# Critical review on preparation and characterisation of red seaweed nanocellulose via acid hydrolysis method

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**ABSTRACT** – Seaweeds are viewed as one of the most significant sustainable resources with industrial potential in various applications. The purpose of this study is to plan a methodology for the preparation of the red seaweed nanocellulose (NC) via chemical treatment. Hence, the effect of hydrolysis time and hydrolysis acid concentration are studied to find the optimum conditions of red seaweed NC due to the richness of cellulose content and lowest percentage of noncellulosic components. The significant parameters using 64 wt.% acid hydrolysis for 250 min had been postulated. The crystallinity index was postulated as 80%, and crystallite size had been hypothesized to 465 nm based on data pattern due to the critical review by X-Ray Diffraction (XRD) analysis.

## 1. INTRODUCTION

Seaweed or the other name is macroalgae which are plant-like creatures that for the most part, live on a rock or other hard substrate in the coastal zone. In the course of the most recent couple of decades, seaweeds have drawn critical worldwide attention because of its possible use in pharmaceuticals, fertilizer, biofuels, synthetic substances, biomedical, hydrocolloids, food enhancements, beauty care products and numerous different fields [1].

Cellulose is known to be used as a raw material in papermaking and composite sheet, food, and additives traditionally and nowadays, the extraction of nanocellulose (NC) from cellulose sources and observation on its applications are becoming more interesting research areas with the introduction of booming nanotechnology [2-4]. However, up to now, a few detailed studies were carried out on the use of seaweed as a raw material in the extraction of NC from seaweed [5,8]. Chen et al., reported that there are low or no lignin in the red seaweed composition compared to brown, green, and waste seaweed which is lignin is the main target to be removed. Furthermore, red seaweed also has higher cellulose than other seaweeds which can be the best candidate to produce high-quality NC [5]. NC has high crystallographic advantages that can be produced through chemical treatments such as acid hydrolysis which cause it to be widely used [6]. At the end of the result, NC will be generated in powdery mildew.

The aim of this current work is to plan the preparation and characterization of NC that derived from red seaweed using acid hydrolysis method by different hydrolysis time and acid concentration. The crystallinity index (CrI) and crystallite size of NC obtained will be further analysed by postulating review data using the selected tools of X-ray diffraction microscopy (XRD).

## 2. METHODOLOGY

The suggested methodology is as follows: a 50g of red seaweed powder was treated with 1 L of 2 wt.% of NaOH, at temperature 120 ºC for 120 min. The mixture had been filtered by cloth sieve and washed with distilled water several times until the pH is 7. The resultant mixture was then being put on the tray and dried in the drying oven at 40 ºC for 24 hours.

After that, the alkali-treated of red seaweed powder will be subjected to the acid hydrolysis stage, with the parameter of 64 wt.% acid concentration, hydrolysis time of 250 min and temperature at 45°C. Then, the mixture stirred continuously until the hydrolysis process completes. The hydrolysed cellulose dialysed a few times by using distilled water to a constant pH 7. After that, the sample of red seaweed NC filtrated and oven-dried at 55°C for 4 h, before subjected to X-ray diffraction microscopy (XRD) analysis [7,8,9].

## 3. RESULTS AND DISCUSSION

As a result, a corresponding crystallinity index (CrI) and crystallite size values are listed in Table 1 and Table 2 that was postulated based on the reviewed data pattern. Out of a number of the review journals that had been reviewed, only three journals used the close parameters and responses related to this study. The previous researches were from Singh et al. [7], Chen et al. [8] and Feng et al. [9].

Based on the data, 80% of CrI is tabulated as the postulated result. The more hydrolysis time is taken, the higher the CrI will get. Nevertheless, it will not exceed 88% crystallinity of NC. This is because the range of the crystallinity of NC is within 54% to 88% [10]. Also, the resulting CrI will be higher after 45 minutes of hydrolysis process time [11]. The CrI will be lower if the hydrolysis time is too short, or too long [12]. If the

time taken is too short, the process of removing lignin and hemicellulose will not occur. If the hydrolysis time is too long, the acidic solutions will damage not only the amorphous area but also the crystalline area. Nevertheless, the longest hydrolysis time taken by the other researcher was up to 24 h [13].

Table 1 The crystallinity index (CrI) of acid hydrolysis treated

| References | Hydrolysis Time (min) | Acid Hydrolysis Concentration (wt.%) | Crystallinity Index (%) |
|---|---|---|---|
| Singh et al. (2017) | 30 | 40 | 60 |
| Chen et al. (2016) | 45 | 64 | 73 |
| Feng et al. (2015) | 240 | 64 | 74.5 |
| Hypothesized result | 250 | 64 | 80 |

Besides, it is postulated that when hydrolysis concentration acid is 64 wt% and 250 min hydrolysis time, the crystallite size is 465 nm. The evidence supported by Lu and Hsieh [14] and Ioelovich [15], which is using 64-65 wt% was recommended to obtain the high-crystalline CrI of NC.

Other than that, when 250 min had been taken, the crystallinity is 465 nm which is still in the range of crystallite size. The hypothesized result was supported by Abdul Khalil et al. [10] which stated that the size of NC is between 100-600 nm lengths, and the diameter is between 2-20 nm. The longer the reaction time, the smaller the crystalline scale [16].

Table 2 The crystallite size of acid hydrolysis treated

| References | Hydrolysis Time (min) | Acid Hydrolysis Concentration (wt.%) | Crystallite Size (nm) |
|---|---|---|---|
| Singh et al. (2017) | 30 | 40 | 408 |
| Chen et al. (2016) | 45 | 64 | 523.6 |
| Feng et al. (2015) | 240 | 64 | 480 |
| Hypothesized result | 250 | 64 | 465 |

## 4. CONCLUSIONS

According to the planned methodology, it is hypothesized that nanocellulose (NC) can be successfully produced from isolated red seaweed powder by using acid hydrolysis approach at 64 wt% acid concentration for 250 min acid hydrolysis time and at constant temperature 45°C. The crystallinity index (CrI) is proposed to be 80% which is higher than the reviewed journals due to the richness of the cellulose content of the red seaweed. Besides, the suggested of crystallite size was 465 nm since the size of NC usually ranges between 100-600 nm.

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