CHAPTER 6

Carboxymethyl Cellulose Production from Empty Fruit Bunch by Ozonolysis Pre-Treatment

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6.1 OVERVIEW

Ozone pre-treatment appears as an effective method for isolation of cellulose prior to further bioproduct development such as a water-soluble cellulose derivative known as Carboxymethyl Cellulose (CMC). The CMC can be used as thickener, binder, and emulsifier as well as a food additive in detergent, food and beverages, pulp and paper, paint, textile, pharmaceutical and cosmetic industries. This chapter elaborates the CMC production from ozonated OPEFB at the recommended carboxymethylation reaction conditions to obtain the desired Degree of Substitution (DS) of 0.3. By employed the response surface methodology technique, the interaction of the process parameter on the selected response can be explained with minimum amount of experiment. The synthesized CMC with DS of 0.3 obtained at the region of 30 to 50 wt.% of NaOH concentration and 1:1.1 to 1:1.15 of SMCA loading. The FTIR spectra verified the production of CMC with the presence of C = O at 1610.06 cm^{-1} wavelength. The

morphology of CMC was amorphous with the microfibrillar cellulose intact due to low DS value. The degradation temperature of cellulose backboned in CMC was decreased.

6.2 BACKGROUND

6.2.1 Empty Fruit Bunch as Cellulose Material

Malaysia is the second-largest palm oil producer and largest supplier in the world. Over 17 million oil palms have been supplied to the world (Yoshizaki et al., 2012). However, only 10% of palm oil trees are converted into Crude Palm Oil (CPO), while 90% become solid waste. One of the solid wastes that have been abundant is the empty fruit bunch (OPEFB). The availability of the OPEFB is about 7,071,044 tons per year after Combined Heat and Power (CHP) has been considered (Reeb et al., 2014).

A few palm oil producers consider excess EFB devoid of value and send it to landfill. Others have applied EFB at the plantation as compost, and a minority of producers sold the EFB for pellet or briquette production (Reeb et al., 2014). Therefore, attempts to transform EFB into value-added products have gained wide attention since waste management is costly for producers besides creating an environmental problem.

Value-added EFB for cellulose-based material might be a convincing way to address these problems as EFB consists of high cellulose content. Cellulose, having the chemical formula $(C_6H_{10}O_5)_n$, is a natural polymer that is found in all plant components and is produced through the photosynthesis process and can be found in solid state (Ngadi & Lani, 2014). The cellulose can be converted into cellulose derivative chemicals using a mechanical, chemical, or biological process. There have

been numerous methods of modifying the cellulose surface structure for the end product. One of the promising is CMC by using carboxymethylation reaction.

Cellulose has a wide market since it is commonly used in packaging, electronics and printing, and healthcare materials. Cellulosic materials have several applications in thermo-reversible and tenable hydrogels, coating additives, paper making, flexible screens, food packaging, optically transparent films and lightweight materials for ballistic protection, automobile windows and others. The structural and physical properties of cellulose have drawn significant attention for multiple applications, including films, packaging, paper, building and coating materials, advanced materials, food, drugs, and flexible electronics. The global cellulose market is expected to grow at a CAGR of 4.1% during the period 2023-2028.

6.2.2 Carboxymethyl Cellulose

Carboxymethyl Cellulose (CMC) is an anionic linear polysaccharide of cellulose derivatives in cellulose ether category. The CMC is viscous, nontoxic, non-allergenic, and biodegradable that is widely used for industrial applications (Rahman et al., 2021; Huang et al., 2017). Various industries such as food and beverages, pharmaceutical, pulp and paper, paint, textile, and cosmetic utilize CMC as a thickener, binder, emulsifier, film forming and lubricant due to their characteristic (Rahman et al., 2021; Crabbe-Mann et al., 2018; Huang et al., 2017; Megha et al., 2018).

CMC is a copolymer of two units of β-D-glucose and β-D-glucopyranosyl-2-O-(carboxymethyl)-monosodium salt. The units are joined by β-(1,4-glycosidic) linkages (Figure 6.1) (Kaewprachu et al., 2021). The units are formed by replacing