

CHAPTER 1

INTRODUCTION

1.1 Background

Biomass waste is generally used as an environmentally friendly fuel. Biomass waste comes from organic materials that have become worthless waste (Parinduri et al., 2020). With the development of nanomaterials technology, Carbon Nano Dots (CNDs) have become one of the alternatives for biosensors, bioimaging, and photocatalysis (Rajkishore et al., 2023). CNDs are carbon particles with a size of < 10 nm. CNDs have high fluorescence properties, good optical stability, and are environmentally friendly (Rahmi et al., 2023). CNDs are luminescent materials with qualities similar to photostability, biocompatibility, and bioavailability (Kim et al., 2022b). The materials used in this study are from the biomass of Empty Palm Fruit Bunches (EPFB) and watermelon rind waste. Empty Palm Fruit Bunches (EPFB) serve as lignocellulosic waste with potential as bioadsorbents due to their active carbon structure (Suryani et al., 2024).

The unique properties possessed by CNDs will form very remarkable structures and optical properties if combined with other substances or compounds, resulting in the formation of nano-structures composites and excellent emission luminescence (Emdadi & Asimov, 2024). Previous research conducted by Duong in 2024 stated that the emission luminescence produced depends on the excitation and quantum transition probability of CNDs. In his study on Carbon Dots (CD), the wavelength peaks produced in the size range of 2,06 – 2,09 nm at an excitation wavelength of 350 nm were assessed, indicating that the emitted luminescence depends on the excitation wavelength due to impurities. The result can support the potential for technological advancements such as in sensors and bioimaging (Van Duong et al., 2024). In the development of CNDs synthesis, the addition of doping FeCl_3 supports the formation of good optical properties. With the presence of metal ions in the synthesis of CNDs, a wider carbon surface is formed are very promising for various applications such as bioimaging (Bedia et al., 2020).

Several previous studies on the synthesis of CNDs have been conducted. Based on the research conducted by Sawitri in 2018, watermelon rind has been

successfully synthesized into a carbon source. The synthesis was carried out using a microwave irradiation technique. In the study, the peaks of absorbance and photoluminescence are in the wavelength range of 300 – 500 nm. The findings in that study state that samples from watermelon rind are capable of exhibiting one of the properties of CNDs in emitting light without the influence of time in the synthesis process (Sawitri & Isnaeni, 2018). Based on the research conducted by Gultom in 2024, it was stated that watermelon rind contains alkaloids, flavonoids, phenols, and tannins, thus having high potential as a carbon source. In this study, the synthesis process was carried out by varying the additives and varying the concentration of FeCl_3 as doping. The UV-Vis characterization result showed an absorbance peak at a wavelength of 200 – 400 nm. Meanwhile, the FTIR result showed the functional groups O – H and C = C (Gultom, 2024). In another study, the synthesis of lignocellulosic biomass waste CNDs exhibited a strong absorption peak between 200 to 400 nm in the absorption spectrum, followed by a tail extending into the visible light range. The absorption peak wavelength typically falls within the range of 200 to 250 nm with $\pi - \pi^*$ transition functional groups (Gan et al., 2023). However until now, there has been no systematic research comparing the synthesis results of CNDs from EFB and watermelon rind with variations in urea mass and variations in FeCl_3 doping concentration. A very important comparison to determine the differences in photoluminescence characteristics produced from two types of biomass with the same synthesis. This will further strengthen the success of natural materials as a source of Carbon Nano Dots (CNDs).

Based on this background, this research will focus on CNDs derived from EPFB waste and watermelon rind waste synthesized using the microwave method with the addition of urea as an additive and doping metal ion in the form of iron (III) chloride FeCl_3 with variations in urea mass and different FeCl_3 concentrations to enhance photoluminescence emission. The characterization conducted in the study used characterization methods such as UV-Vis Spectrometer to determine the absorbance peaks of CNDs, XRD (X-Ray Diffraction) to determine the structure and crystal size, FTIR (Fourier Transform Infrared Spectroscopy) to identify the functional groups of the compound, SEM (Scanning Electron Microscopy) to determine the

size, morphology, and particle distribution, and PL (Photoluminescence Spectroscopy) to determine the fluorescence properties. This research is expected to support the processing of biomass waste into valuable materials and develop safe, simple, and environmentally friendly bioimaging technology.

1.2 Problem Formulation

1. What are the differences in the characteristics of Carbon Nano Dots (CNDs) produced from EPFB and watermelon rind?
2. How does the variation in urea mass and FeCl_3 concentration affect the optical characteristics of Carbon Nano Dots (CNDs) synthesized from EPFB and watermelon rind?

1.3 Research Objectives

1. To determine the differences in the characteristics of CNDs produced from EPFB and watermelon rind.
2. To understand the effect of variations in urea mass and FeCl_3 concentration on the optical characteristics of Carbon Nano Dots (CNDs) synthesized from EPFB and watermelon rind.

1.4 Research Benefits

1. Contributing to the development of science, particularly in the synthesis of Carbon Nano Dots (CNDs) based on biomass waste and their application in the fields of bioimaging.
2. Providing characterization information of CNDs synthesized from Empty Palm Fruit Bunches (EPFB) and watermelon rind, as well as the influence of varying urea mass and FeCl_3 concentration on the optical properties of CNDs, particularly fluorescence intensity and stability, thereby supporting the utilization of CNDs as bioimaging materials.
3. Contributing to the processing of Empty Palm Fruit Bunches (EPFB) and watermelon rind waste into beneficial product thru the synthesis of CNDs into high-value, safe, and environmentally friendly materials.

1.5 Hypothesis

1. Carbon Nano Dots (CNDs) synthesized from Empty Palm Fruit Bunches (EPFB) and watermelon rind exhibit different structural and optical characteristics due to differences in the chemical composition and carbon content of the precursor materials.
2. Variations in urea mass and FeCl_3 concentration significantly influence the optical characteristics of Carbon Nano Dots (CNDs) synthesized from EPFB and watermelon rind by modifying their surface functional groups, electronic structure, and photoluminescence properties.