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FTO (Fluorine-Doped Tin Oxide) Conductive Transparent Glassware Manufacturing for Organic Compound Based Solar Cell Kits

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ABSTRACT

Practical activities based on the latest science are rarely carried out because they are constrained by expensive equipment, one of which is solar cell technology. The use of conductive glass has become an interesting topic in recent technology. This technology can be implemented in photovoltaic cells (solar cells) and organic lightemitting diodes (OLED), which are very close to our current needs to face the energy crisis. This study aims to develop practical activities in a chemistry. laboratory for the manufacture of fluorine-doped Tin Oxide (FTO)-based surface conductive glass. This research was conducted using educational design research methods using the framework of the Model of Educational Reconstruction (MER). This research produces Transparent Conductive Glass FTO (Fluorine-doped Tin Oxide) with spray deposition technique / Spray Pyrolysis using a Bunsen burner, the result of optimization of some surface conductive glass with sheet resistance of about 1 – 10 kΩ. These results were obtained by applying ten times of SnO2.F deposition on the glass, three times of spraying, and a heating time of about five minutes at a temperature of 250 – 300 °C. This procedure is obtained using a simple laboratory apparatus such as a Bunsen burner, which is available in the Basic chemistry laboratory for applying NOST (Nature of Science and Technology).

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1. INTRODUCTION

Indonesia's participation in the study of the International Program for International Student Assessment (PISA) shows that the achievements of Indonesian students are not too encouraging in the 2015 PISA report. As many as 70 percent of students in Indonesia are still below the minimum competency in reading, with 71 percent in mathematics and 60 percent in science (OECD2016, 2015) One of the reasons The low scientific literacy of Indonesian students is remembered because of the curriculum, process learning, and tourism that does not support science literacy education. They still, focus on the memory dimension of knowledge (memory of science), namely memorizing and forgetting about other dimensions of content (knowledge of science), process/competence (thinking ability), and the context of the application of science (Firman, 2007). One way to improve the quality of the learning process, educators must understand NOST (Nature of Science

and Technology) to help students explain scientific phenomena correctly in understanding some of the concepts in the learning process. To apply scientific concepts in a particular context, participants Students must have an understanding of scientific concepts as a whole (Garthwaite, France, & Ward, 2014). A partial understanding of the concept will make students not get the main idea of the learning concept. In the process of learning in the classroom, educators have an important role to provide concepts to students. Some studies believe that to provide a strong understanding to students, educators must understand the nature of science / Nature of Science (NOS) (McComas, Clough, & Almazroa, 1998). Apart from understanding NOS, in this era of rapid development, it will also be very important to develop an understanding of the Nature of Technology (NOT) and its relationship with science and with society (Tairab, 2001) By modernizing learning content that integrates aspects of material content lessons and aspects of the context in everyday life that are closely related to technological advances. It is hoped that it will attract interest and increase understanding of students' learning in learning science-based technology (techno-science). One of the contexts of new and cutting-edge technology is glass conductive materials that can be used in Organic Compound Sensitization Based Solar Cells / Dye-Sensitized Solar Cell (DSSC).

2. METHODS

The Educational Reconstruction (MER) model is used as a reference for the steps in the development of this practicum activity. MER has three components: clarification and analysis of science content, teaching and learning research, and design and evaluation of the teaching and learning environment (Fakayode, 2014) which can be seen in the figure 1. FTO (Fluorine-Doped Tin Oxide) Conductive Transparent Glass Manufacturing For KIT Organic Compound Based Sensitization Solar Cells / Dye-Sensitized Solar Cells (DSSC) Spray Deposition Technique Using a Bunsen Burner and Simple Tools

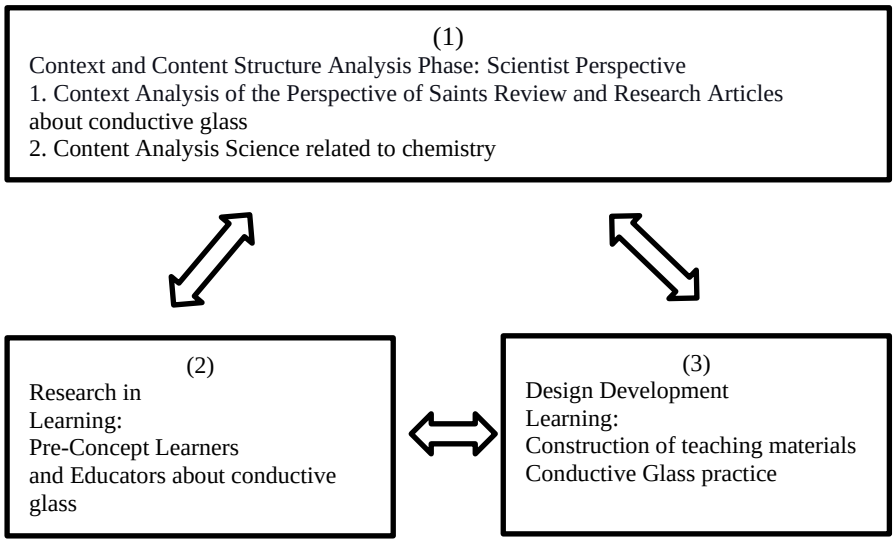

Figure 1. MER Model Research design

The developed NOST aspect refers to the modified Tairab (2001) taking into account the scope of ontological, epistemic, and axiological aspects knowledge to generate questions that will be developed in the material teach practicum so that they can understand: the nature of science and technology, characteristics science and scientific theories, ways of obtaining scientific knowledge and theories, the goals of science and scientific research, and the relationship between science and technology (Tairab, 2001)

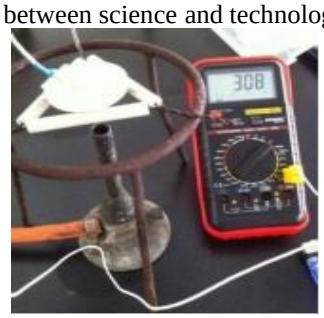

Figure 2. Glass temperature measurement with ceramic heating base Bunsen

Figure 2 shows the measurement of the glass surface temperature using an AVO (Ampere, Volt, Ohm) Meter with a Thermocouple (maximum temperature 750°C) indicates a temperature of 308 ° C. So this equipment can be used for SEO2F deposition where the glass surface temperature required for the deposition process is between 250 – 420 °C (Purwanto, Widiyandari, & Jumari,2012).

The material used to make FTO is microscopic object glass, Sn/Tin granules, concentrated HCl (technical), concentrated HNO3 (technical), NH4F dopant in ethanol 95%. SnCl 2. F solution was prepared by dissolving 7 grams of Sn granules into 20 mL Concentrated HCl and 5 mL HNO 3 as a catalyst. After completely dissolved, then 95% ethanol was added to a volume of 50 mL to reduce the acidity of HCl. Dopant NH 4 F 10% in 0.5 MHCl was then added to a solution of SnCl 2 until completely dissolved (Purwanto et al., 2012). The SnCl2F solution was then sprayed with a spray angle of 45° with distance of 5-10 cm to the glass which has been heated to a deposition temperature of between 250 – 300 °C with ceramic bottom / incandescent cup/crucible lid visible on figure 3.

Figure 3. SnO2F deposition tool set using the burner Bunsen

Figure 3. shows the deposition of SnO2F arranged on glass using a Bunsen burner with a ceramic base with a porcelain triangle and three-legged triangle support.

3. RESULTS AND DISCUSSION

Guided Inquiry practical teaching materials Aspects of understanding NOST that are poured into practical teaching materials It is hoped that students will understand:

1. The Nature of Science and Technology

By conducting scientific experiments related to the latest technology such as conductive glass in practical teaching materials, students will be able to understand real science and technology.

2. Characteristics of science and scientific theories

By giving the material contained in the glass practicum teaching materials conductive which contains knowledge and theory of Basic Chemistry, students will be more understand the characteristics of scientific knowledge and scientific theories.

3. How to acquire knowledge and theories scientifically

From a series of experiments in practical teaching materials with variables that affect the manufacture of conductive glass, students will be able to FTO (Fluorine-Doped Tin Oxide) Conductive Transparent Glass Manufacturing For KIT Organic Compound Based Sensitization Solar Cells / Dye-Sensitized Solar Cell (DSSC) Spray Deposition Technique Using a Bunsen Burner and Simple Tools Syntax Literate, Vol. 7, No. 5, May 2022 5639 know and experience how to acquire knowledge and theories scientific research carried out and built by previous scientists.

4. The purpose of science and scientific research

After the students experimented with making conductive glass, students will know the purpose of science and scientific research that is built needed to solve local and global problems related to crises of current energy.

5. The relationship between science and technology

By incorporating the concept of conductive glass chemistry in teaching materials practicum, students are expected to know the relationship between science and technology, whether influencing or being influenced in a particular context. There are six inquiry activities in practical teaching materials, of which three The first activity is pre-experimental, followed by one experimental activities and the last two activities are post-experimental, the activities are:

1. Presenting questions

Students are given facts in the form of pictures or related tables with conductive glass, (energy crisis, renewable energy, examples of energy applications the alternative in life) are then asked questions related to the facts that leads to the practical goal of making conductive glass that can be used in solar cells.

2. Create a hypothesis

Students are asked to write hypotheses about the questions given about the conductivity of materials that can be conductors, insulators and semiconductors (glass, gold, tin, carbon, and related materials for the manufacture of glass conductive) and predict what if the glass that was originally an insulator conductive material.

3. Designing an experiment

Students write down tools, materials, and procedures to be carried out to prove the hypothesis. Test variables such as concentration of SnCl 2 F solution, concentration dopant NH 4 F, Deposition time, amount of deposition, amount of spraying, spraying angle, spraying distance, and other variables according to the tool and ingredient used.

4. Doing experiments

Students conduct experiments based on the procedures that have been made with the distribution of different variables from each group.

5. Collect, process, and analyze data

Students make observation tables, record data, make graphs and analyze the relationship between the data and the variables tested.

6. Make a conclusion

Students make and explain conclusions from the results of the practicum and match it with the hypothesis that has been made and then report it in class, discussions to exchange information on optimization results.

3.2. Optimization of Conductive Glass Manufacturing Standards

Optimizing the results of making conductive glass using a Bunsen burner ceramics by paying attention to the time variable of deposition, the amount of deposition and the amount of spraying can be seen in Table 2.

Table 2. Effect of deposition time on sheet resistance

Sample	Time deposition (minute)	Amount deposit (time)	Amount spray (time)	Resistance slabs (K/sq)
FTO 1	3	10	1	-
FTO 2	5	10	1	50 - 100
FTO 3	10	10	1	50 - 100

Table 2 shows the effect of SnO2F deposition time on the glass produces an optimal deposition time of 5 minutes and has no effect against sheet resistance when the Deposition time becomes 10 min with other fixed variables. Even with a longer Deposition time will cause the glass to break easily.

Table 3. Effect of deposition amount on sheet resistance

Sample	Time deposition (minute)	Amount deposit (time)	Amount spray (time)	Resistance slabs (K/sq)
FTO 4	5	5	1	>100
FTO 5	5	10	1	50 - 100
FTO 6	5	15	1	50 – 100

Table 3. shows that the optimal amount of deposition occurs at 10 repetitionsand does not reduce the sheet resistance if the repeat is increased to 15 time. Just add a white crust on the glass surface so that it produces non-transparent glass (small transmission) that can block light absorption the sun when applied to solar cells. FTO (Fluorine-Doped Tin Oxide) Conductive Transparent Glass Manufacturing For KIT Organic Compound Based Sensitization Solar Cells / Dye-Sensitized Solar Cell (DSSC) Spray Deposition Technique Using a Bunsen Burner and Simple Tools.

Table 4. Effect of Spraying on sheet resistance

Sample	Time deposition (minute)	Amount deposit (time)	Amount spray (time)	Resistance slabs (K/sq)
FTO 7	5	10	1	50 - 100
FTO 8	5	10	2	20 – 50
FTO 9	5	10	3	1 – 10
FTO 10	5	10	4	- 10

Table 4. shows the optimal amount of spraying of SnCl2F solution at glass 3 times, depending on the size of the perfume spray nozzle used. The larger the spray mist size, the less spray needed. If the amount of spraying is added from the optimum condition, then the glass will break easily because the glass shrinkage process is too fast by the SnCl2F and will only add a white crust to the glass. The author has also conducted experiments using other equipment that easy to reach like a gas stove to replace Furnace and Bunsen as well as asbestos and non-asbestos cassa base to replace ceramic base/crucible cup lid (Deposition time 5 minutes, 10 times Deposition, and 3 x spraying. Spray, With a spray angle of 45° and a spray distance of 5-10 cm with a temperature of deposition 250 - 300 °C). The results can be seen in Table 5.

Table 5. Effect of using other heaters and glass bottoms on sheet resistance

Sample	Heating	Glass base	Glass Temperature (°C)	Rstance Sheet Optimal (K / sq.)	Glass surface
FTO 11	Gas stove	Asbestos cassa	225	-	White spot
FTO 12	Gas stove	Cassa non asbestos	215	5 – 100	broken/melted glass
FTO 13	Gas stove	Ceramic	275	5 – 20	Shine like a rainbow
FTO 14	Bunsen	Asbestos cassa	230	-	White spot
FTO 15	Bunsen	Cassa non asbestos	220	5 – 100	broken/melted glass
FTO 16	Bunsen	Ceramic	300	1 – 10	Shine like a rainbow
FTO 17	Furnace	Ceramic	400	1 - 5	Shine like a rainbow

From table 5 it can be seen that the use of best tool for glass-making conductive by spray pyrolysis method is to use a furnace with a ceramic mat. However, not every Basic Chemistry laboratory has a furnace, using a Bunsen or gas stove using a ceramic base will. produces conductive glass with a sheet resistance of 1 -10 KΩ/sq which is shown in figure 4.

Figure 4. Measurement of the resistance of the resulting FTO glass sheet by using the AVO meter

Figure 4 shows the measurement of the resistance of the FTO glass sheet using an AVO meter KΩ scale which shows a sheet resistance value of 2.63 KΩ.

4. CONCLUSION

In this research, we develop practical teaching materials in the laboratory based on guided inquiry experiments to make conductive glass using Bunsen burners to apply NOST and designed using the MER design research method. FTO (Fluorine-Doped Tin Oxide) conductive glass manufactured with the spray pyrolysis method using a Bunsen burner has a resistance of 1 to 10KΩ/sq sheet with 5 minutes deposition time treatment, 10. deposition time times and spraying 3 times with a spray angle of 45° and a spray distance of 5-10 cm with a Deposition temperature of 250 - 300 °C. The structure of SnO2 can then be analyzed using XRD (X-Ray diffractometry) which will show a tetragonal structure so expect This conductive material can be used to make solar cell electrodes Made of FTO (Fluorine-Doped Tin Oxide) Conductive Transparent Glass For KIT Organic Compound Based Sensitization Solar Cells / Dye-Sensitized Solar Cell (DSSC) Spray Deposition Technique Using a Bunsen Burner and Simple Tools.

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