Business Model Development of Oil Palm Empty Fruit Bunch and Trunk Carbon Nanofibers – Based Water Purifier

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Abstract. Indonesia have confronted the decrease in water quality due to mining, industry, agricultural practices, and waste disposal. Carbon nanofibers derived from oil palm empty fruit bunch (OPEFB) and oil palm trunk (OPT) have the economic potential to be commercialized as water purifier. This paper aims to analyze the potential economic value by means of a business model from OPEFB and OPT carbon nanofibers. The methods used in this paper were the qualitative method and the business model development. The result showed that the carbon nanofibers based –water purifier has high economic value. The economic value of this innovation is predicted to increase from $1.6 billion in 2007 to $6.6 billion in 2015 in the market. Furthermore, the suitable business model for water purifier from OPEFB and OPT carbon nanofibers was the fabless business model (FLBM). That model is more focused on the core competencies (research, design, development) and marketing of the nanotechnology products. This FLBM was suitable for the new startup business with innovative technology to enter the market by collaborating with key partners (manufacture, government, academic, research center, and community).

1. Introduction

1.1. Background

Indonesia have confronted the decrease in water quality due to mining, industry, agricultural practices, and waste disposal. There are many factors which cause water pollution in Indonesia. An increasing human population and industrialization rates resulting in a decreasing of environment quality, especially water quality [1]. Indonesian Ministry of Environment (2013) [2] reported that 75.25% of Indonesian rivers belong to heavy polluted with the pollution sources are from household waste, livestock, agriculture, industry, and others (Figure 1). Then, based on the data of Indonesia country water assessment in 2016, the mining activity is also a main source of water pollution in Indonesia [3].
Human activities especially in agricultural, mining and other industrial activities have the heavy metal contents such as iron (Fe), manganese (Mn), lead (Pb) and copper (Cu). These heavy metal containing toxic substances that affecting the water quality and organism health. Heavy metal is a type of pollutants substance that most often found in the waters. It can be transferred from the environment into organisms and from an organism to other organisms through the food chain [4]. Heavy metals in the waters will go down and settles on the water basis, and forming the sedimentation, as well as causing the community who consume the water will be contaminated by those heavy metals. The water containing heavy metals will be a poison for live organisms [5]. The discovery of these water contaminants has been extensively investigated by Ezekwe et al. [6], Wilopo et al. [7], Irnawati et al. [8], Riza et al. [9].

As a solution, there have been many ways to overcome the problem of water pollution, such as: the treatment of household waste disposal, the practice of environmentally friendly agriculture, the treatment of industrial waste disposal, anti-pollution policies and regulations, educative campaigns and eco-friendly individual businesses. Indonesian government has developed a national program called Program Kali Bersih (Prokasih) to clean the river and reduce the water pollutants, as well as to improve the water quality of Indonesian rivers since 1980s. However the implementation of this program need to be suplemented. The efficient technology or approach are very necessary. One of the ways is by using chitosan in carbon nanofibers technology.

Chitosan is one of the second abundant biopolymers available after lignocellulosic biopolymers. Chitosan can be extracted from the chitin via deacetylation process found in shrimp, crabs, mushrooms, and shellfish. Chitosan polymers also have advantages, including: non-toxic, biologically compatible, degradable, adhesive and responsive, antimicrobial, wound healing [10], good oxygen inhibitory properties [11] soluble in aqueous solutions, and has the ability to form complexes [12], as well as is widely applied in biomedical fields [13]. Chitosan has been widely used as flocculants for purifying water pollution [14, 15, 16]. Purification of water made by chitosan due to chitosan can act as a metal ligand that forms a stable complex with many metal ions, and acts as a protein coagulation agent.

The role of chitosan in purifying water needs to be enhanced by the addition of nanotechnology materials so that its effectiveness in water purification is better than just chitosan alone. In addition, the addition of nano-sized materials can provide new properties of water purifier products. One of the nano-sized materials that have superior properties is carbon nanofibers. Carbon nanofibers are collections of carbon that form nano-sized tubes isolated by electric-arc discharge techniques, laser ablation, chemical
vapor deposition [17]. The carbon nanofibers can be extracted from lignocellulosic materials, such as oil palm empty fruit bunches (OPEFBs) due to OPEFBs consisting of 44.4% cellulose [18], 30.3% hemicellulose, and 21.6% lignin [19]. Based on Das et al. [20], carbon nanofibers are superior absorbents for water pollutants, for example: organic pollutants (pesticides, insecticides, herbicides, fats, volatile components, and perchlorates), inorganic (heavy metals, ammonia, and salt), and biology (bacteria, virus, algae, and mushrooms). Carbon nanofibers derived from oil palm empty fruit bunch (OPEFB) and oil palm trunk (OPT) have the economic potential to be commercialized as water purifier.

![Figure 2. Oil Palm Empty Fruit Bunch (OPEFB) and Oil Palm Trunk (OPT)](image)

1.2. Objective

The objective of this paper is to analyze the potential economic value by means of a business model from OPEFB and OPT carbon nanofibers.

2. Method

The methods used in this paper were the qualitative method and the business model development. Identification of the nanotech business model types using the Dagnino’s approach [21]. There are two nanotech business models: the fab business model (the traditional model) and the fabless business model. Furthermore, the business model canvas analysis tool developed by Osterwalder and Pigneur [22] is used to analyze the nine main elements of developing carbon nanofibers - based water purifier business. There are nine main elements of business model canvas (BMC) are customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. BMC can be a guide in developing innovative and comprehensive business models.

3. Results and Discussions

The result showed that the carbon nanofibers based–water purifier has high economic value. The economic value of this innovation was increased increase from $1.6 billion in 2007 to $6.6 billion in 2015 in the market [23]. Price of selected nanomaterials for water sector can be seen on Table 1. According to Brame et al. [24], nanomaterial Fullerenes (C60) has the highest price valuation of US $ 330 / gram followed by Nano Silver of US $ 19.6 / gram in the second position. Nanocarbon fibers based on OPEFB and OPT was also predicted to has high economic value for water purifier. Market and commercialization potential were quite large in developing countries.
Table 1. Price of Selected Nanomaterials for Water Sector

| Nanomaterial            | Price (US$/gram) |
|-------------------------|------------------|
| Nano zero-valent iron   | 0.14             |
| Nano TiO$_2$            | 0.18             |
| Nano-Magnetite          | 0.44             |
| Nano Iron-Oxide         | 1.20             |
| Nano Silver             | 19.60            |
| Fullerenes (C$_{60}$)   | 330.00           |

Source: Brame et al. [24]

Furthermore, the suitable business model for water purifier from OPEFB and OPT carbon nanofibers was the fabless business model (FLBM). That model is more focused on the core competencies (research, design, development) and marketing of the nanotechnology products. This FLBM was suitable for the new startup business with innovative technology to enter the market by collaborating with key partners. FLBM of carbon nanofibers based water purifier can reduce the large capital investment for building a manufacture and reduce maintenance and operating cost of manufacture. Other benefits of the FLBM implementation were more flexible to adapt with the economic fluctuation and can provide better supply chain of products. Based on the BMC analysis tool, detailed results of the nine main elements for carbon nanofibers-water purifier startup business have been developed (Figure 3). Each element has a connection and implication with each other. The expected impact of the carbon nanofibers based purifier startup business are improved water quality, reduction of oil palm waste, and increased income of users. The mission of carbon nanofibers based water purifier were improving water quality for the community, reducing oil palm waste as carbon nanofibers, and increasing income of users. The measurement of the mission and impact of the business model were water quality level, buyer response, and level of sales.
Figure 3. BMC of Carbon Nanofibers based Water Purifier

Based on BMC analysis, value proposition business model was water purifiers made from carbon nanofibers by utilizing oil palm waste in supporting to improve water quality in the community. Customer segments of this business consist of companies, local governments, and end consumers. Customer relationship programs to keep and increase consumer loyalty were partnership contract and after sales program. This carbon nanofibers based water purifier business using several channels through direct selling, website utilization and social media optimization.

Some key activities of this business model were research development, production, marketing, partnership, website and social media development. The carbon nanofibers based water purifier business needs capital production equipment and materials, human resources, and financial resources to implement the key activities. The fabless business model (FLBM) type must involve vendor / factory, NGO, research center, government, and media to achieve business sustainability.

4. Conclusions

The carbon nanofibers based–water purifier has high economic value. The suitable business model for water purifier from OPEFB and OPT carbon nanofibers was the fabless business model (FLBM). BMC of carbon nanofibers - based water purifiers can be applied sustainably by involving key stakeholders (manufacture, government, academic, research center, media, and community).

5. References

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