but some of them answered combination of physics and chemistry	Using the principles of electrochemistry, chemical bonding and electromagnetic radiation	Electroluminesence, ie emission of light by electric current
Chemistry concepts related to OLED	Mostly answered correctly, ie electrolysis, organic compounds, chemical bonding, redox, polymers and electromagnetic radiation. Others have not been correct: static and dynamic electricity	Organic compounds (associated with the basic materials OLED), electrochemical (because of similarities with the OLED principle of electrolysis), electromagnetic radiation / atomic structure (related to the emission of light) and chemical bonds (as an explanation of OLED components). However, redox concept unfortunately does not appear as the main principle of OLED	Organic compounds (conjugated system), redox (electron transfer concept), electrolysis, atomic structure (the Bohr atomic theory of energy levels)

V. CONCLUSION

OLED context-based teaching materials developed by MER with considering three stages. Results from students and teachers preconceptions showed that their knowledge of OLED is still not correct, but they showed a positive attitude towards the construction of these teaching materials. Chemistry concepts associated with OLED are organic compounds (conjugated system), redox (electron transfer concept), electrolysis, atomic structure (the Bohr atomic theory of energy levels).

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